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Department of Science & Technology

विज्ञान और प्रौद्योगिकी मंत्रालय

Ministry of Science & Technology

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Executive Summary

The Department of Science and Technology, founded in 1971, has been readjusting its programmes and plans to suit the changing needs of the science and technology sector of the country. In the early phase of development, programmes and plans were selected on the basis of budget and resources available to the Ministry. Resource constraints formed an important consideration in development of plan programmes of the R&D sector during the periods prior to economic liberalization.

In many of the previous plan periods, the Department identified various programmes and assigned inter-se priorities among the various schemes and programmes and allocated the available resources among the selected programmes. The Department has attempted to plan the 12th plan proposals with a difference. DST has now made an attempt to define R&D outputs for each programme, map and estimate the fund requirement and propose optimum resource needs based on bench marks.

The approach paper of the Planning Commission for the 12th Plan, for the first time has included a section on science and technology as well as Innovation. DST, recognizing the expectations of the country from the science and technology and innovation sector has adopted a difference in approach for the preparation of the 12th Plan proposals. An output directed planning approach has been adopted. Several consultation processes with stakeholders as well as science advisory and expert advice mechanisms have enabled the planning methodology.

The approach to planning has related to the needs of the society and demands for R&D outputs from the Science and Technology sector. A thematic planning approach has been adopted. An attempt has been made to identify and quantify the deliverables expected from the 12th plan programmes of the Department.

Objectives of policy formulation have been specified. Policy formulations with an objective to double private sector engagement into R&D, promote Public Private Partnerships for R&D, and expand the R&D base of the country etc.

have formed the priorities. A proposal is made that DST would attempt to place 4 bills and 16 policy documents before the Government during the 12th plan period for consideration. The Department proposes institutionalization of policy research and preparation of several thematic and periodic reports on the R&D sector complete with inter-country comparisons. A provision of Rs 50 crores and effort intensive plan has been made.

Objectives of programmes for strengthening and building human capacity for R&D have been elaborated. As many as 21 programmes have been identified and their resource requirements mapped. Programmes for mobility of employed women, "**Disha**" scheme for women in science, new doctoral and post-doctoral fellowships for training abroad, Building Educators for Science Teaching and Start-up grant for new recruits in academic sector from Indian Diaspora are proposed new initiatives. INSPIRE scheme initiated in 11th plan has been received exceedingly well by the science and technology sector. Initial results are encouraging. It has received favourable review. The Department proposes to continue the scheme during the 12th plan with some modifications of parameters. During the mid-stage of 12th plan, the INSPIRE award scheme could be evaluated for possible continuation through Ministry of Human Resource Development during the 13th plan period. Strengthening and building Human Capacity would form a major focus area for resource deployment. It is estimated that as many as 3 million Indians would be receiving support through the programmes proposed by DST for implementation during the 12th plan. The level of allocation for the programmes proposed by DST under Human Capacity building is Rs 7090 crores during the 12th plan.

Objectives of the programmes under strengthening institutional capacity during the 12th plan through DST have largely relied on consolidation and further augmentation of ongoing and 11th plan initiatives. The focus of 12th plan programmes under this objective would be to relate investment into strengthening of institutional capacities based on outputs and expected outcomes rather than limiting objectives to infrastructure strengthening alone. Challenge Award concepts for institutional capacity building are being introduced. Specific targets for the number of institutions and science departments to be served through the 12th plan programmes of DST have been stipulated. Deployment of Rs 6975 crores has been proposed by DST during the 12th plan.

The Department of Science and Technology has responded to the changing stakeholder aspirations with respect to Technology Development and Deployment programmes. Whereas the programmes of the Department of science and Technology under Technology Development and Deployment in the previous plans were generally focused on demonstrating the viabilities of technologies developed by public funded institutions, proposals for the 12th plan under this objective have been developed under a different paradigm. User needs for technologies have been accorded high priority in selection of technology goals. Technology platform for solving real-life challenges is a novel approach suggested by the Sub-group. Total of four technology platforms have been suggested. The Department has proposed a total of eight platforms. Climate change programmes, modernization of Survey of India and NATMO, district level technology interventions for increases in per-capita incomes are new objectives of the 12th plan programmes. Technology deployment will receive as much focus as technology development. Total investment of Rs 6395 crores has been envisaged for implementing the proposals.

Partnerships and alliances for technology development and deployment form essential linkage capitals. Objectives of the programmes under partnerships and alliances are generally based on reciprocity and parity principle for international cooperation and for value generation of R&D outputs from the public funded research under national linkages. New Mechanisms have been proposed for Public-Private Partnerships and Centre-State Technology partnerships. Established mechanisms are proposed to be employed for bilateral and multi-lateral S&T cooperation. The approach paper of the Planning Commission has proposed PAN-India mission where R&D outputs are linked to gainful applications. The Department of Science and Technology has made a provision of Rs 300 crores for deployment into PAN-India mission. A total provision of Rs 4565 crores has been made for implementing all the proposals under partnerships and alliances.

Social contract of S&T has remained an important programme of the Department. DST has recently constituted a Council for Science and Technology for Rural India, (CSTRI) providing new mechanisms for delivering technologies to the Rural India. Delivery of Technologies to North East Region has remained a special challenge area. A New North East Centre for Technology Applications and Reach (NECTAR) has been proposed. National

Innovation Foundation, an autonomous institution of DST offers scope for promoting open source innovations. The 12th plan proposal includes development of special mechanisms for efficient delivery of 5% of total budget of DST programme activities relating to the benefits for SC/ST population. A special focus on R&D for addressing women and child health related issues has been proposed. A provision of Rs 1025 crores has been made for the implementation of the programmes proposed under the objective and function of social contract of S&T.

The country has taken a policy decision to invest judiciously into the establishment of Super computer with carefully selected capacity and maintain global competitiveness. The Planning Commission has indicated to provide an allocation of Rs 5000 crores for establishing the right sized Super Computer Facility and assigned the responsibility to DST for coordination.

During the 12th plan period, DST has proposed a number of new initiatives. They are a) 1000 Overseas Doctoral scholarships, b) 250 Overseas Post-doctoral fellowships, c) Women mobility scheme for employed scientists, d) Enlarging the PI base to include about 500 teachers from colleges and universities, e) Start-up Research grant for Indian Diaspora undertaking faculty assignments in Indian academia, f) "**Disha**" for women in Science programme, g) Building Educators for Science Teaching, h) Challenge awards for institutions for global positioning, i) National Centres for Advanced Research, j) Technology Platforms, k) Centre-State Technology partnerships, l) Contributions to PAN India missions, m) Joint (Virtual) centres and n) North East Centre for Technology Applications and Reach. A new cell for Policy formulation has been proposed.

The Department of Science and Technology has prepared the proposals for 12th plan programmes to be implemented by DST after taking into account of the changing context of the country in the emerging global knowledge economy. A balance among the various S&T priorities of the country has been taken into account.

Gaining global competitiveness in the Science, Technology and Innovation sector calls for three important considerations namely the Gross Expenditure on R&D as a percentage of GDP, the absorption capacity within the R&D

landscape for additional investments and the ability of the National R&D systems to connect the R&D spend to the value creation for the society. On the basis of analysis of various scenarios, the Department envisages an increase in investments of India into R&D from the current levels of ~1% to ~1.45% of GDP by 2017. If the private sector engagement into R&D were to double from the current levels by the end of 12^{th} plan, public investments into R&D considered necessary could be worked out at US $ 101 billion over the entire 12^{th} plan period. After correcting for Purchase Power Parity, a level of investment of public funds could be worked out. The proposal of DST seeks such an investment (without including investments into Super Computer facility) of about ~17% (same as the current proportion) of total investments of public funds into R&D.

Indian science sector has gained growth momentum during the last three years. Timely investments into the programmes of DST offer scope for building a viable platform for the science and technology sector to contribute to the national developmental objectives. The Department has adapted, to the extent possible, evidence-based approaches to make its proposals for investments during the 12^{th} plan. DST hopes to deliver matching values to the country for the investments made. DST seeks investments into hope and a role in the rise of the nation where science and technology could play a meaning role.

CHAPTER 1

BACKGROUND

Planning Commission of India has adopted an approach to build well-structured inter-sectoral linkages into the 12th plan programmes. A matrix type structure has been developed for while planning the programmes proposed to be supported during the 12th plan period. The overall approach of the country for the 12th plan is focused on "faster, sustainable and more inclusive growth". Under the current approach of the Planning Commission, Science, Technology and Innovation (STI) sector should be directly linked to several developmental programmes of the country.

An effort is being made by the STI sector to link the Science and Technology plan to the overall objective of the 12th plan of India. The approach paper of the research and development sector has taken into account of the expectations from the STI sector, while planning for the 12th plan programmes. An equal emphasis on both discovery and solutions sciences has been considered necessary in the approach paper prepared for planning the 12th plan programmes of the STI sector.

The recently prepared Indian Science Vision[1] has emphasised the planning needs for discovery science leading to scholarship and global leadership in some frontier areas of science. The importance of solution science providing tangible solutions of national problems of securities of food and nutrition, energy and environment, water and sanitation, and affordable health care has been emphasized by various advisory groups[1, 2].

Global survey on manufacturing competitiveness has indicated some emerging opportunities for India[3], which are closely linked to the progress in Science, Technology and Innovation sector during the 12th plan period. The Government of India has declared 2010-20 as "Decade of Innovations". National Innovation Council has been emphasizing the importance of designing, developing and positioning a structured innovation ecosystem[4]. National Knowledge Network has opened up a possibility to link the centres of higher learning and innovations. In light of several developments during the 11th plan period, new opportunities have emerged for the Indian Science, Technology and Innovation sector.

The approach paper developed for the Indian Science, Technology and Innovation sector by the Planning Commission[5] for the 12th plan programmes has expressed both stepped aspirations and increased commitment to developing viable scientific solutions to some national challenges.

The Department of Science and Technology, as an agency engaged in the formulation of S&T related policies and promotion of research and development through Extra Mural Research Schemes has mounted a large number of proactive schemes and measures during the 11th plan period. The Department is also committed to align its 12th plan programmes and initiatives to support the overall plan of the Indian Science, Technology and Innovation sector. Several new initiatives have been considered necessary by DST for implementation during the 12th plan period. However such initiatives should be preceded by a careful and critical review of all the programmes of the Department and decisions to consolidate successful on-going schemes as well as the 11th plan new initiatives. While formulating the 12th plan programmes the Department considers it necessary to adopt an output directed development path and relate inputs to expected and targeted goals. Accordingly an investment plan for the 12th plan proposal is formulated.

CHAPTER 2

REVIEW OF ONGOING PROGRAMMES

Background

The Department of Science and Technology, founded in 1971, has emerged as the major National Extra Mural Research funding agency of the Indian Research and Development sector over the previous plan periods. During the 11th plan period, DST had assumed a proactive role and developed some new programmes. The Department undertook a review of the on-going 11th plan programmes for their outputs and value for continued implementation during the 12th plan period.

1. Review of the New Initiatives of 11th Plan Programmes

The Department of Science and Technology, founded in 1971, has emerged as the major National Extra Mural Research funding agency of the Indian Research and Development sector over the previous plan periods. The Department assumed some proactive roles and developed a large number of programmes and initiatives. A comprehensive list of such programmes and initiatives is presented in **Annexure 1.**

Flagship Initiatives of the Department during the 11th plan

- **Science and Engineering Research Board:** A constitutional autonomous body has been created through an Act of Parliament for functioning as the major Extra Mural Research body for the country[6]. Premises have been rented and the entity is ready for full operation during the last year of the 11th plan. A budget of Rs 300 crores has been earmarked for the Board for the year 2011-12. The entity is expected to grow significantly during the 12th plan period and implement wide ranging programmes of the Department of Science and Technology.

- **Innovation in Science Pursuit for Inspired Research (INSPIRE) and Scholarship for Higher Education (SHE):** INSPIRE is a new flagship initiative of the Department of Science and Technology aimed at the attraction of talent for study of science and careers with research[7]. Various components of the scheme have been initiated during the 11th plan period.

INSPIRE AWARD component addressed the need for excitements among the children in the age group of 10-15. During the period spanning 2009-till date, more than 4 lakh of the 1 million awards have been sanctioned and it is expected that the final tally for the 11th plan period would be of the order of 0.7 million.

INSPIRE Internship is a scheme aimed at inspiring youth in the age group of 16-17 to study of science. Science camps are organized for youth in the age group of 16-17 in several locations in the country who have secured marks within the top 1% of class X examinations held by any school board. About 300 camps have been organized since December 2008 and more than 75000 students have participated in these camps.

Under **Scholarship for Higher Education a complementing component of INSPIRE**, students obtaining grade within the top 1% of class XII examinations of any board or those qualifying in set of national competitive examinations like JEE, AIEEE, KVPY etc. and choose to join science courses are awarded high value scholarships for studying BSc/MSc courses in basic sciences. More than 6000 students have already been offered these scholarships. Agreements with various school boards have been already made by the Department of Science and Technology to release eligibility letters along with mark sheets of board examinations starting 2011. Increasing enrolment of board toppers into undergraduate education in science courses is being reported lately. **INSPIRE Fellowship** scheme aims to attract university toppers in any branch of science, engineering, technology, agriculture, medicine, animal sciences for doctoral research. The scheme is focussed on the age group of 22-27 and was formally initiated in 2010 with a provision for 1000 fellowships. Total of 1040 qualified candidates have been awarded the fellowships. Among the qualified candidates, 66% were women and areas like agriculture received large representation. As against the total PhD output of ~210 in agricultural sciences in 2009, 186 awards for PhD studies in agriculture under INSPIRE fellowship scheme merit special attention in planning. During 2011, interests among the university toppers seem to have increased as evidenced from the responses to call for INSPIRE fellowships.

INSPIRE Faculty scheme focused on the age group of 27-32 and those holding doctoral degrees. It aims to provide assured opportunity for careers with research. Under the scheme 1000 contractual positions for PhD degree holders in any branch relating to science, engineering, technology, medicine, agriculture or animal sciences with a financial compensation matching those of Assistant Professorships of IITs and a research grant of Rs 7 lakhs per year have been approved. Implementation processes of the scheme have been finalized and global call for qualified citizens has been made. The scheme is expected to become operational during 2011-12.

- **Rejuvenation of Research in Universities**: Changes in Parameters of on-going Scheme **Fund for Infrastructure Strengthening of S&T (FIST)** and New Initiatives **Promotion of University Research and Scientific Excellence (PURSE), Special Packages of Regional balancing under FIST,** and **Consolidation of University Research Innovation and Excellence (CURIE) for women universities** have formed family of new initiatives mounted during the 11^{th} plan period by DST for rejuvenating research in universities in the country.

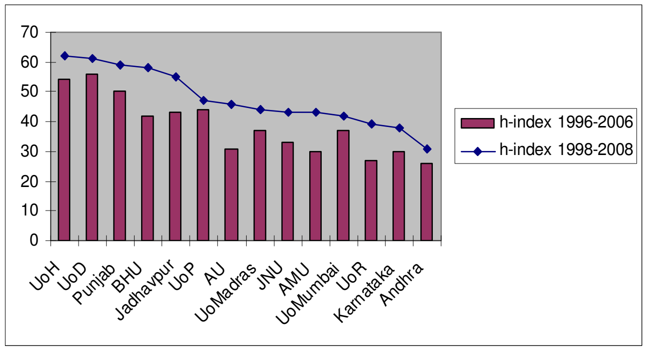
FIST is a successful on-going programme of DST. Under this programme at the start of the 11^{th} plan total number of 961 departments had been supported for strengthening of infrastructure in academic institutions. The scheme was subjected to a third party review in the year 2007-08[8]. Salient recommendations of the review committee are presented in **Annexure 2.**

FIST is a scheme welcomed by the academic community widely. Parameters of the scheme were changed during the 11^{th} plan to include colleges and institutions providing the pipeline of researchers. As many as 700 additional departments and colleges have been supported during 11^{th} plan period. Further preferred status for university departments over elite institutions like IITs and IISc was accorded by setting fund allocation benchmarks. Currently, the ratio of fund earmarked for elite institutions to university departments is 1:2.

Further analysis of data revealed a regional imbalance on account of probably the competitive nature of FIST scheme. Nearly 70% of the funds deployed under FIST during the earlier plans were into institutions from Tamil Nadu, Karnataka, Maharashtra and Delhi. Therefore, special packages were developed under FIST for North East Region, Jammu and Kashmir and Bihar during the years 2008, 2009 and 2010, respectively. Evidence of benefits in modification in parameters for development of special packages is already registered by way of increases in number of proposals received for Extra Mural Research funding from these regions.

Promotion of University Research and Scientific Excellence (PURSE) is a sub-component of FIST commenced during the 11th plan period since 2008. Under this component, Research Incentive Grants are awarded to universities based on number of publications and H-index as evidenced from Scopus data base. Publication profile of India during 1996-2006 period was mapped in 2008[9]. Total of 35 institutions in the country had contributed to 47% of publications during the decennium of 1996-2006. Among them 14 were universities. Based on H-indices of these 14 universities, size of Research Incentive Grants was determined and released. Total funds sanctioned were Rs 202 crores over three year period. The performance of these institutions as evidenced from publications was reviewed. All the 14 institutions had registered improvements in scientific outputs, as evidenced from the improvements of H-indices of all 14 universities.

Performance enhancement of all Universities receiving PURSE grants



As per the parameters employed 30 new universities had qualified. The base is now expanded to 44 universities and their national share publications have increased to 25%.

Consolidation of University Research and Innovation and Excellence (CURIE) for women only Universities is another component of FIST targeted to improve Science and Technology Infrastructure in women only universities. There are total of six such universities. Infrastructure support funds have been provided to all the six universities.

- **International Science and Technology Cooperation** is an ongoing programme of the Department for many years. During the 11^{th} plan period, some strategic approaches were adopted for stepping up bilateral as well as multilateral and regional cooperation in the area of science and technology. Technology diplomacy, Technology Synergy and Technology Acquisition formed three pillars of international S&T cooperation. For Technology Diplomacy asymmetric support and *"giving is gaining"* were the adopted paradigm. Technology Synergy is based on the principle of reciprocity and parity where co-investment and co-generation of values formed the basic principle. Number of joint funds have been established with ASEAN countries, Australia, Canada, European Union, France, Germany, UK have been established. New joint centres have been established under bilateral mode. There has been significant stepping up of the International cooperation activities during the 11th plan period.

- **Policy formulation Initiatives** received sharper focus during the 11th plan period. Science, Technology and Innovation policy, National Data Sharing Access Policy[10], Vetting of Imageries and Geospatial Information for Licensing (VIGIL) for National Security are some examples of the policy formulation focus of the Department. An Academy for Science Policy Implementation and Research (ASPIRE) is a step towards capacity building in policy formulation. It is proposed to set up a dedicated cell for Policy, Planning and Coordination.

- **Establishment of New Autonomous Institutions:** The Department has gained approvals for the establishment of new institutions during the 11th plan period. Institute for Nano Science and Technology, Mohali, National Centre for Molecular Material Research, Thiruvananthapuram, taking over of Institute for Advanced Studies for Science and Technology (IASST) Guwahati, conversion of National Innovation Foundation, Ahmedabad as an autonomous institution are some of the important steps. Nodal centre for National Centre for Himalayan Glaciology has now been established at Wadia Institute for Himalayan Geology, Dehradun. Efforts are underway to establish National Centre for Himalayan Glaciology.

- **Nano Mission:** The Department of Science and Technology has mounted a Nano Mission with a budget outlay of Rs 1000 crores for five years for implementation during the 11th plan. Under the mission several new initiatives have been made in the frontier area of Nano science and Technology. Output indicators are reviewed periodically by the National Nano Mission Council and summarized[11]. Some major highlights of the mission are presented in **Annexure 3.**

- **Institution of Name Fellowships: JC Bose Fellowship and Ramanujan Fellowships:** Some Fellowship schemes have been launched for promotion of research in established research groups in the country and attract scientists of Indian origin for work within the country. JC Bose

Fellowship scheme is focused on supporting research in established schools in the country. Ramanujan Fellowship scheme is for attraction of new talents for research in the country. Total of 183 people have been awarded JC Bose Fellowships and 102 Ramanujan Fellowships so far. Among the 183 JC Bose Fellows, 67 have completed 5-year term. Scientific outputs of the 67 JC Bose Fellows are presented in **Table 1**

Table 1 Scientific Outputs of JC Bose Fellows

Total Publications	People trained		Patents		IF aggregate	IF/ paper	Paper/ scientist/ yr
	PhD	Other	National	Inter			
2207	358	538	53	64	7865.07	3.564	6.6

- **Some New Initiatives during the 11th Plan period:** The Department of Science and Technology launched new initiatives under the titles Water Technology Initiative, Security Technology Initiative, Mega facilities for basic research, Innovation Cluster, and Cognition Science Initiative. With the approval of Cabinet, DST has mounted Nano Mission and National Spatial Data Infrastructure. These initiatives were launched to seed new programmes of relevance to the country. National Action Plan for Climate Change was enunciated by the Government of India. Under NAPCC, eight missions were mounted. National Mission for Sustaining Himalayan Ecosystem and National Mission on Strategic Knowledge for Climate Change have been allocated to DST. Under the Supreme Court Order, DST has mounted a Technology mission for Winning Augmentation and Renovation (WAR) for water. Solar Energy Research Initiative has been launched. Drug and Pharmaceutical Research Programme was modified to provide grants for private sector for Research and Development on neglected diseases. Science Express is a novel concept of the Department to create an awakening in science in the country. As many as 65 lakh people have visited the science express. Gaining entry into the Good Laboratory Practice (GLP) for India is a major accomplishment for the country.

2. Review of the On-going Programmes of The Department and Changing Paradigms of the 11th Plan programmes

The Department of Science and Technology has been engaged in the implementation of several on-going schemes of importance to the science and technology sector in the country. Changing paradigms of the on-going programmes of the Department of Science and Technology have been highlighted in **Table 2.**

Table 2 Planning Approaches for Enhancing Stake Holder Base and Value

Role	Main stake holder	Approach	Paradigm
Policy building	Government	Evidence based	Innovation ecosystem
Strengthening human capacity	Research community	Talent attraction and support	Proactive measures
Strengthening institutional capacity	Community university	Increased competitive grant size	Expansion and excellence
Technology development	Industry, society, government	Participative	Convergent solutions
Societal interventions	Government and society, NGO's	Supply driven to demand driven	Interventions to empowerment
International S&T cooperation	Government and S&T community	Strategic cooperation	Reciprocity/ parity and diplomacy

Review of Schemes under Research and Development: This is a flagship of the Department of Science and Technology. There have been significant increases in the number of Extra Mural Research projects supported during the 11th plan period. **(Figure 1)**.

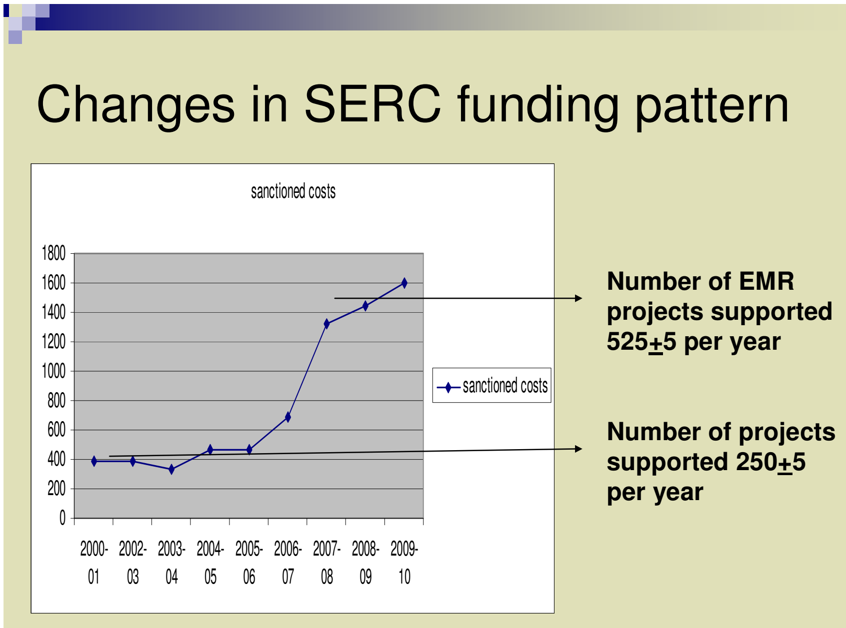


Figure 1. SERC Funding Pattern during 11th Plan

During the 11th plan period there has been a doubling of the number of research proposals being supported under Extra Mural Research Scheme of Science and Engineering Research Council. There has been doubling of both number of quantum of funds supported per scientist. For the year 2007, data on total Impact Factor aggregate of scientific publications for the total funds provided for SERC based EMR projects were obtained. It has been estimated that at Rs 13 lakhs budget support per scientist in the year 2007, Impact Factor aggregate per crore of budget support is 6.6. This compares favourably with Impact Factor aggregate per crore of plan funds deployed in other research agencies in the country. Analysis makes a case for increasing the budget support per scientist per year from the current level of Rs 13-15 lakhs (without non plan related expenditures like salary of permanent staff scientists) to say Rs 25 lakhs.

Currently about 1300-1500 scientists are supported for investigator based research annually deploying about Rs 180-200 crores. DST may need to consider doubling the levels of budget support per scientist for such investigator based research while spreading also the base of R&D during the 12th plan. More close monitoring and review of projects should also be implemented when the funding levels are raised.

One of the serious concerns associated with Extra Mural Research funding programmes expressed by the community has been the lengthy procedures and mean process time required for DST for decision making on the proposals received. DST desired to reduce the mean process time to less than 6 months initially and to less than 100 days in the due course of time. This could be achieved only partially and only in case of some specific discipline areas.

A case study in the case of engineering sciences discipline where such a time bench mark has been achieved during 2007-2010 period is presented in **Table 3.**

Table 3

Discipline	**Number of projects received**	**Number of PAC meetings held**	**Average time to decision**	**Average time for financial sanction**
Chemical Engineering	205	32	53 days	85 days
Electrical, Electronics and Computer Engineering	243	17	80 days	136 days

Such time-based bench marks could not be sustained in areas like life sciences and physical sciences partly on account of spurt in the number of proposals received and the length of time required to complete the due peer review processes. It is desired that National Science and Engineering Research Board may be able to implement the schemes with improved time bench marks for mean process time.

Stake holder Analysis of Fast Track (Young Scientist) Programme: The Department also undertook a stake holder analysis of Fast Track Research programmes by seeking opinion of 125 young scientists supported under Fast Track research programmes. (**Figure 2**).

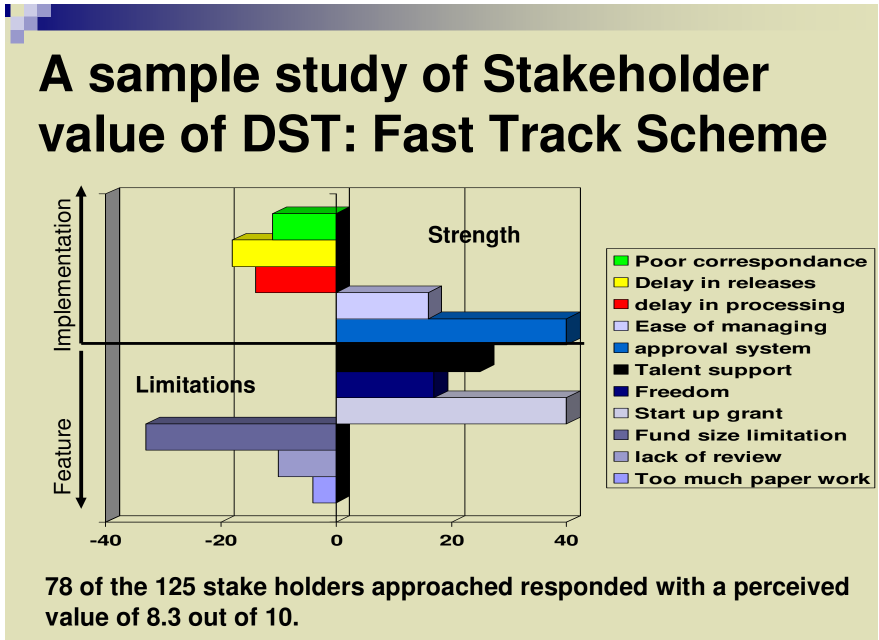


Figure 2. Stake holder Evaluation – Fast Track Scheme

Based on the feedback received, parameters have been received for the Fast Track programme. The fund size has been increased from Rs 17 lakhs to Rs 26 lakhs. Provisions for online submission and reviewing are being made. There has been a quadrupling of funds invested into the fast track young scientist programme. Annual Research outputs from the young scientists supported through DST are presented in **Table 4.**

Table 4 Annual Research outputs from the young scientists Project

Year	Discipline	No. scientists supported	Funds deployed (Rs. In Lakhs)	No papers	No PhDs trained	No patents, if any	Paper/ scientist
2008	Engineering Sciences	57	882.2	150	-	3	2.6
2008	Chemical Sciences	76	1400.7	205	30	-	2.7
2008	Physical & Mathematical Sciences	52	692.9	140	16	-	2.7

Sophisticated Analytical Instrumentation Facility (SAIF) Programme: SAIF is a scheme being implemented by DST for more than 25 years. The scheme has been subjected to a serious professional review. After critical review, the stake holder perception has revealed that there is a need for continuation of the scheme; with a focus on Tier -2 centres and successful Tier 1 centres playing mentoring roles for new locations. There are 12 centres in the country which are delivering high values and testing and analytical services. Data reveal that as many as 1.2 lakhs testing services are being delivered through the SAIF created over years. After critical review, decisions have been made to continue the scheme for providing nee facilities for less-endowed institutions and universities. Annual investment under the scheme is currently at Rs 16 crores .Continuation of SAIF scheme during the 12th plan period is expected investments at current levels.

Intensification of Research in High Priority Areas (IRHPA): Intensification of Research in High Priority Research Areas (IRHPA) is an established scheme of DST. This has delivered high values over years. Development of R&D capacities in Structural Biology, High Energy Physics, Nuclear Magnetic Resonance, Materials Sciences etc. could be traced to timely investments made by DST under IRHPA. Recently, areas like National Centre on Combustion Research and Development, Advanced Manufacturing etc. are being considered for investments under IRHPA. Investments into these areas are based on record of high performance of scientists involved and the size of R&D groups being supported. The scheme is proposed to be implemented through National Science and Engineering Research Board during the 12th plan period.

Women Component Programme (WoS A): Women Component Programme WoS-A is a special scheme designed to provide a re-entering opportunity for women scientists, who had to take a career break for personal and family reasons. Data pertaining to women scientists supported under re-entry scheme are presented in **Table 5.**

Table 5 Women scientists supported under re-entry scheme

Year	No of scientists applied	No of scientists supported	Satisfaction Ratio	No of projects completed
2007-11	2359	818	34.5%	534

Glaciology: DST has been coordinating an observation and Research programme on Himalayan Glaciers for more than 15 years on projects modes[12, 13]. In light of climate change related programmes and National Mission on sustaining Himalayan Ecosystem, DST subjected the on-going programmes to a review by experts. A science plan for Himalayan Glaciology has also been prepared by a team of experts[14]. Activities under Himalayan Glaciology therefore need to be further fortified during the 12th plan period under National Mission for Sustaining Himalayan Ecosystem (NMSHE).

Earth Sciences: After the formation of Ministry of Earth Sciences, several programmes supported by DST under various schemes under Research and Development have been transferred to the new Ministry. However, the basic research programmes on geology relating to sub-surface hydrodynamics in different rivers basins leading to coordinated effort has been continued to be supported by DST. Progress of research under the coordinated national programme has been reviewed. Based on the outputs to inputs relationships, decisions to continue support to the basic research activities under the R&D schemes of DST during the 12th plan period have been taken.

Review of Schemes under Technology Development Programmes: The Department of Science and Technology has been supporting programmes leading to demonstration of feasibility of technologies developed by various public funded institutions under academic and Research and Development Sector.

Technology Demonstration Programmes: These initiatives enabled testing of the technical viabilities of technology assets under real life conditions. Typically these demonstration activities related to micro-hydel projects with typical energy outputs of 50-100 kV for decentralized power generation, purification of water through removal of arsenic, fluoride, iron etc., bio-diesel from non-edible oils, disposal of hospital and solid wastes etc.

Typically a demonstration project for evaluating the field level applications of ultra-filter based water purification system based on technology from National Chemical Laboratory for use in North East Region was supported by DST. About 600 units were supplied for decentralized use and after two years, a third party audit study was undertaken to evaluate the performance of the technology and units. The study revealed that while about 66% of the units performed well and the technology was successful, about 34% of the units had failed. The third party audit revealed conditions where the technology is likely to fail.

After careful scrutiny of many demonstration projects supported by DST during the 9th and 10th plan periods, DST developed a new paradigm for technology development programmes during the 11th plan period. The changed paradigm is to attempt convergent solutions to problems rather than demonstration of technologies.

Areas of focus for demonstrating convergent solutions are challenges relating to water, security, fertilizers, solar energy etc. Plants for convergent technology solutions for water challenges and decentralized solar energy in Shive, Maharashtra have been established. (**Figures 3)**.

Figure 3. Decentralized solar energy Plant in Shive, Maharashtra

Solutions were tested also for their social and financial viabilities apart from technical viability. Revenue models for sustained applications of technologies were tested. Preference was made for technologies for social and public good rather than private good.

Support to State Science and Technology Councils: The Department has been extending core Support to State Science and Technology Councils for several years. These councils are expected to serve as bridges between the central S&T sector and the states in promoting the applications of technologies. However, several of these state S&T councils have remained weak links between the Department of Science and Technology and their respective states excepting in case of some specific states.

Since 2009, Annual conferences of Chief Secretaries are being organized by the Cabinet Secretariat in February. At these conferences, science and technology sector has been provided an opportunity to showcase technology assets available with public funded institutions. A New Centre-State Technology partnership concept has been developed. State Science and Technology Councils are expected to play more active roles during the 12^{th} plan periods.

Total of three review meetings of State Centre Science and Technology councils were organized during the 11^{th} plan period. A Consultation meeting for devising programmes under Centre-State Technology partnerships under 12^{th} plan period was organized in July 2011.

One of the major recommendations emanating from the discussions on Centre-State Technology partnerships promoted by State S&T council mechanism has been the creation of special fund for competitive bidding by states for technology deployment.

Drug and Pharmaceutical Development Programme: Drug and Pharmaceutical Development Programme is an on-going scheme of DST which has promoted creation of National Facilities in public funded institutions and research and development under Public and Private Partnership models in private sector in drug sector. Total of 14 national facilities and 23 PPP for R&D on drug have been supported so far. In 2008, a cabinet decision was taken that public funds could be deployed as grants for promotion of research and development on neglected diseases like, TB, Malaria, Kala Azar, etc. At this time, 9 drug molecules are under different stages of clinical trials, with 3 under Phase 1, 4 under Phase 2 and 2 under Phase 3 as outputs of the DPRP scheme of DST.

The scheme has been successful and delivering desirable results at this time. Since a new Department of Pharmaceuticals has now been established, DST proposed that the scheme along with methodologies could be transferred to Department of Pharmaceuticals for implementation during the 12th plan. However, the standing parliamentary committee on science and Technology and environment has directed that the scheme should be continued to be implemented by DST during the 12th plan. It is nationally important that the scheme should continue during the 12th plan regardless of which Ministry implements the scheme. Planning Commission may like to consider the issues while formulating the 12th plan. DST proposes to focus on biomedical devices, technologies and instrumentation under the ongoing programmes after the revision of scope of work.

National Science and Technology Management and Information System (NSTMIS): National statistical data on science and technology sector are gathered and collated by the Department of Science and Technology for several years. These data are useful as resources as well as sources of information. The lag between time relevancy of the compiled data and needs of decision support system for planning the development processes and policy formulation during the growth phase of India is posing some challenges. Some corrective measures to update the data set to reach time currency have been made. NSTMIS inputs for evidence-based policy building are critical. DST plans to establish a new division called "Policy, Planning and Coordination". It is hoped that NSTMIS work could be advantageously leveraged through such a new coordinated effort starting the 12th plan period. The division could monitor the growth trajectories of the Indian Science sector *vis-a-vis* other science leaders of the world.

Review of Activities under Survey of India and NATMO: Survey of India (SoI) is a 240 year knowledge based service organization. Internal review processes have revealed an urgent need for modernization of SoI and NATMO. Scope and speed of work for the organizations merit changes. The formation of an independent Department of Survey and Mapping under the Ministry of Science and Technology may be way forward for enriching the role and performance of SoI.

Review of National Resource Data and Management System and National Spatial Data Infrastructure (NRDMS and NSDI): DST has been implementing National Resource mapping related activities under NRDMS for long. In 2006, National Spatial Data Infrastructure has been constituted with the approval of the Cabinet. Under these programmes, a proposal has been made to establish State level Spatial Data Infrastructures. The division has been engaged actively in the preparation of some policy papers for sharing of data among the arms of the Government of India and other important aspects of national security related issues in recent times.

Review of National Council for Science and Technology Communication (NCSTC): Several important initiatives for science communication related activities have been undertaken through NCSTC. Science Express is one the flagship and successful programmes of DST. Children Science Congress organized annually through NCSTC network has been a major event in the country. This programme has received participation by children from other countries as well. NCSTC has undertaken an internal review of on-going programmes and made an effort to consolidate the important activities. DST plans to implement Building Educators in Science Teaching through NCSTC unit.

Review of International S&T Cooperation: In recent years, S&T related activities in the Department have increased both in quantum and quality of engagement. Many countries are desirous of stepping up their S&T engagement with India. Several regional and multi-lateral cooperation related activities are increasing. There have been significant increases in resource deployment into International S&T cooperation related activities. Internal mechanisms are being positioned to periodically review the outcome of the engagements with international partners and maintain a healthy momentum. For operational convenience, the International cooperation related activities are being arranged through two divisions namely, International Bilateral Cooperation Division (IBCD) and International Multilateral and Regional Cooperation Division (IMRCD).

Review of Entrepreneurship Development: National Entrepreneurship Board has been actively engaged in establishing incubators and Science and Technology Entrepreneurship Parks and participating in Innovation clusters. The division has also been implementing a skill development programme for more than two decades. The division has undertaken an internal review. NEB reviews all the on-going programmes periodically and makes suggestions for course corrections. The Board has recently approved the proposal of NEB to dis-engage from skill development activities, especially in the wake of skill development mission and a corporation to implement the mission. NEB is planning to step up activities relating to the establishment of Research Parks in the formal innovation system. NEB plans to focus in enhanced cooperation with Technology Development Board in future.

Review of Science and Technology Advisory Committee: Science and Technology Advisory Committee is a mechanism deployed by DST to relate R&D outputs from the S&T sector to programmes of the socio-economic ministries. Interactions between Ministry of Science and Technology and other socio-economic ministries have increased significantly in the areas of Steel, Human Resource Development, Mines, Micro, Small and Medium Enterprises, Information Technology, New and Renewable Energy Sources, and Ministry of Environment and Forests. Enhancing efficiencies of the ongoing mechanisms of STAC has been discussed at different times. New structures for partnerships and alliances under STAC are being proposed.

Review of Science and Technology Missions: DST has been implementing some Missions. DST implemented Fly Ash mission. The mission had focussed on implementation of established technologies for increasing the utilization of fly ash in the country. After the conclusion of Fly Ash mission, the Department has converted the activities into Fly Ash Utilization Programme and focused on new R&D and technology deployment. National Mission on Bamboo Applications has gained momentum. Several projects have been implemented. Structural applications of bamboo for housing for public utilities like school, hospitals, housing for earth quake and flood affected victims have been exploited. The mission has been delivering its stated goals and targets. A need to absorb the successful activities into a long term programme for penetration and larger impact has been felt. The Department is considering a proposal to merge the activities of NMBA into long term programmatic activities of North East Centre for Technology Applications and Reach.

Review of Autonomous Institutions: R&D outputs of autonomous institutions nurtured by DST have been periodically reviewed and assessed. Annual review meetings have been organized during the 11^{th} plan period. S&T output indicators reveal that some of the institutions nurtured by DST are emerging knowledge hotspots. Annual performance reports of the institutions are being brought out. A parametric approach based on performance based incentives and budget planning model has been developed and implemented at least partially. Several important scientific leads have emanated from the work being carried out in the autonomous institutions nurtured by DST. Performance reports of the autonomous institutions are being brought out. Some of the institutions match global benchmarks with respect to number of publications per scientist per year and average impact factor per paper.

Review of Science and Society Programmes: DST has been implementing a range of programmes for connecting S&T with society. S&T innovations for supporting the elderly, physically challenged, weaker segments of the society, Tribal sub-plan and some women component programmes are implemented by through the division. Recently DST has constituted a Council for Science and Technology for Rural India, CSTRI. New mechanisms and operational methodologies are being developed for enlarging and enriching the activities of DST under the science and society programme.

Summary

The review of on-going programmes of 11th plan indicates satisfactory outputs for investments made. New Initiatives like INSPIRE, PURSE, CURIE have been welcomed by the scientific community with enthusiasm. There is a significant increase in the number of research proposals received for funding. This has expanded the executive functions and scope of work of DST. The Department has also expanded its role in policy formulation and coordination. Developmental roles of DST have multiplied many-fold during the 11th plan period. Formation of National Science and Engineering Research Board is likely to emerge as a major step forward for the science funding in the country.

The Department of Science and Technology has adopted several mechanisms and processes to review the on-going programmes and efficiency of resource deployment. Periodical reviews of the fund utilisation of various schemes are made. Almost all the on-going schemes have been subjected to internal reviews and course corrections have formed the strategy of DST during the 11th plan programme implementation.

While formulating programmes and policies of the Department for the 12th plan period, DST has considered it necessary to reference the 12th plan proposals to the current situation of research and development base of the country.

CHAPTER 3

INDIAN RESEARCH AND DEVELOPMENT: CURRENT SITUTATION

Background

Research and Development base in the country is undergoing transformational changes currently. Various advisory councils have made several recommendations to step-up the investments into R&D. The Honourable Prime Minister of India has committed to double public spending on Research and Development. A growth trend in the sector is observed since 2004. The current situation and growth trends need to be sustained and taken into account while the 12th plan proposals of DST are developed.

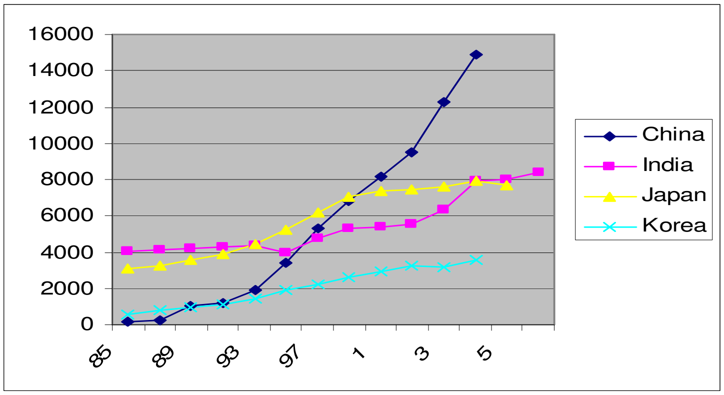
1. Growth Trends in Indian Science and Technology

Growth trends of number of PhDs trained, scientific publications, citations of papers published, patents filed in India as well as USA for indigenous R&D efforts and PCT applications filed have been monitored during the last decade[15a-15c]. They are presented in **Figures 4a-4c** as well as **Table 6.**

Table 6 Growth Trends

Growth Indicator	Number in 2000	Number in 2010	CAGR 2000-10	CAGR over last three years
PhD outputs in science	5400	8900		
Scientific publications	19000	36000	~8%	~12%
Citations of papers			~11%	~15%
Patents filed in India for indigenous R&D	~500	~3000	~22%	-
Relative rank in patents field in USA	25th	16th	-	-
PCT applications	4164	23431	21.2%	5.8%

Growth in PhD outputs in S&T



Brazil produced 10,000 PhDs in 2008

Figure 4a. Inter-Comparison of Indian with other Economies of Science

- Whereas in china more than 80% of patents are generated by research in china, about 80% patents filed in India originated from research carried out elsewhere
- However, relative position of India with respect to patenting in USA has improved from 25th in 2000 to 19th in 2006

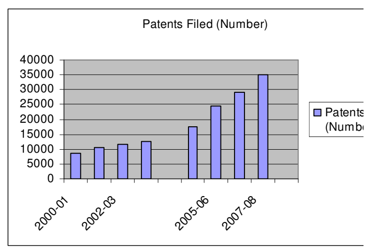


Figure 4b. Patenting Trends in India

India has registered about 12% annual growth rate during the last three years, as against the value of about 4% of the world; However, India could perform better

Figure 4c. Global research Trends – Thompson Reuters

2. Current Status of Indian Science and Technology Sector

Science and Technology output indicators of various countries are monitored by different agencies in the world. It is widely known that India was among the top ten countries in the world with respect to the number of scientific publications emanating from research carried out in this country during 1985. Whereas Indian outputs from science sector continued to grow at relatively slow pace during 1985-2000 period other emerging economies like China, Korea invested heavily into their Science and Technology sector and grew their S&T outputs much more vigorously. Consequently, relative position of India with respect to scientific output indicators slipped to relative ranks below 15 by 2003.

On account of several promoting measures taken by the country, there seems to be some positive trends with respect to S&T output indicators during the last few years. The relative position of India with respect to scientific publications has improved from 15th in 2003 to 9th in 2010. A correlation of the number of scientific publications against the Gross Expenditure as % of GDP as well as Number of Full Time Equivalent R&D personnel for top 15 countries in scientific leadership is presented in **Figure 5** and **Figure 6,** respectively[12b].

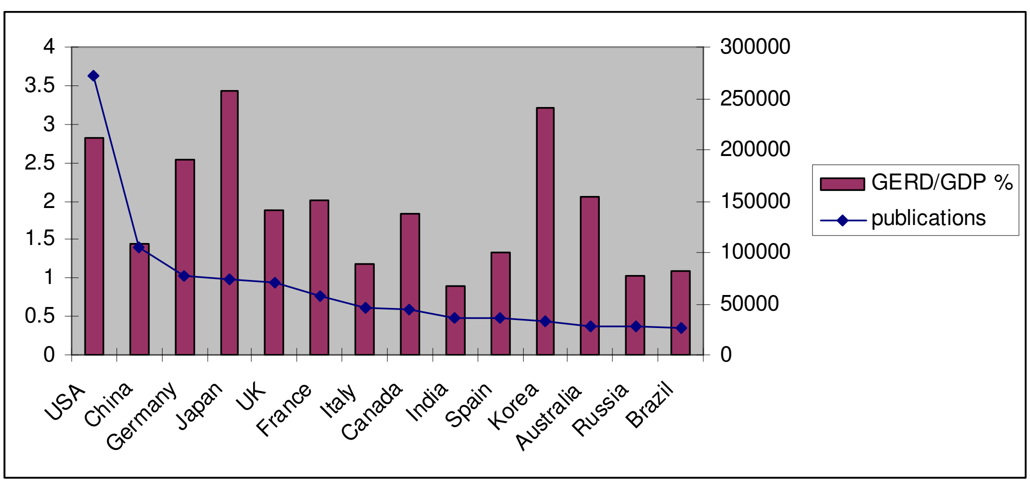


Figure 5. Correlation of Scientific Publications against % GDP

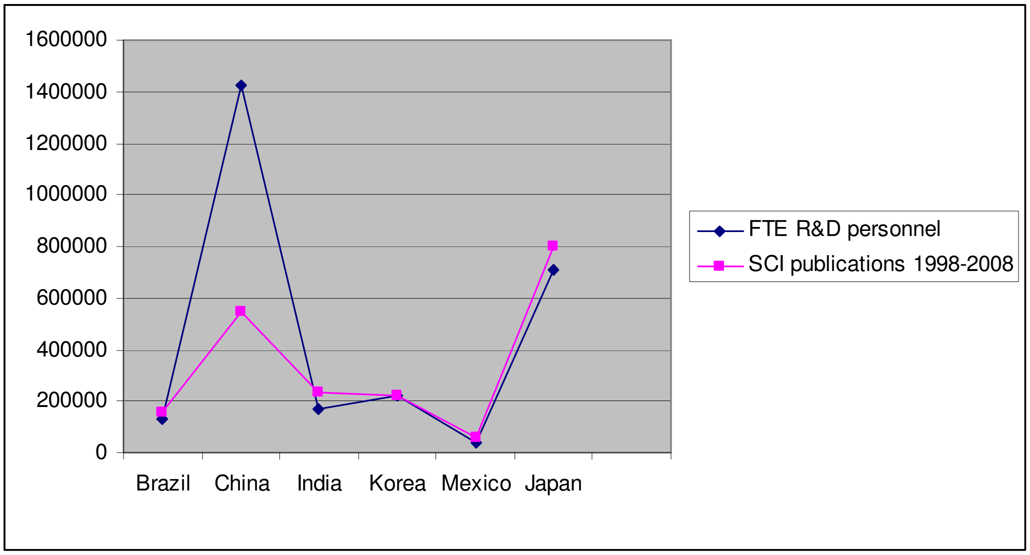


Figure 6. Correlation of Scientific Publications against Full Time Equivalent R&D personnel

Whereas some positive trends are registered with respect to the number of scientific publications in science citation indexed journals, there remains a concern that the global share of high impact making discoveries in science is relatively small.[1] This issue could be best addressed only by broadening the R&D base of the country and attraction of talent to careers with research on the one hand and increasing significantly the Gross Expenditure on Research and Development as a percentage of GDP.

In order that Gross Expenditure on Research and Development increases significantly, engagement of private sector into R&D must be quantitatively increased over the 12th plan period. Such increases would be forthcoming only when indigenous research leads also intellectual products which are globally competitive in market and knowledge economies. Although there have been substantial increases in growth rates of patents filed in India during the last decade, the share of patents filed for work in India through indigenous research is less than 20% of total patents filed. Policy interventions are necessary for stimulation of private sector engagement and investments into R&D.

3. Science Vision of India

Science Advisory Council to the Prime Minister has prepared a Science Vision for the country[1, 16]. It is expected that during the next twenty years, Indian economy would have emerged as major global economy with economic prosperity leading to better access to education and health care for larger sections of the population which would live with hope and security. It is envisioned that science would be at the heart of strategies for meeting the next stage of national developmental demands. Science Advisory Council to the Prime Minister has presented a vision for the growth of Indian science[1] that can help the national strategy for developmental plans succeed, and a road map for India to emerge simultaneously as a global leader in science.

For realizing the science vision of India, conscious efforts to synergize various programmes of the country in both private and public funded institutions are essential. Agencies like the Department of Science and Technology are required to play a critical and changing role during the 12th plan period, if science vision for the country for emerging as a leader in global science were to be realized.

4. Changing Role of Department of Science and Technology

The Department of Science and Technology has played as major funding agency for basic research under Extra Mural Research support. While such roles should be continued to be played by DST, it is relevant that various policy functions and other promotional roles are also accorded equal priorities by the Department.

The current science vision of India demands that science should be able to play a more centric role and forge linkages with the developmental programmes of the country and the basic research programmes of the Indian science sector should be enlarged. Some roles of DST for promotion of Indian science sector in wake of changing context of the country have been mapped and summarized thus.

1. Policy formulation for science sector with a stronger focus on enlarging the role of private sector into Research and Development.
2. Strengthening of Human Capacity with a vision to broaden the R&D base of the country while promoting excellence in science education and research.

3. Strengthening of institutional capacity with a focus on rejuvenation of research in the university sector and multiplying the number of centres of excellence.
4. Establishment of Technology Platforms with a special emphasis on convergent technology solutions in key areas of national importance like water, home-land security, fertilizers, solar and clean energy.
5. Promotion of new mechanisms and structures for national S&T partnerships among academia, research and industry for technology development, developing and strengthening bilateral, multi-lateral and regional S&T cooperation of India with other countries for technology diplomacy, technology synergy and technology acquisitions and Public-Public-, Public-Private- and Public-People- partnerships for innovations and technology deployment.
6. Serving and servicing social contract of Science and Technology for increasing living choices to people and
7. Coordinate the establishment of large R&D facilities in cooperation with other agencies in the country.

5. Stake Holder Priorities and Perceptions

The Department of Science and Technology held several discussions and brainstorming sessions to capture priorities and perceptions of stake holders in developing its 12^{th} plan programmes. Key recommendations emerging from various discussions are listed in **Annexure 4.**

For long, DST had been perceived as the main funding agency for especially investigator centric projects in basic research by stakeholders. Competitive Research Grant system established under Science and Engineering Research Council by DST has been a major funding mechanism for Extra Mural Research Funding system. SERC is a flagship programme in the National R&D Sector.

With the establishment of National Science and Engineering Research Board, competitive research grant system for basic research through investigator centric R&D proposals could be operated through an alternative mechanism.

Stakeholder's priority that DST should strive to expand the R&D base and promote research and development leading to technologies for addressing national developmental challenges has been strongly expressed.

The role of DST in establishing Centre-State Technology partnerships is an area of stake holder priority. DST has assumed a horizontal function in linking R&D outputs of the S&T sector with socio-economic ministries and other stakeholders.

Summary

Designing and developing an enabling innovation ecosystem has been considered national priority. DST is expected to assist the development of such an innovation system through both policy and programmatic support. The Department has adopted an approach to planning process based on the a) expressed stake holder aspirations, b) alignment of planning to the Results Framework Document enunciated by the Government of India to monitor the delivery of outputs, c) changing role of DST along the growth trajectories of the Indian Science and Technology systems.

CHAPTER 4

Process Adopted by DST for planning the 12th plan programmes

Background

The Department of Science and Technology has been adopting a programmatic planning approach in the previous five plan periods. It had adopted an input-led growth model. In other words, the Department had been articulating the needs for investments to grow science in the public funded research institutions. Such an approach enables the development of R&D infrastructure in the country.

With a robust economic growth, the Nation is currently in a position to make necessary investments into R&D and relate the outputs to the developmental goals of the country. Accordingly, the planning process needed for such an output-directed development path is different. For the development of the 12th plan proposals, DST has adopted a thematic and a mix of goal oriented and target based planning approach. This involved consultation with a large number of experts, advisors and scientific community.

1. **Study of Input to Output relations:** Several on-going programmes were subjected to review and study of output to input relations in scoping and sizing the investments into the 12th plan period. The various sub-groups of the working Group of DST reviewed the on-going programmes of DST and suggested some revisions and modifications as listed in **Annexure 5**. Most of the projects and programmes supported by DST are of 3-5 year duration. DST has developed an internal process methodology to correlate resource inputs to their measured outputs with a phase interval of ~3years from the date of sanction of the projects. In the case of autonomous institutions nurtured by DST, there is now a mechanism to review the output indicators annually through a review process. Parametric tools have been developed to relate inputs to autonomous institutions based on faculty strength and outputs performance.

2. **Global Benchmarking:** Indian Science Vision has enunciated an aspirational goal to emerge as a global leader in science[1]. If India were to emerge as global leader in science and technology, policy inputs,

strengthening of human as well as institutional capacities, Technology Platforms based on new mechanisms for relating knowledge to solve national problems and international and national alliances and partnerships would become necessary. Main streaming of Indian R&D systems to match global bench marks in Science, Technology and Innovation indicators may require some integrated as well as disaggregated approaches[17]. Global bench marks for Science, Technology and Innovation indicators have been collected and comparisons made with corresponding Indian indicators for recognizing the areas of gaps and needs. This is to develop an evidence based planning approach for the 12th plan proposals of DST.

3. **Expert Group Advice:** Various inputs received from the Science Advisory Councils to the Prime Minister and Scientific Advisory Council to the Cabinet and National Innovation Council as well as Science and Engineering Research Council and National Science and Engineering Research Board were studied[18a-18c] extensively in the alignment of the proposal of DST for the 12th plan period to the extent possible.

4. **Formation of Working Group:** The Planning Commission has constituted a Department specific Working Group taking into account of the multi-sectoral stake holder base of DST. The composition and the Terms of Reference of the Working Group have been presented in **Annexure 6.**

5. **Formation of Sub-Groups of the Working Group:** The working group divided its function for convenience and efficiency into six sub-groups with specific terms of reference for each sub-group. Each sub group was serviced by a convener and a co-convener from DST representing different age groups and seniority levels for internalization of the recommendations emanating from the sub-group and working group for implementation. The compositions and Terms of Reference for each sub-group are presented in **Annexure 7.**

6. **Goal and Target Setting:** The Working Group constituted by the Planning Commission discussed targets and goals for the programmes of DST and presented a perspective for the 12th plan proposals. These perspectives were developed based on multiple inputs received by DST from the extensive discussions with stake holders through the bottom-up

engagement as well as from the advice received from the Expert groups and other Top-Down advisory councils. Perspectives of DST for the 12th plan period are as listed here under.

12 Points Policy Inputs for 12th Plan Programmes

1. Stimulation of private sector engagement for investment into R&D: From the current 0.24% to about 0.5% level
2. Public-Private Partnerships for promotion of R&D and Clean Energy: New policies for relationship for co-investment
3. Enlarging Research in the University Sector: Through new Private-Public and Public-Public partnerships
4. Expanding research in the Technology areas: Through technology partnerships with Socio-economic ministries
5. Policy for investing into R&D through Indians abroad: For contractual R&D and Diaspora recruitment
6. Stimulating states for investments into deployment of technologies: Under state-center technology partnership models
7. Revisions of Existing policies: S&T policy for including innovation
8. Quadrupling Full time Equivalent R&D personnel through multiple mechanisms: Tapping all possible sources of Indians
9. Data Sharing and Access Policy: For proactive transparency
10. Global Scale Innovation clusters: For R&D for five areas of strategic knowledge domains
11. Enlarging coupling between technology and manufacturing and trade and Technology: Evidence based selection of sectors for early impact
12. Performance related Investment Strategy: For Global positioning of India

10 Points for Human Capacity Building during 12th plan

1. Strengthening of ongoing 11th plan initiatives
   - INSPIRE, Name Fellowships etc.
2. Building Educators for Science Teaching
   - A joint initiative with MHRD
3. Gender parity Initiatives in R&D sector
   - Mobility, Parameters for women re-entry programmes
4. Challenge Award Schemes
   - For Global Competitiveness in R&D
5. Expanding Start-up R&D grants for individual and team research
   - New modes of selection and decentralized implementation

6. Building critical mass in important research areas
   - Computer and mathematical sciences, earth and environmental sciences including glaciology, clinical medicine etc.
7. Expanding the base of Human capacity for research
   - 1000 overseas doctoral and 250 post-doctoral fellowships during the 2012-17 supported by assured career opportunity
8. Attracting Indian Diaspora for contractual R&D
   - For Grand R&D challenges in select areas
9. Expanding the Name fellowships/ professorships schemes for larger coverage
   - Evidence based selection criteria
10. Performance Related Incentive Schemes for S&T professionals
    - Global schemes for local implementation

8 Points for Institutional Strengthening during 12th plan

1. Strengthening Ongoing 11th plan programme initiatives
   - FIST, PURSE, CURIE, Special State and regional packages etc.
2. Expanding the role and base of National Science and Engineering Research Board
   - For major national programmes and larger investments
3. Stepping up Nano Mission
   - With new scope for industrial R&D and applications for nano science
4. Establishment of Plan R&D centers in Existing Elite academic institutions
   - With major Funding for Nationally Selected R&D programmes
5. Establishment of major National R&D facilities
   - In India investment
6. Participation in Establishment of Global mega scale R&D Infrastructure
   - Off shore investment
7. Virtual Joint R&D centers in select areas of research
   - National and bi-national joint centers
8. Competitive grants for decadal Institutional R&D programmes in select areas
   - Climate change, new energy and sustainability science

8 Points Technology Agenda for the 12th plan proposal

1. Investments into solution science for national challenges

- Strengthening on-going programmes in solar energy, water, internal security etc.

2. Implementation of Missions under National Action Plan for Climate Change
   - NMSHE, NMSKCC
3. Location specific convergent technology interventions
   - For linking to per capita income growth
4. Promotion of PPP for R&D and clean energy
   - In five key and select sectors
5. Investing into State Specific Technology Deployment Plans through competitive grants for state actions
   - For pilot and Demonstrations in credible scales
6. International Reciprocal Technology Partnerships
   - For Example Dutch India Water Alliance for Leadership Initiative and Bi national Technology Missions
7. Virtual Joint Bi national Centers for R&D
   - In areas like clean energy, automotive research etc.
8. Biomedical Engineering, Devices and Technology
   - For inter-disciplinary research with socio economic impact

New Models for partnerships and alliances

1. Technology diplomacy programmes
   - For investing into International asymmetric into technological relationships
2. Technology Synergy
   - For investments into reciprocal and parity based International relationships
3. Technology Acquisition models
   - For Investments based on due diligence
4. Private Public Partnership models
   - For industry ready private sector R&D
   - For R&D for public and social good
5. Public-Public Partnership models
   - State-Center partnerships in R&D scaling

Contracting Science and Technology for Social Good

1. Strengthening and Expanding ongoing 11^{th} plan programmes
   - Council for Science and Technology for Rural Initiatives

2. Scoping and Strengthening of R&D initiatives for Weaker Social Segments
   - SC/ST population: Technology interventions complete with market linkages
3. Socio economic impact of Technology changes
   - Social divides: Counter strategies

7. **Recommendations of the Sub-Groups of the Working Group:** All the sub-groups constituted have submitted their reports and recommendations. They are presented in Annexure **8a – 8f.**

Summary

The Planning Approach and process adopted in the development of the 12th plan proposals by DST based on themes has enabled articulation of expected outputs and deliverables. Results Framework Document is now aligned with the planning model. Programmes of a science department focused on both outcomes in the long term horizon and midterm results and outputs required a mixed approach to planning. In alignment to the faster, sustainable and inclusive growth model of 12th plan programmes of the country, equal emphasis has been laid on both excellence and expansion in Research and Development sector. Accordingly the programmes of the Department have now been proposed.

CHAPTER 5

Programmes and Proposals for 12th plan period

Background

Planning process adopted in consonance with the stated objectives and functions of the Department and science vision of the country has led to the identification of areas of priority and a relationship between the investments and expected outcomes. Policy objectives have been articulated in the plan document by the Department in the making the proposals for 12th plan period. If the aspiration to India to emerge as a global leader as envisioned in the Indian Science Vision were to be fully realized, programmes undertake during the 12th plan period should focus on strengthening human and institutional capacities on the one hand and relate the investments to developmental goals of the country on the other.

A paradigm for planning the technology development and deployment objectives of the Department has been proposed by the Sub-group of the working group. Partnerships and alliances within the country among academy-research and industry and with international partners in the area of innovation seem a valuable next step.

Social contract of S&T has been articulated in the 12th plan proposal of DST. In order to deliver social goods to the community, new delivery mechanisms may be necessary. The 12th plan proposals of DST have identified the need for such delivery mechanisms and differences in approaches in relation to the schemes suitable for delivering resources to formal innovation systems in the universities, research institutions and industry.

The programmes proposed by the Department for the 12th plan are on the basis of detailed studies and identification of priorities and targets on the one hand and necessary differences in relating programmes to the various stake holders of the sector on the other.

1. **Policy Formulation:** National requirement of Science, Technology and Innovation policy has been spelt out. Proposals for the 12th plan programmes need to flow from an enunciated policy for Science,

Technology and Innovation. If India were to emerge as one of the top five knowledge powers in the world by 2030, right sizing of R&D investments as well as the R&D base along with stronger participation of private sector would be necessary. Policy interventions for promotion of excellence as well as broadening of R&D base are recommended.

Whereas public investments into Research and Development have reached global levels of 0.75-1.0% of GDP, investment of private sector into R&D has remained low at about 0.25% currently as against levels of 1.2-2.0% of GDP in many developed and emerging economies. While policy and other instruments could facilitate increase in investment into R&D, building human and institutional capacity to absorb larger outlay for R&D and deliver values for investments is not easy. Policy readjustments to increase the number of Full time Equivalents of R&D personnel are key requirements. Policy instruments may need to enable tapping all sources of Indian R&D personnel to quadruple Full Time Equivalents of R&D personnel in a time bound manner.

The sub-group has recommended some specific directions in terms of deriving policy inputs for a) increasing investments into R&D by ~55% in terms of GDP during the 12^{th} plan period, b) facilitating knowledge flow into wealth creation sector, c) for promoting Public-Private Partnership for R&D, d) reduction of bureaucracy, e) personnel management, f) financial audit system for science, g) incentive systems based on performance, h) mobility of R&D personnel and i) scientific assessment of regulatory processes.

The Department of Science and Technology has planned to establish an in-house Policy, Planning and Coordination Cell within DST during the 12^{th} plan period. The proposed cell would commission policy research and forecast studies in various knowledge institutions and function as a unit for proposing to the Government various generic policy readjustments required for a growth sector like science, technology and innovation with due inter-ministerial consultation. An Evidence-based approach for policy formulation for R&D sector would be adopted.

DST, with the help of knowledge institutions propose to bring out annual reports of Science, Technology and Innovation output indicators with adequate peer review support. While policy interventions for R&D in specific knowledge domains and technology areas would remain with the specific department and ministry, generic issues in R&D with cross cutting roles in several areas would form the focus of policy effort in DST.

2. **Programmes for Strengthening of Human Capacities:** The sub-group has recommended re-inventing of three on-going programmes of DST, namely, Fast track scheme for young scientists, women scientists scheme and SERC schools. The sub group has recommended nine specific targets to be achieved through strengthening human capacities prior to 2017.

The Sub-group has recommended national targets for increasing the scientific publications from the current 3% to 5% levels, adding 2500 new Full Time Equivalent R&D personnel per year up to 2017, enrolling 700 new investigators into Extra Mural Research annually, increasing the PhD outputs in science and engineering to 10,000 per year by 2017 and enrolling 500 college teachers into R&D per year.

Three broad principles have been adopted in selecting the priorities for the 12th plan programmes. They are a) differentiated criteria for different sections of R&D manpower, b) size-expansion of R&D manpower base and c) mechanisms for scaling the successful programmes for impact.

New schemes have been proposed for tapping latent (hidden) talent for research in the country, building research networks, institutionalization of training and renovation programmes and engagement of private sector into R&D. Schemes have been proposed for motivating college and university teachers into research and broadening the role of women in science.

The sub-group has proposed a strong role for DST in mounting schemes for research scientists, post-doctoral fellows and establishment of industrial R&D centres in academic and research institutions.

The Department of Science and Technology has also undertaken a review of both Fast Track scheme for young scientists and women scientist programme and has independently identified the need to revise the scheme and parameters.

DST has proposed a special scheme to facilitate the mobility of women scientists, called “Disha”. Recognizing that need to avoid or reduce difficulties faced by employed women in mid-career to move from one place of employment to another within in India on account family reasons, DST has proposed an expenditure – neutral scheme for creating 1000 contractual positions which could be carried within India to any location. The scheme is specifically designed to meet the needs of employed women needing mobility for family reasons.

DST is also proposing a new scheme for providing start-up grant to academic professionals of Indian origin returning to India for joining R&D functions in academic institutions. Under the scheme, the host institution appointing academicians could seek a grant from DST for providing a specific start-up grant for independent research for faculty returning to India for careers in Indian institutions.

3. **Programmes for Strengthening of Institutional Capacities:** The sub-group is strongly in favour of consolidating programmes like IRHPA, FIST, PURSE, CURIE, special packages for specific regions and enlargement of investments, coverage and increasing the per project support. The Sub-group has suggested new approaches for funding research consortia, basic research collaboration with other countries in reciprocity model while retaining the IP rights in favour of India and creation of mega R&D facilities through international participation.

   The sub-group recommends a special competitive challenge award scheme for supporting 5-10 academic institutions for gaining ranking within the top 300 institutions in the world. The sub-group also recommends a development fund scheme for providing one time allocation of Rs 5 crores for new state-funded institutions and universities. The Department proposes to revise parameters of FIST for providing Rs 5 crores support for new universities. Special R&D plan grant model for elite institutions like IITs, IISc for supporting specific large programmes with nationally important goals have been recommended.

Strengthening of Institutional capacities in nationally important and inter-disciplinary research areas like climate change, energy and environment, mathematical modelling and atmospheric science through a competitive bidding model has been suggested.

The sub-group recommends continuation of nano mission during the 12^{th} plan and focus on nano technology areas for realizing more potentials of the investments through applications. The sub-group recommends strongly the participation of DST in the building mega R&D infrastructural facilities both in India and abroad. The sub-group recommends the establishment of Sophisticated Analytical Instrumentation Facilities in less endowed Regions and institutions for spreading the R&D base of the country.

The Department has recently approved a proposal to establish National Centre for Combustion Research and Development[19] on a consortium model to support all the 55 established researchers in the country. Similar concepts are being developed for creation of national capacities in the areas like advanced manufacturing and engineering education and research.

The Department has been assigned the task of coordinating the proposal to establish Super Computer facilities in the country to gain global competitiveness. DST and DAE together have developed plans for promoting mega science and participating in establishing large R&D infrastructural facilities in areas like astronomy, high energy physics etc. India has already enrolled as an observer in the project on Thirty Meter Telescope (TMT), Facility for Anti-proton and Ion Research (FAIR). National Solar Large Telescope (NSLT) is another major large scale investment being planned after due diligence[20].

Institutional capacities in the areas like Himalayan Glaciology, North East Centre for Technology Applications and Reach (NECTAR) are being planned during the 12th plan period.

4. **Technology Development Programmes:** The Sub-group has made some important recommendations involving changes in the paradigm of planning for the 12th plan programmes of DST for the technology sector. The sub-group traces lack of active participation between academia and industry to the prevailing public policy promoting the academia's presence in their comfort zone and the Industry finding the necessary barriers to competitive entry.

The Sub-group urges the importance of the need to usher in an 'Innovation' phase with technology leading to a sustainable development minimizing environmental footprint, while aiding distribution of wealth, sustainable food supply and affordable health care. The sub-group opines that the country could not afford to wait for the industry to embrace technology. A proactive approach going beyond the current reality and identifying ways for translating the nascent intellectual properties being developed in our academic institutes into practice has been suggested.

The Sub group recommends to DST role in a) taking a lead in improving the Industry Academia partnership, b) development of a web based information system providing access to entrepreneurs to good quality support for IP, legal and Accountancy and c) instituting of a fund for 'incubation' of technologies in premier institutions. The sub-group recommends both soft loan and a loan against equity. Development of a live technology portal for India has been recommended.

The Sub-group has recommended innovative methods for selecting technology priorities complete with techniques for deriving benchmarks and suggested mechanisms for promoting development of convergent technology solutions for some key challenges of India using a novel Technology Platform (TP) approach.

The Sub-group has defined salient characteristics of Technology Platforms. They a) are themes requiring multidisciplinary science and engineering inputs to address challenging questions and solutions rather than discovery (driven by 'what' rather than 'how') and b) demand contributions from stakeholders in defining the solutions needed and plurality of Technology Missions, products and processes, d) span more than one institution, f) require skillful leadership with an ability to deal with complex situations and g) enable identifying unique and often breakthrough solutions.

The sub-group has defined the processes for identifying and selecting Technology Platforms. The key sectors of importance have been identified as a) Solar energy, b) Water technology, c) Telecommunication, d) Materials and e) Drugs & Pharmaceuticals.

Mounting of four Technology Platforms are proposed for initiation during the 12th plan capitalising on perceived India-Centric opportunity with clear user-centric focus. These Technology Platforms are a) Distributed Solar Energy Generation and Storage, b) Membranes as technology platform and novel rapid contaminant detection sensors for potability of water, c) Integrated computational material engineering, and d) Energy Efficient low emission wireless technology. Quantitative deliverables of these Technology Platforms are expected as at least 4 vibrant Private Public Partnerships for R&D in areas relating to public and social good. These Technology platforms could include also state as stakeholders.

5. **Partnerships and Alliances:** The sub-group has addressed the needs and scope for a wide range of S&T partnerships and alliances. The international S&T cooperation under both bilateral and multi-lateral modes based on the principle of reciprocity and parity have been strongly recommended. Recommended approach suggests the mapping and profiling of opportunities and benefits of International S&T engagement through a strategic planning. Proactive increase in India's engagement in S&T cooperation with select countries and regions by increasing the number of science counsellors from 4 to 20 has been recommended by the sub-group.

The proposal recommends also backing of select bilateral and multilateral with funds for developing the cooperation based on mutual and global interests. India's participation in creation of large R&D infrastructures and mega science has been strongly supported by the sub-group. Creation of Technology Acquisition as well as Science and Technology Assistance Funds and the establishment of Global Innovation and Technology Alliance have been proposed.

A need for promoting Private-Public Partnerships in R&D through a holistic approach has been stressed. Some schemes to implement some of the recommendations of the sub-committee of PM's Council on Trade and Industry by DST have been proposed[21]. Strengthening of innovation and entrepreneurship agenda of the country through S&T support has been strongly recommended.

Specific suggestions for the expansion of Technology Business Incubators, contributions to the promotion of an innovation ecosystem and scaling up Innovation clusters in consultation with National Innovation Council have been recommended by the Sub-group.

Partnerships with states along the lines of the concept note[22] prepared by the Department of Science and Technology for the promotion of technology deployment in states have been supported. The sub-group recommends establishment of at least 5 centre-state technology partnerships for state specific technology interventions for linking technology to planned increases in per-capita incomes.

New mechanisms for developing S&T partnerships with other socio-economic ministries have been recommended[21]. Establishment of test-beds for proving the concepts of convergent technology solutions under S&T partnerships with socio-economic ministries has been proposed. Creation of Technology deployment fund for co-investments with other socio-economic ministries has been recommended.

Adequate provision for funds for deployment into PAN India S&T missions on key sectors identified by the Planning Commission has been suggested. Alignment of the programmes and schemes of DST to several cross-departmental programmes and linkages has been suggested as a better means of implementation. The suggestions include a) enhancing capacity for growth in partnership, b) Technology and Innovation, c) securing technology future for India d) improved access to quality education, e) managing the environment and f) enhancing skill and employment generation.

Wide scale increase in Science and Technology communication and enlargement of on-going programmes have been recommended. Several new partnerships and alliances for reaching out to the community various science based developments have been suggested by the sub-group.

6. **Societal Interventions:** The sub-group on societal interventions has recommended a series of new programmes and changes in operation methodologies for implementation of the programmes of DST under the 12^{th} plan for eliciting the social contract of S&T. The sub-group has made more than 50 recommendations for 12^{th} plan programmes of DST under societal interventions.

   The programmes suggested are broadly grouped as under a) encouraging rural enterprise and production systems, b) innovations for better quality of life, c) encouraging youth in developmental process, d) science and technology for social good. The sub-group has also recommended the continuation of National Mission on Bamboo Applications and National Mission on Geo-spatial Applications by DST during the 12^{th} plan period.

   The sub-group has made some important changes in operational modalities for implementation of the societal S&T interventions. They are a) inviting proposals on consortia mode on select themes, b) inviting proposals for S&T solutions to specific problems, c) building network programmes for horizontal spread of successful technology packages, d) concurrent mentoring and monitoring of programmes by expert groups, e) Third Party Assessment and Evaluation, f) involvement of academies in Fellowship programmes and g) larger involvement of S&T councils.

The Department has proposed the absorption of national missions on Bamboo Applications and Geospatial Applications on programme mode into a newly proposed North East Centre for Technology Applications and Reach, (NECTAR). This proposal of DST for developing successor programmes for the two missions stems from the needs recognized for continuation of the activities even beyond the 12^{th} plan period for maximum impact on a programme rather than mission mode.

The Department has constituted Council for Science and Technology for Rural India during the 11^{th} plan. DST proposes to enlarge the activities of the council and develop new mechanisms and operational changes for the implementation of the recommendations of CSTRI during the 12^{th} plan period.

One of the important changes in the programmes of DST during the 12^{th} plan period is in the development of suitable delivery systems for the S&T interventions for benefiting SC and ST populations in line with the assigned responsibility of allocating 5% of the DST budget to such social responsibilities.

New programmes and schemes for promoting the role of Women in Science and S&T interventions for improving women and child health are envisaged for implementation during the 12^{th} plan period. DST proposes to establish task forces to study various recommendations of the sub-group and bring about changes in operational methodologies in the implementation of 12^{th} plan programmes of DST for societal S&T interventions.

7. New Initiatives Proposed by the Department of Science and Technology for Implementation during the 12th plan period

1. **Creation of Major National Facilities under Partnerships:** The Planning Commission has assigned a responsibility and role for the Department to coordinate and support the establishment of Super Computer facility in Peta and or Exa scales, in order that India builds capacity and capability to establish global scale super computer facilities within the country. It is a programme of National priority. Preparation of Detailed Project Report has already been commissioned to Indian Institute of Science. A provision of Rs 5300 crores is being made for the 12th plan period for establishing super computer facility in the country.

2. **Programmes for Centre-State Technology Partnership:** The present mechanisms for deployment of S&T outputs by the states require major structural changes and improvements. During the annual conference of Chief Secretaries organized by the Cabinet Secretariat, the states have sought the creation of special fund for promotion of technology deployment. The Department proposes to set up a competitive grant model for states to participate in the deployment of technologies developed by various public funded institutions and are sourced from National Technology Portal. In order to promote Technology Applications and Reach in North East, DST proposes the establishment of North East Centre Technology Applications and Reach.

3. **Building Educators for Science Teaching:** It has been widely recognized that for development of a viable innovation ecosystem within the country, there is a need to invest on science teaching. Various motivational measures for teachers engaged in primary, secondary and tertiary levels have been felt necessary. Since education is a concurrent subject, any interventions for educators would call for extensive and intensive collaboration among centre and states. In order to make significant impact on a National scale, the programme should be developed as a joint initiative of Ministry of Human Resource Development and Ministry of Science and Technology. DST proposes such a joint programme for Building Educators for Science Teaching during the 12th plan period.

4. **Investments into Mega Science for Creation of R&D infrastructure within India and Abroad under partnerships:** DST is emerging as a major partner for creation of large R&D infrastructural facilities for mega science in India and abroad. A budgetary provision for such facilities under partnership models would be made for implementation during the 12th plan period. However, specific approvals would be sought as the scope of investments into each facility and scope of financial participation are determined more precisely.

Summary

While policy objectives and social contract of S&T may be effort intensive, other objectives including technology development and deployment may be resource intensive. A conscious attempt has been made by DST to map the resource needs of the various proposals based on past experience and global bench marks while preparing the 12th plan programmes and proposals. To the extent possible, the Department has made an attempt to specify expected deliverables and outcomes while preparing the proposals for the 12th plan period. The Department is however conscious of its role of the foundation-builder for the Indian Science and Technology sector and therefore the outputs and outcomes for the investments need to be created by the scientific community and stake holders only. An attempt has been made by the Department to list deliverables and map the resource requirements based on outputs desired.

CHAPTER 6

Expected Deliverables and Mapping of Resource Needs and Projections

Expected Deliverables

1. Policy Objectives

- Introduction of at least 4 major in the parliament on S&T related aspects
- Framework preparation and formulation of 16 policy documents based on evidence gathering for positioning of India in global science, technology and innovation landscape
  - Preparation of five inter-comparison reports of Indian science sector with selected other economies
  - Preparation of annual reports on Indian Science, Technology and Innovation sector
  - Global bench marking study reports for Indian Science, Technology and Innovation sector
  - Development of country specific models for promotion of PPP for R&D
- Complete implementation of all the policies enunciated during the 11^{th} plan

2. Human Capacity building

- Achievement of all targets of INSPIRE and Expansion of INSPIRE award components
- 1000 overseas doctoral and 250 post-doctoral fellowships
- Contributions to 40-50% Increases in the number of Full Time Equivalents of R&D professionals through various mechanisms and measures including new schemes for enrolling latent R&D capacity in colleges and university teachers and women scientists
  - Gradually increasing the number of Principal Investigators in Extra Mural Research projects from the current level of 560-580 per year to 700 per year by 2017

- Enrolling at least 500 faculties and teachers in colleges and universities into competitive R&D systems
- Creating 1000 India centric positions for employed women scientists for mid-career mobility within the country
- Enabling enrolment of 2500 Full Time Equivalent scientists per year during the 12th plan period through both policy and programme support
- Re-invention of Fast Track young scientists scheme, SERC schools and women component porgamme

3. Institutional Capacity Building

- Doubling the outputs of 10 elite institutions in basic research
- Doubling the R&D outputs of 10 lead universities in the country
- Significant increases in the R&D outputs of 40 universities in the country
- Significant Strengthening Research capacities in five states in the country
- 10 States will have significant improvement in research capacities
- 5 Institutions will be within top 300 world institution list,
- 50 % enhanced research output 10 Institutions and 15 Universities,
- 25 % enhanced research output in 100 Colleges.

4. Technology Development and Deployment

- Implementation of Technology deployment solutions in 10 district level interventions
- Contributions to National Strength in five key areas of technology needs like solar energy, water technology, homeland security, nano and bio medical technologies
- Establishment of input-outcome linkages in technology interventions
- At least 4 vibrant PPPs for R&D (Technology Platforms) in areas relating to public and social good like water, energy, telecommunication and computational materials technology developing appropriate technologies.

5. Partnerships and Alliances

- Strengthening five major international partnerships and alliances
- Building five new global alliances and partnerships based on reciprocity principles
- Establishing at least five major PPP and 5 State-Center technology partnerships

6. Social Contract of Science and Technology

- Establishing sound delivery mechanisms for 5% of the allocated budget to weaker segments and developing impact assessment systems
- Launching 50 model demonstration projects through CSTRI for rural applications
- Launching R&D initiatives for women and child health

Mapping Resource Needs and Projections

1. Policy Objectives

The Department attaches high importance to approaches for policy building based on evidence gathering and linking inputs to expected outcomes. This approach, therefore, calls for research studies and data gathering for evidence building.

Commissioning of investigations and research studies for policy research would become important inputs as reflected in deliverable section.

DST anticipates that as more than 77 research studies and reports would need to be commissioned during the 12th plan. The Terms of Reference for these studies would be jointly decided in consultation with Planning Commission and important stake holders. Resource needs for pursuing policy objectives are presented in **Table 7a.**

Table 7a. Resource Needs for work proposal for policy Objectives of DST

No	Work Elements	Number of Reports/ research studies	Cost unit	Budget Provision (Rs in crores)
1	Commissioned Study Reports	15	Rs 40 lakhs	6.0
2	Commissioning policy research studies	10	Rs 30 lakhs	3.0
3	Development of STI indicators for India	➢ 3 major ➢ 10 minor	Rs 1 crore Rs 20 lakhs	3.0 2.0
4	Inter-country policy comparison studies	5	Rs 3 crore	15.0
5	Publications and Annual Reports	12	Rs 25 lakhs	3.0
6	External consultations and inter-country STI indicator reports	➢ 12 ➢ 10	Rs 1 crore Rs 50 lakhs	12.0 5.0
7	Minor reports and other costs			1.0
	Total			**50.0**

Resource needs for these studies are expected to differ in the range of Rs 25 lakhs to 250 lakhs depending upon the scope of the study. The Department proposes also to commission preparation of Detailed Project Reports for all the major R&D infrastructure projects being supported by DST. A provision of Rs 50 crores is made undertaking for preparation of DPRs for major investments, all research studies and evidence gathering exercises for policy building for science, technology and innovation sector for the entire 12th plan period in the proposal of DST.

2. Human Capacity building

The Department has prioritized building of human capacity for promoting excellence in research as well as enlarging the R&D base of the country through various on-going and new schemes proposed for implementation during the 12th plan.

Innovation in Science Pursuit for Inspired Research, INSPIRE is a new programme designed and developed by DST for implementation during the 11th plan period with a long term commitment to transfer the scheme to MHRD after stabilization. Currently all segments of the INSPIRE programme are in position. This is a new scheme without international parallels; with respect to size and scope. The Department proposes that INSPIRE Award scheme is scaled-up further (from 1 million to 2 million awards in a plan period) and stabilized during the 12th plan. DST is currently working in fine tuning the scheme and therefore another cycle of INSPIRE Award is best implemented through DST. After gaining experience and a review the scheme could be examined for possible implementation through Ministry of Human Resource Development.

Other schemes under INSPIRE and Scholarship for Higher Education have gained momentum. Continuation of these components with parameters remaining the same as in the 11th plan is proposed during the 12th plan period. Resource needs of the various schemes and sub-schemes proposed by DST for strengthening human capacity during the 12th plan have been mapped and presented in **Table 7b.**

Table 7b: Resource Needs for the schemes proposed for the objective of strengthening and building human capacity

No	Scheme	No of people targeted	Financial projection per person	Total Outlay projected (Rs. In crores)
1	Overseas Doctoral Scholarships	3000 man years	Rs 12 lakhs/ man year	**360**
2	Overseas Post-doctoral Fellowships	500 man years	Rs 50 lakhs for 2 year	**250**
3	Women mobility scheme for employed scientists	1000 India positions	--	**Expenditure neutral movement***

4	Enlarging PIs to 700 from current 575 levels	725 additional man years	Rs 20 lakhs	**145**
5	Investigator centric Extra Mural Research Support at the current level of 575 PIs per year	1625 man years	Rs 20 lakhs	**325**
6	Enlarging the PI base to include about 500 teachers from colleges and universities	1500 man years during plan period	Rs 7 lakhs	**105**
7	Start-up Research grant for Indian Diaspora undertaking faculty assignments in Indian academia	1000 man year Full Time Equivalents	Rs 20 lakhs per man year	**200**
8	INSPIRE Award scheme	2 million awards during 12th plan	At current levels of support	**1400**
9	Scholarship for Higher Education	Awards increasing to 10,000 in 2017 covering about 30,000 new scholars during 12th plan period	As per current parameters of support	**240**
10	Other INSPIRE relate schemes; Fellowship, Internship, and Faculty scheme	As per current provisions	As per current parameters of support	**1200**
11	Women component Programmes	With revised parameters on the ongoing schemes		**300**
12	BOYSCAST	500 Young Scientists	Rs. 10 lakh per scientist	**50**
13	Fast track projects for Young Scientists	2200 projects	Rs. 15 lakh per project	**330**
14	JC Bose	750 man years	Rs 15 lakhs/yr	**~115**
15	Ramanujan	450 man years	Rs 20 lakhs	**90**
16	Swarnajayanthi	150 man years	Rs 80 lakhs	**120**

17	AIs focused on Human Capacity building	BI, IACS, SN Bose, CLCR, JNCASR		**1250**
20	Programmes like ➢ Training Cell, ➢ International Travel support ➢ Conferences and Seminars etc.	 ~2500 people ~2500 travels/yr ~3000 conferences/yr		 **30** **55** **60**
21	Building Educators for Science Teaching			**425**
22	Minor Programmes			**40**
	Total			**7090**
* The Budget of Research and Development of DST would however, make a provision for meeting the salary compensations				

3. Institutional Capacity Building

Strengthening existing and building new institutional capacities for high end research in the country is a major priority of the Department during the 12th plan. If India were to gain global leadership at least in some select areas of frontier and cutting edge research, significant investments into such selected R&D areas during the 12th plan period are of paramount importance.

Global competitiveness of Indian R&D system is closely related to the national ability to strengthen select areas of research and build a critical mass and strength of research capacity.

India made significant investments into nano science during the 11th plan period and there is evidence that India might emerge as one of the major contributors to advanced scientific research outputs in the world. In the area of astronomy and astrophysics, India enjoys relative strength. Further investments in the area could enhance the leadership status of India in the world.

During the 11th plan, some important initiatives were made to rejuvenate research in the university sector in the country by strengthening R&D infrastructure. There is evidence for favourable changes with increases in the National share of university sector in scientific publications from ~15% in 2003 to 31% in 2010. Therefore consolidation and expansion of some of the initiatives of the department taken during the 11th plan during the 12th plan is proposed. DST has been investing about Rs. 69-70 lakhs per department during 10th and 11th plan under FIST. It is proposed to increase the per-capita investment of FIST to Rs 80-85 lakhs per decision unit during the 12th plan period.

Sub-group has recommended a competitive grant to institutions for enhancing their global competitiveness in advanced scientific research as evidenced from per faculty outputs of S&T output indicators like scientific publications, intellectual properties created, PhDs trained etc.

Resource needs of the various schemes and sub-schemes proposed by DST for strengthening institutional capacities during the 12th plan have been mapped and presented in **Table 7c**.

Table 7c: Resource Needs for the schemes proposed for the objective of strengthening institutional capacity

No	Scheme	No. of Institutions / facilities targeted	Financial projection per institution or decision unit	Total Outlay projected (Rs. In crores)
1	FIST	1200-1500 departments and 500 colleges	~80-85 lakhs Rs 50 lakhs per college	**1700**
2	Special Regional Packages	5-7Regional packages	Rs 70-100 crores per package	**450**
3	PURSE	50 Universities	Graded performance related incentive for research grant	**800**
4	CURIE	6 universities and 50 women	Graded investments	**50**

		colleges	based on the number of women trained into R&D	
5	IRHPA	15 research areas	Rs 40-50 crore /area	**750**
6	SAIF	25 new centres and 10 select centres	Rs 5 crore/ centre Rs 10/ centre	**225**
7	AIs focused on Institutional Capacity Building	ARIES, BSIP, WIHG, RRI, IAAST, IIA, IIG		**1750**
8	Nano Science & Technology Mission			**500**
9	Challenge award for global positioning	5 institutions	Rs 75 crores/ unit	**375**
10	National centres in Advanced Research	5 areas through competitive bidding	~Rs 75 crore	**375**
	Total			**6975**

4. Technology Development and Deployment

The sub-group of the working group has made some important suggestions for strengthening the Technology development and deployment components of the Department. There is a change in the paradigm from development of technologies to design and demonstration of solutions by establishment of Technology Platforms.

The sub-group has identified and recommended the establishment of Technology Platforms in four specific areas. While the Department welcomes the proposals to establish such platforms in the recommended four areas, it is proposed to develop a suitable scheme and methodology for mounting Technology Platforms in more than 4 areas through a transparent process.

Resource needs of the various schemes and sub-schemes proposed by DST for supporting Technology development and deployment during the 12th plan have been mapped and presented in **Table 7d**.

Table 7d: Resource Needs for the schemes proposed for the objective of supporting Technology Development and Deployment

No	Scheme	No. of Technologies and decision units targeted	Financial projection per decision unit/ technology area focused	Total Outlay projected Rs. In crores
1	Technology Development & Transfer, IDP, IS-STAC through the ongoing programmes	200 technology demonstrations 150 proof of concepts 25 cooperative investments with other socio economic ministries	Rs 1 crore per demonstration unit Rs 1.5 crore per concept Rs 6 crore per programme	**525**
2	Water Technology Solutions			**180**
3	Security Technology R&D for product design			**90**
4	Drugs & Pharma Research Programme			**300**
5	Climate Change Programme			**1000**
6	Solar Energy Research Initiative			**200**
7	AIs focussed on Technology Development	Sree Chitra, NABL, ARCI, Agarkar, ARI, NCMM and new institutions for automotive research		**1750**

8	NRDMS & NSDI	State Spatial Data Infrastructure	Competitive Grant for co-investment	**500**
9	Technology Platforms	4 identified areas 4 additional areas after selection through national bidding	Rs 50 crore each Rs 50 crores each	**400**
10	Modernization of SoI and NATMO	Special package and drive for 1:10,000 mapping	Specific proposal to be prepared	**400**
11	Challenge Awards for Technology Solution Design	10 major challenges	Award sizes 10 crores 25 crores 50 crores	**250**
12	District level Technology Intervention	10	30 crores each for	**300**
13	Nano Science and Technology Mission (Technology component)			**500**
	Total			**6395**

5. Partnerships and Alliances

Sub-group has made many and important recommendations suggesting sharing of objectives and co-investments of resources and co-generation of values through partnerships and leveraging of alliances by the Department during the 12th plan period.

Investments into mega science for creation of R&D infrastructure both in India and abroad would demand building national consensus on priorities and development of investment strategies.

Planning Commission has proposed the launch of PAN-India missions for S&T support for national missions and goals. DST has identified roles and participation in such PAN India missions. Some of the investments proposed by DST under Technology Development and Deployment as well as building of institutional capacities would reflect the contributions of DST to PAN India mission.

International S&T cooperation under both bilateral and multi-lateral modes is currently being stepped up under the broad principle of reciprocity and parity. Investments matching those of international partners are planned.

Centre-State technology partnership for leveraging the technology assets created through public funded research in various institutions is an emerging theme. DST as a coordinating department for state-centre technology proposes to establish a competitive fund for states and their state S&T councils to make competitive bids for deployment of technologies identified and selected by them.

Resource needs of the various schemes and sub-schemes proposed by DST for engaging into partnership and alliances during the 12th plan have been mapped and presented in **Table 7e**.

Table 7e: Resource Needs for the schemes proposed for the objective of engaging into partnerships and alliances

No	Scheme	No. of partnerships and alliances targeted	Resource deployment principle and units planned	Total Outlay projected (Rs. in crores)
1	International S&T Cooperation through bilateral and multi-lateral/regional collaborations	• Grand partnerships and alliances • Reciprocal partnerships • Technology diplomatic alliances	• Reciprocity and parity principle with equal investments • Asymmetrical investments based on merit	**375** **150**

2	Centre-State Technology partnerships	At least five viable partnerships through programme support	State S&T councils • Core support • Programmatic competitive fund	**125** **465**
3	S&T Entrepreneur development and partnerships	Special programmes and Technology Business Incubators		**250**
4	Linking national funding agencies on coordinated programmes under bi-lateral models	At least five funding agencies from other countries	Coordinated calls and harmony in merit ranking and peer evaluation; providing mobility funds for international partnerships	**150**
5	Public Private Partnership for R&D	One mega PPP for national challenge area Five PPP for large scale challenge 25 PPPs for proof of concepts for technology solutions	Equal investment with private sector investment and joint management systems as approved by the PM's council on Trade and Industry	**500**
6	Establishment of Joint (virtual) centres	20 centres	Rs 5-10 crores	**150**
7	Science Communication networks, NCSTC and autonomous bodies			**150**
8	Partnerships through PAN India S&T missions	3 of the PAN India missions	Shared investment based on specific need and scope of work	**300**

9	Mega science investments ➢ In India partnerships ➢ Global consortia partnerships			**1500**
10	Innovation partnerships and clusters	• 25 partnerships • 10 clusters • 10 Research parks	• Rs 3-5 crore/ partnership • Rs 25 crore • Rs 10	**100** **250** **100**
	Total			**4565**

6. Social Contract of Science and Technology

The Sub-group of working group has recommended strongly changes in the paradigms of operations and social contracting of S&T. Further strengthening of Council for Science and Technology for Rural India (CSTRI) developed during the 11th plan period has been recommended strongly. Consortium mode of programme implementation and solution design as a theme has been suggested.

The Department has enrolled into the national objective of directing about 5% of investments for S&T interventions benefiting directly the weaker segments of the community.

S&T interventions to bridge the rural-urban divides in the country promoting equity and improved access to developmental choices to people have been accorded priority.

North East region Centre for Technology Application and Reach (NECTAR) has been proposed for promoting and delivering technologies for mainstreaming the developmental programmes of the region through focused efforts. The proposed centre will service all the science departments in the central sector.

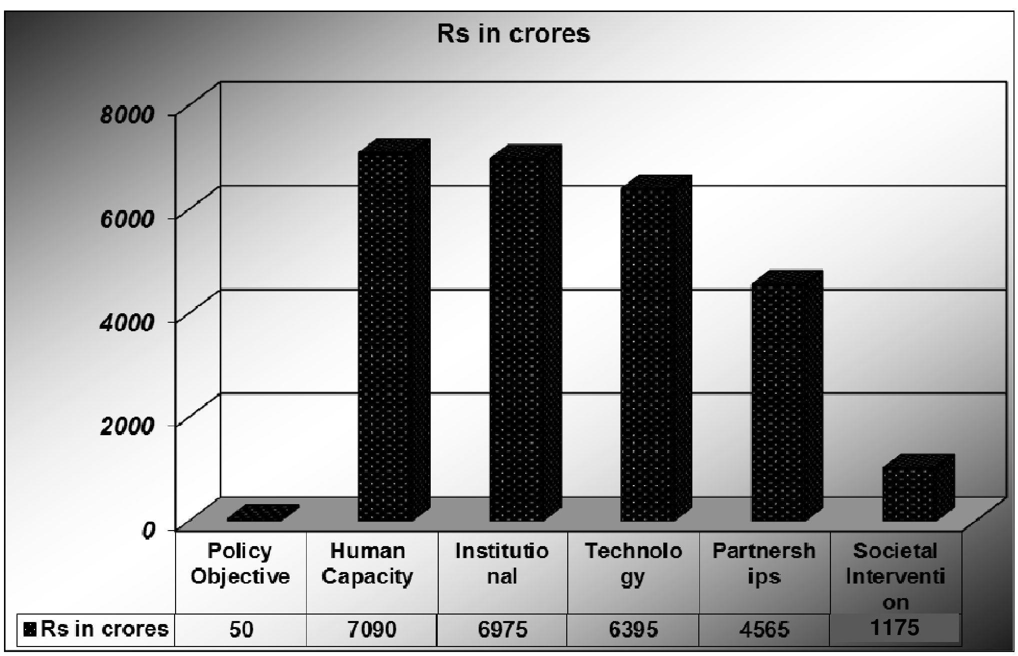
Resource needs of the various schemes and sub-schemes proposed by DST for serving social contract of S&T during the 12th plan have been mapped and presented in **Table 7f**.

Table 7f: Resource Needs for the schemes proposed for the objective of serving the social contract of S&T during the 12th plan

No	Scheme	No. of programmes and projects planned	Financial projection per investment unit	Total Outlay projected (Rs. in crores)
1	Science for Equity, Empowerment & Development	100	Variable investments based on nature and scope of work	**100**
2	National Mission on Bamboo Applications & Mission for Geospatial Application	Establishment of NECTAR		**200**
3	Open Source innovation system	National Innovation Foundation model		**175**
4	Model Demonstration projects	50	Village as decision unit at Rs 2 crore/ unit	**100**
5	Solution design through R&D consortia for S&T technology sizing for decentralized applications	10 challenges	Rs 5 crore per challenge	**50**
6	Public outreach of S&T options for social contract of S&T	Campaign models for successful technologies		**50**
7	Rural Technology parks	25	2 crore each	**50**
8	Women technology	25	2 crore each	**50**

	parks			
9	R&D for women and child health		Competitive grant	**50**
10	Programmes for bridging rural-urban divides through S&T		Interventions developed through demand driven models	**80**
11	Synergy Projects			**120**
12	Women Mobility Scheme for Employed Scientists			**150**
	Total			**1175**

Resource needs mapped for the various proposals for meeting the six objectives proposed by the DST during the 12th plan period has been indicated in **Figure 7.**



Responding to the National Flagship Programme for the Establishment of Super Computer Facility in the Country

It has been recognized by the national planners and various Science Advisory Councils that Indian capability and capacity in the area of supercomputing should match the global developments. Technology for super computing is an area where the country cannot afford to lag behind.

In 2007, the Indian capacity in supercomputing was in within the top five in the world and country matched the capacity of China. Since 2007, the global developments in the supercomputing discipline have left India far behind. A policy decision has now been taken in the Government to fast forward the development of super computer technology in the country and assemble a National Expert team for commissioning the appropriately sized super computer facility.

The expert committee under the chairmanship of Professor N Balakrishnan has been assigned the task of developing a Detailed Project Report and DST to coordinate the development and commissioning of the facility. A budget requirement of Rs 5300 crores has been indicated by the National Expert Team. Accordingly, DST has included a special provision of Rs 5300 crores exclusively for the super computer facility proposed to be developed.

Other user agencies of the Super Computer facility like Council of Scientific and Industrial Research is expected to include in their proposal a provision for establishing super computer facility for their requirements. DST recommends that suitable provisions may be made within the Rs 5300 crores for the Super computer facility for such users.

Summary

Summarizing the programme proposal and resource needs of the Department for the 12th plan period, after taking into account of also the requirements for the establishment of Super Computer facility in the country, the fund requirements have been projected at Rs 31,550 crores. Establishment of Super Computer in the country as a strategic investment would also receive similar requests from the users of such facilities. Hence, there is a need for coordination in the development of investment plans. It is hoped that the Detailed Project Report would address these issues.

The projections of the resource requirements for the implementation of the 12th plan proposals of DST are presented in **Table 8.**

Table 8. Projections of Resource needs mapped for implementation of the proposals of DST during the 12th plan period

Objectives	Major outputs	Budget projected (Rs in crores)
Policy	At least 4 bills; 16 policy documents & frame works; Full Implementation of 11th plan policies	**50**
Human Capacity Building and Strengthening	Achievement of all INSPIRE targets; 1000 overseas doctoral and 250 overseas post-doctoral fellowships; Quadrupling Full time Equivalents of R&D professionals from 2006 levels	**7090**
Institutional Capacity Strengthening	Doubling the outputs of 10 elite institutions in basic research; Doubling the R&D outputs of 10 lead universities in the country; Significant Strengthening Research capacities in five states in the country	**6975**
Technology Development and Deployment	Implementation of Technology deployment solutions in 10 district level interventions; Contributions to National Strength in five key selected areas of technology needs; Establishment of input-outcome linkages in technology interventions	**6395**
Partnerships & Alliances	Strengthening 5 major international partnerships and alliances; Building 5 new global alliances and partnerships based on reciprocity principles; Establishing at least 5 major PPP and 5 State-Centre technology partnerships	**4565**
Societal Intervention	Establishing delivery mechanisms for 5% of the allocated budget to weaker segments & developing impact assessment systems; Launching 50 model demonstration projects through CSTRI for rural applications; Launching R&D initiatives for women and child health.	**1175**
Establishment of Super Computer Facility	A coordinated effort assigned to DST by the Planning Commission. This would involve multi-stake holder investment. Hence this is presented as a separate activity	**5300**
Total		**31,550**

CHAPTER 7

Budget Outlay (Programme wise)

The Budget proposals of the Department are generally prepared in the on-going programmatic structure. Thematic goals have been structured into the programmatic architecture of the budget planning. An attempt has been made to present thematic proposals in to programmatic indicators in the subsequent statements, **Table 9.** These are indicative and would be revised after the allocations for the 12th plan proposals are finalized based on inter-se programme requirements.

Table 9 XII Plan Outlay – Proposed Projections: Ongoing Programmes

Sl. No.	Name of the scheme / Project / Programme	Proposed XII plan outlay (Rs. In crores)
	On-going programmes	
1	Research & Development Support	2665.0
2	Technology Development Programme	1225.0
3	S&T Programme for socio-economic development	1635.0
4	International Cooperation	675.0
5	State Science and Technology Programme	590.0
6	Modernization of Mapping Organizations (SOI & NATMO)	400.0
7	Autonomous Institutions & Professional Bodies	4900.0
8	Technology for Bamboo Products (Mission Mode Project)	200.0
9	Synergy projects (o/o Pr. Scientific adviser)	120.0
10	Information Technology	30.0
11	National Training Programme for Scientists/Technologists working with Govt. of India	30.0
12	Drugs & Pharmaceuticals Research	300.0
13	National Mission on Nano-Science & Nano-Technology	1000.0
14	Science and Engineering Research Board	2715.0
15	Scholarships for Science in Higher Education (Oversight Committee Recommendation)	240.0
16	Water Technology Initiative	180.0
17	INSPIRE	2600.0
18	Innovation Clusters	70.0
19	Security Technology Initiative	90.0
20	Mega Facilities for Basic Research	1500.0
	Total Plan	**21,165.0**

New initiatives planned for implementation during the 12th plan period and their resource requirements have been shown separately, **Table 10.**

Table 10 XII Plan Outlay – Proposed Projections: New Programmes

Sl. No.	Name of the scheme / Project / Programme	Proposed XII plan outlay (Rs. In crores)
	New programmes	
1	Policy Objectives: Study reports, policy research studies, development of STI indicators	50.0
2	Overseas Doctoral Scholarships	360.0
3	Overseas Postdoctoral Fellowships	250.0
4	Women Mobility Scheme for Employed Scientists	150.0
5	Building Educators for Science Teaching	425.0
6	Start-Up Research Grant for Indian Diaspora	200.0
7	Challenge Award for Global Positioning	375.0
8	National Centres in Advanced Research	375.0
9	Climate Change Programme	1000.0
10	Technology Platforms	400.0
11	Challenge Award for Technology Solution Design	250.0
12	District Level Technology Intervention	300.0
13	PPP for R&D	500.0
14	Establishment of Joint Centres	150.0
15	PAN India S&T Missions	300.0
16	Establishment of Super Computer Facility	5300.0
	Total Plan	**10,385.0**

CHAPTER 8

Submission of the Proposals of DST

The Department of Science and Technology has made the proposals for implementation of 12th plan programmes after extensive exercise involving a large number of representatives from the scientific community and stakeholders. The proposals have been prepared after taking into account of a) the essentiality of the programmes proposed in the changing context of R&D base in the country, b) the role that science and technology could play in the developmental programmes of India during 2012-17, c) the aspirations of the scientific community as well as stakeholders, d) relationships between outputs and input requirements, e) fund requirements for effective implementation and delivery of R&D outputs, and f) global positioning of the National Science, Technology and Innovation landscape.

The need for realism in the projections made for the fund requirements has been accorded serious consideration. One of the exercises carried out by the Department internally is the **"Cost-of–not Doing"**. When there is an opportunity for the country to emerge as one of the global leaders in the emerging knowledge economy, deployment of resources into the R&D sector need to be based on "investment mind-set" rather than "expenditure control" behaviour. Therefore, DST has adopted an investment mind-set in preparing the proposal for 12th plan programmes.

The Department of Science and Technology has for the first time proposed an institutional mechanism for developing an evidence-based policy formulating capacity within the sector as a part of the 12th plan proposal. Significant, but necessary investments are proposed in the areas of Human capacity building, strengthening of institutional capacities and Technology Development and Deployment. The investments proposed into partnership and alliance building and Social contract of S&T are also focused on delivery systems for reaching the outputs to the value creation activities.

DST makes a submission that the 12th plan proposals of the Department may be accorded a serious consideration and viewed as a planned effort to unleash the creative potentials the Indian R&D community, which is capable of developing affordable innovations for the needs of people of India.

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Annexure 1

Some highlights of the Major Programme Initiatives of The Department of Science and Technology during 11th plan

1. Science and Engineering Research Board (SERB)

A Bill to constitute a Science and Engineering Research Board has been passed by the Parliament of India through an Act in 2008. The compositions of the Board and Oversight committee have been notified. These committees have met and several decisions have been taken.

A new premise has been rented. Although the board has become functional through deputation of staff from DST, actions are in progress to appoint the Executive Secretary and staff of the Board.

The Science and Engineering Research Board is expected to serve as the major national funding body for competitive research similar to the National Science Foundation of the United States of America.

2. National Spatial Data Infrastructure (NSDI)

National Spatial Data Infrastructure (NSDI) approved by the cabinet and passed through a resolution is a national platform created under a partnership between the Department of Space and Department of Science and Technology in 2006 has emerged a data sharing platform for geospatial data among various arms of the Government of India.

NSDI has been established in separate office premises with CEOP and has become fully functional. NSDI is actively promoting the concept of establishing state level Spatial Data Infrastructures.

3. Innovation in Science Pursuit for Inspire Research (INSPIRE)

Innovation in Science Pursuit for Inspired Research (INSPIRE) is a new programme proposed and implemented by the Department of Science and Technology for the Government of India. INSPIRE was launched on 13th December 2008 by the Hon'ble Prime Minister of India.

INSPIRE is an integrated programme for attracting youth to study science and careers with research spanning the age group of 10 to 32. INSPIRE includes

2 lakh Awards for the age group of 10-15, 50,000 Internships for 16-17, 10,000 Scholarships for 17-22 for studying BSc/MSc level courses in biology, chemistry, mathematics and physics, 1000 Fellowships for 22-27 for PhD studies and 1000 New Blood Faculty for 27-32 age group to provide assured opportunity in research career on an annual basis.

Table 1 INSPIRE

Sub-scheme	Feature	Awarded and in position
INSPIRE Award	Covers all 4.6 lakh middle and secondary schools in the country. Minimum of 2 awards per school assured. School to nominate the child for Rs 5000 award for entering into project competition. Awardee undertakes project and enters district level competition. Jury selects 5-10% for state level competition. 3 member jury selects 5% for state level entries for national level. The Scheme opened up from 2008-09.	**4, 20, 930 National, Regional and State awards, respectively released. All 28 states and 6 UTs have been enrolled into the project.** **District and state level competitions held in several states.** **National level competition is scheduled for 14-16th August 2011 at Delhi.**
INSPIRE Internship	Top 1% performers of all school boards at class X level studying science courses in class level are invited to Science camps in different parts of the country. Provisions are made for attracting ~50,000 interns per year in different camps. The Scheme opened up with effect from 2007.	**More than 3000 resource persons have been enrolled for the camp.** **More than 250 camps attracting more than 75000 students.** **17 Nobel Prize winners have attended the camps so far.**
Scholarship for Higher Education	10,000 scholarships at a value of Rs 80,000 per year for a period of five years for study of science courses in mathematics, biology, physics and chemistry at BSc and MSc levels have been instituted. Qualifying bench marks are top 1% in class XII board examination of all Indian boards or ranks in national competitive examinations within the stipulated cut off. The sub scheme opened up with effect from 2007.	**Total of 5600 scholar are receiving the scholarships currently. In order to increase the outreach of information and enrolment starting 2011, all school boards have been enrolled into releasing eligibility letter along with mark sheets of board examination scores.**

INSPIRE Fellowship	Currently INSPIRE fellowships are restricted to top ranker in any recognized university in any branch of science, engineering, medicine, technology, agriculture, animal sciences etc. 1000 slots were announced and the sub scheme opened up in 2010-11.	**1040 fully eligible candidates (66% women) applied and were awarded.** **So far 1340 candidates have been awarded and 790 candidates are under review**
INSPIRE Faculty	The Sub scheme offers assured opportunity in research careers with doctorates with less than 2 years of post doctoral experience and under the age of 32. It provides a contractual position for a period of five years with an annual research grant of Rs 7 lakhs.	The sub scheme has been opened up for the financial year 2011-12 with three parallel streams of appraisal. The call for nominations and applications has been made.

4. Promotion of University Research and Scientific Excellence (PURSE)

Rejuvenation of research in University sector in the country has been fore most priority of the Department of Science and Technology. In order to Promote University Research and Scientific Excellence (PURSE) has been mounted by DST.

Scientific publications emanated from the country in peer reviewed journals were profiled for the ten year period of 1996-2006. Total of 37 institutions had contributed to more than 47% of India's publications. Among them 14 were universities. Research incentive grants with four slabs based on H-Index namely Rs 30, Rs 15, Rs 9 and Rs 6 crores for H indices of >50, 40-49, 30-39 and 25-29 were granted. These grants were also associated with freedom to select investments in heads other than buildings and works and services. A committee reviewed the performance of the 14 universities after two years in 2010. All the universities report improved performance in publications.

Data were complied for the period 1998-2008 in 2010. 30 additional universities have qualified by the same token of parameters. They have also been added to the PURSE grantees in 2010. Funds are being released during 2011-12.

Whereas the share of scientific publications of the Indian university sector was reported as only 15%, in 2010, the corresponding share is estimated at 31%.

5. Consolidation of University Research, Innovation and Excellence (CURIE) for Women Universities

There are a limited number of women only universities in the country. As a proactive measure to address the women in science, a new scheme, titled as Consolidation of University Research, Innovation and Excellence (CURIE) has been designed and launched for women-only universities by DST in 2008 -09. Under this scheme, all six universities were provided a research infrastructure grants of the range of 2-5 crores have been made based on their ability to absorb and provide values. Each university was also provided a mentor support for deciding investment priorities. The performance of the universities has been monitored.

6. Special Packages for North East, J&K Bihar

DST has been implementing a Scheme called as Fund for Infrastructure Strengthening of Science and Technology (FIST) since 2000. This being a competitive grant model, majority of projects won by departments of sciences emanated from institutions from four major states namely Tamil Nadu, Karnataka, Maharashtra and Delhi. With a view to spread the R&D base in the university sector in other regions in the country, state and region specific special packages have been designed and delivered starting 2008-09.

In 2008-09, academic sector in North Eastern Region was focussed. During 2009-10, academic institutions in J&K region and 2010-11, institutions in Bihar have been focused for developing need based special packages. These packages have generally consisted of support to colleges for establishing laboratory facilities, visiting fellowships for faculty and students from the region to other institutions in the country as well as visiting professorships for faculty to teach in institutions in the region, infrastructure support and creation of common facilities over a period of five years. Internal alert review meetings have been held. There are indications that this mode of support through special packages may promote improvement of regional balances in Science and Technology sector.

7. FIST for colleges (Level 0 FIST)

Fund for Infrastructure Strengthening of Science and Technology (FIST) has generally focussed on support to science departments in university and centres of excellence. Over a period of 11 years 1660 departments have been supported under FIST. A special scheme for supporting colleges where post graduate courses are conducted and students qualify for National Eligibility Test. This sub scheme of FIST is essentially to invest upon experimental laboratories for successful colleges in the country. A special committee has been constituted for this sub scheme of FIST and total of 56 colleges have been selected for support during 2010-11.

8. Nano Mission

Government of India has mounted Nano mission through the Department of Science and Technology on 3rd May 2007. The mission has provided Rs 1000 crores for a period of the 11th plan period. Under the initiatives of DST on nano science, total of 8 units and 11 Centres of Excellence have been supported. Total of 650 students have pursed their doctoral studies and additional 550 students have been trained. India has ranks among the top six with respect to scientific publications currently. Some important lead contributions in nano science and technology have emanated from India. They are listed in **Annexure 3**.

9. Cognition Science Initiative

Understanding of processes behind human Cognition has emerged a major global theme for research. DST mounted a national initiative on Cognition science in 2007-08. Under this scheme, more than 30 research groups have been supported for research in cognition science. Total of 71 individual research projects have been supported. Coordinated research initiatives on Learning of language and Neural networks have been mounted. The initiative has supported 53 doctoral and post doctoral students for research. A report on important findings emanating from the initiative is being compiled.

10. Science Express

An open class room for creating excitements in science among various segments of the society has been designed under an Indo-German joint initiative and housed in train for reaching out among the youth of the country. DST has bought a train and furnished it with educational materials on some important topics affording a learner an opportunity to experience hands on learning. The train was flagged off on 30th October 2007 by Chancellor Germany and the Hon'ble Prime Minister of India. The train has since then been run as a National initiative. It has covered so far more than 220 stations and as many as 65 lakh visitors have visited the train. It has opened up a good level of excitement among youth.

11. WAR for Water

Access to Water has emerged a major challenge to many people in the country. The Supreme Court of India passed an order in March 2009 that the water problem in the country must be solved using best of recourses to technology. The Secretary Science and Technology has been assigned the task of addressing water challenges using the best of technologies in the world. Technology Mission Winning, Augmentation and Renovation (WAR) for Water has been launched with a budget of Rs 145 crores.

DST has listed total of 26 types of water challenges in the country and enrolled all the states and UTs in identifying some hot spots where such challenges are dominant. Based on the feed back obtained, total of 49 clusters have been selected for technological interventions. Expression of Interest was sought from solution providers and contracts have been issued to such solution providers who offer technological solutions. Currently 17 of water challenges are being addressed in 26 locations covering a population target of 1,55,000.

The mission is expected to prove technical, social and financial viabilities of some integrated and total solutions for different water challenges in the country. Total of eight research packages are expected to be delivered to line ministries dealing with water for multiplication and penetration.

12. National Mission for sustaining Himalayan Ecosystem (NMSHE)

National Programme on Climate Change has enunciated total of eight missions. Among them the National Mission for sustaining Himalayan Ecosystem has been allocated by the Government to the Department of Science and Technology. Sustaining an ecosystem as fragile as Himalayan ecosystem demands selection of sound scientifically assessed methods supported by implementation by the respective Himalayan States. Therefore, the mission in its first phase is focused on developing knowledge networks and both human and institutional capacities. Deliverables of NMSHE have been defined.

One of the key deliverables is establishment of a world class National Centre for Himalayan Glaciology. A nodal centre has been established on a project mode in Wadia Institute of Himalayan Geology. The Department is planning to establish the national centre in Uttarakhand within 18 months.

Since there is an urgent need to develop human resource in the area of glaciology, special scholarship scheme to attract young scientists for training in the area is being developed.

13. National Mission for Strategic Knowledge on Climate Change (NMSKCC)

National Mission on Strategic Knowledge for Climate Change (NMSKCC) is a mission assigned to the Ministry of Science and Technology by the Government of India. It involves a function that connects to all other seven missions under NPCC. The mission is focused on developing national and human capacities in the area of climate change. It is a PAN India mission involving many departments and institutions.

Deliverables have been defined. Call for proposals for establishing knowledge centres have been made and short-listing of the proposals for support has been complete.

14. Revision of Doctoral Fellowships

The value of doctoral fellowships had not been revised for many years. It was Rs 8000 plus HRA in 2006. This has made research less attractive to many talented youth especially when service economy had been performing well. DST made a proposal to the Government of India that the doctoral fellowships were revised to Rs 12,000 plus HRA. This was accepted by the Government with effect from 1st April 2007. After the revision of pay scales based on 6th CPC, the fellowships were revised to Rs 16000 plus HRA with effect from 1st April 2010.

DST proposes to move a proposal that the doctoral fellowships are revised and include an annual increase rather than revising at periodic intervals. Especially when the inflationary trends are high and there is no mechanism for providing DA for research fellows and post doctoral fellows, there is a need to revisit the policy. DST proposes to position a national policy on the fellowships for research fellows.

15. Academy for Science Policy and Implementation Research (ASPIRE)

Science policy and implementation demands special professional skills different from those of civil servants as well as laboratory scientists. While professionals with scientific background are employed in science policy and management functions, there is a felt need for an academy which provides an opportunity for scientific professionals who have taken science management for a career to update their knowledge domain and engage in science policy research and develop new implementation methods. Such an academy has now been started in Administrative Staff College of India, Hyderabad on a project mode to assess the pre-feasibility of the concept. The Academy has been launched in 2010. Efforts are ongoing to enrol all science departments into deputing their middle level scientific staff. The Academy is expected to generate research documents and well researched reports for policy building.

16. National Data Sharing and Access Policy (NDSAP)

The current policy regimes of the country do not enable seamless sharing of data gathered deploying public funds even among various arms of the Government. Lack access of such data gathered through deployment of public funds makes such valuable data assets not available to planning and development. Civil society needs of data are not being met in the current policy framework. After a number of inter ministerial discussions, the Department of Science and Technology has developed a National Data Sharing and Access Policy.

The cabinet has accorded approval to the policy and directed the Department to develop general policy framework and share it with other departments of the Central Government within three months. Various departments of the Government are expected to develop their own policies for sharing data and provide negative lists of data which would not be shared. The policy also provides support for digitization of analog and archival data. The policy has been finalised after extensive inter ministerial discussions. NDSAP is being submitted for approval by the cabinet.

17. Fiscal Benefits for Technology Business Incubators (TBIs)

Technology Business Incubators form effective tools to convert ideas and early stage innovations into business enterprises. These are essentially risky and small investments and support mostly micro and small and medium enterprises. The Government has extended fiscal benefits through tax exemptions. The facility has now been extended for further period with a view to promote knowledge based enterprises and small business. DST has championed for the policy support.

18. Revision of parameters for Women Component Programmes

Women in Science has emerged a major global theme. DST had introduced a number of gender sensitive initiatives with the objective of gaining gender parity in science sector in short time as possible. A task force was constituted based on the advice of Science Advisory Council to the PM. The task force submitted its report in 2008. The task force recommended revision of some parameters of the schemes being implemented by the Department of Science and Technology for enabling of women for re-entry into science related functions. All the major recommendations of the task force have been accepted and actions implemented on most recommendations. Revised parameters of the Women component programmes implemented by DST are listed below.

Table 2 Women Scientist Schemes- Changing Parameters

Programme	Existing parameter	Revision suggested
Fellowship schemes for women scientists **WOS-A, WOS-B & WOS-C**	Duration: The duration of the project was 2 years with a provision of extension by one year	Fellowship will be awarded in cycles of 5 years with a review after 1 and 3 consecutive years.
	Selection criteria: The selection was based on the basis of comments of screening committee followed by presentation of proposed project.	Selection criteria: The initial selection would be based on the academic qualifications instead of a proposed project.
	Eligibility: Women scientists, with a minimum of PG degree, in Basic or Applied Sciences/ B.Tech / MBBS or other equivalent qualification Maximum age limit for this category is 35 years at the time of submission of project	Women scientists who have a break in carrier would undergo a one year internship after which they can opt for the various categories of fellowship being offered.
	Women scientists having a Ph.D. in Basic or Applied Sciences/M.Tech./MD/MS in Medical Sciences from recognized Universities can	The 5 year cycles can continue till the scientists attains the age of 60 years.

	apply up to the age of 50 years. Fellowship: The amount of fellowship for such candidates will be Rs. 35,000/- PM.	A consolidated fellowship will be provided along with consumables, contingency and travel. The amount of fellowship will be reviewed in consecutive years of cycle.
WoS C	1. Fellowship 2. Maximum age for application is 50 years	**1. Stipend will be given to candidates undergoing the 1 year training.** **2. There will not be any minimum age bar.** **3. Maximum age for application will remain 50 years**
General		**All the fellowship schemes will be named DISHA-Fellowship for Women Scientists & will be operated in different categories to cover Basic & Applied research, Social contract of science and capacity building.**

Department is working on a proposal to create 1000 India centric contractual positions for employed women in science sector which is potable to any place in the country. Employed women needing to shift on account of family reasons, could avail these positions, if they could gain attachment in any public funded institution in the new location. The department is proposing to move the proposal for approval of the cabinet.

19. Budgeting Guidelines for Autonomous Institutions of DST

Budgeting guidelines for all autonomous institutions nurtured by DST have been clearly enunciated using transparent criteria. They are derived from budgeting principle that expenditure control mechanism is necessary for administrative costs while developmental programmes in science establishments should be based on investment mindset. Budget support for scientist has been worked out based on negotiated parameters. A general budget principle is that allocations to AIs would not exceed the total budgetary allocation for SERC and SERB.

The new principles of budget planning for the AIs include also performance based element. Annual review meetings reveal that the collective performance of the institutions supported by DST maintain high outputs per scientist.

20. Good Laboratory Practice (GLP)

India has been making an all out effort to gain full membership of the OECD protocol for observing Good Laboratory Practice and seek mutual recognition for certifications. DST is the national GLP authority. It has been possible to gain full membership and sign mutual recognition treaty for GLP in March 2011. Already 18 laboratories have gained GLP certification in the country. It is expected that before the end of financial year 2011-12, additional 7-10 laboratories may be added to GLP certified laboratories in the country.

21. Test Bed for Hybrid power for off-grid solutions

Power from Solar energy is yet to gain parity with fossil fuel with respect to cost of delivered power on the basis of currently available technologies. In order to assess the potential of hybrid technologies based on solar and biomass in gaining diesel energy parity, the establishment of a test bed in a village, Shive, in Maharashtra has been commissioned to a company. The 256 KW power plant will generate power from solar energy in the day time and from biomass in the night time and is expected to deliver power at the cost of less than Rs 9/KWH. Inputs to policy formulation based on scientific assessment of viability gaps and levels of compensation required for generation based subsidy will form the major outputs from the plant apart from designing and providing a viable technical off-grid solution to rural electrification needs.

22. Test bed for Potash fertilizer

India is a major importer of potash based fertilizers. Import costs of fertilizers are needed to be subsidized. Indigenous technologies for potash based fertilizers are in national interest. Central Salt and Marine Chemicals Research Institute (CSMCRI) of CSIR has developed a technology for potash from sea. The technology has been patent protected and licensed to some private companies already. The technology standardized by CSMCRI is based on a batch process. A test bed based on a collaborative effort between CSMCRI and Tata Chemicals is now being supported by DST. It is expected that the test bed would provide for the Government scientifically assessed information and data on the cost of production of potash based fertilizers based on indigenous technologies. This will enable the Government of derive evidence based policy formulation on the levels of subsidy for potash fertilizers.

23. PAN IIT Solar Energy Research Initiative (SERI)

Globally Technology breakthroughs are required to drive the costs of delivered solar energy power DST has mounted a PAN IIT Solar Energy Research Initiative. Under this initiative, the IIT consortium is required to establish dedicated research groups in the area of solar energy research and seek technological breakthroughs by developing new energy harvesting materials and devices, storage systems and devices, power electronics and synchronization of asynchronous power systems and aim at crossing the global bench mark parameters. Total of 41 faculties and more than 250 students are expected to work in this area.

24. Innovation Cluster

There are several industrial clusters in the country which have evolved on account of natural and market forces. For example, auto clusters in Chennai, Pune, NCR and Pharma clusters in Hyderabad, IT clusters in Bangalore, and electronic clusters in Bangalore and NCR. While these clusters have supported industrial activities, networking of manufacturing with locally available knowledge systems has not been registered. DST developed a model of innovation cluster which focused on there development of networks among the manufacturing and knowledge systems. Total of four clusters have been selected. An Innovation fund (Rs. 48 crores) has been created under Public Private Partnership with a group of industrial associations like NASSCOM. DST has earmarked Rs 24 crores for the fund. Innovation clusters in select themes are being supported under the innovation cluster model.

25. US-India R&D Endowment Fund

India and United States have established a joint endowment fund for promoting innovations and joint research and development. The size of the fund is US$ 30 million. The fund will be managed by a joint board constituted already. The fund will be serviced by Indo US Science and Technology Forum (IUSSTF). The focus of the fund will be on the promotion of industrially relevant innovations to be supported by private sector for commercialization. The board has identified two topics for focus namely “Healthy individuals and “Citizens”. The first call for proposals has already been made with an expectation that the first awards may be released in October/ November 2011.

26. Joint Clean Energy Research and Development Centre (JCERDC)

India and United States have signed an agreement to promote jointly research on the topic of clean energy by forming virtual joint centres. Department of Energy in the USA has committed a fund of US $ 5 million per year for five years. The Ministry of Science and Technology through the Departments of Biotechnology and Science and Technology has committed matching funding on the broad principle of reciprocity and parity. US will fund American research groups and India will support Indian research groups. The successful projects would also receive Private sector participation on 1:1 basis. The first call has been made with last date for submission of expression of interests is 16^{th} August 2011. The total size of the support is expected at US $ 100 million with 1:1 sharing of private and public funds.

27. EU-India Initiatives in R&D

European Union and India have entered into an agreement to announce coordinated calls for research and development in select priority areas of mutual interest to partners. EU and India have committed 5 million Euro per year for five years to support research in priority areas. The first coordinated call was made in 2009-10 on computational materials science. In 2010-11, call made for solar energy materials. In 2011-12, call is being made for water technologies. Reciprocity and parity principle has been adopted in the project areas and selection methodologies. This mode of funding offers scope and opportunities for Indian laboratories to share IPR.

28. Indo-German Science and Technology Centre (IGSTC)

A dedicated bi-national Indo-German Science and Technology Centre has now been established at Gurgaon. The Director of the centre has now been appointed. The centre will focus on the promotion of industrial research in mutually gainful areas of interest to both Germany and India. Both Germany and India have committed 10 million Euro each for a period of five years. The bi-national centre is expected to promote aggressively research and development in application related areas.

29. Indo UK Science and Innovation Council

Indo UK S&T cooperation has been stepped up significantly on the advice of Indo-UK Science and Innovation Council. India joined UK India Education and Research Initiative for joint funding in 2006 and established joint funding programmes with EPSRC, UK for supporting research in the areas Solar PV materials, Next Generation Network, Fuel Cell and Bridging Rural-Urban divides. Both collaborating partners have set apart about 30 million UK pound each for supporting joint projects in mutually agreed areas of research. Impacts of joint research initiatives have been reviewed through joint consultation mechanism.

30. Global Innovation and Technology Alliance (GITA)

In the generation of a viable innovation ecosystem, international collaboration in the area of industrial Research and Development is considered essential. In order to promote and bridge gaps in the research-industry partnerships, an initiative under the title Global Innovation and Technology Alliance has been mounted between Department of Science and Technology and Confederation of Indian Industries (CII) since 2007. GITA has functioned as arms length partnership unit for both DST and CII and servicing arm for collaborative projects with Canada and Israel. GITA has serviced also many other industrial research and development related activities for promotion of innovation. Efforts are ongoing for establishing GITA as an entity for the promotion of research- industry partnerships on innovations.

31. Innovation Funds and partnerships

The Department of Science and Technology has partnered with a large number of national and international agencies and entities in the promotion of innovations. Some of the lead innovation partnerships of DST are with INTEL, Lockheed Martin, Indian Institute of Management (A) and Economic Times, CII through GITA. The partnerships have focused on scouting and supporting innovators up the levels of their becoming entrepreneurs. Partnerships with INTEL and Lockheed Martin are associated with an award scheme for innovators which is backed up by participation in international fairs and mentoring in formation of start-up companies. One of such awardees has now been rated as #1 young entrepreneur of India in survey conducted by Business India. DST mounted an initiative called “The Power of Ideas” in partnership with Economic Times and IIM (A). A call was made for ideas with application potentials. Total of 16500 ideas were received. They were peer assessed and finally ~250 ideas were selected for further development and discussions with venture capitalists. An award scheme forms part of the scheme. After all due diligence support was extended to powerful ideas for formation of companies. Total of 11 companies have been funded by DST seed fund already based on the one call for “The Power of Ideas”. Innovation fund of Rs 48 crores has been created for PPP investment for supporting Innovation clusters.

32. Council for Science and Technology for Rural India (CSTRI)

The focus of most formal Research and Development systems is on areas and technologies to benefit urban and global population. Differential access to technologies and innovations seem to cause rural-urban divides. DST has constituted a Council for Science and Technology for Rural India to address specifically technology solutions that meet the needs of rural India. This is a new advisory mechanism for solution design and development. CSTRI has constituted two executive units, one in Chennai and the other in Jorhat for scouting designer solutions to problems of rural India in specific locations and support the proof of concept of the solutions. This is a new initiative in the stage of development.

33. Africa Fund

As a measure of Technology Diplomacy, India has created an Africa fund to promote India and Africa collaboration in the area of Science and Technology. Size of the fund is Rs 180 crores. Under this fund, total of 420 CV Raman Scholarships for citizens of countries in Africa have been announced. FICCI is extending service facilities in the implementation of the scholarship scheme. Already ~85 fellowships have been offered to citizens of countries in Africa. Strengthening of two institutions in the continent has been included as a part of the priority of Africa fund. Identification of the institutions for strengthening is underway.

34. Australia-India Strategic Research Fund (AISRF)

At the levels of the Prime Ministers, decisions were taken to mount bi-national research partnerships between India and Australia in 2006. A joint strategic research fund of Australian $ 30 million was established to support joint R&D. within two year, based on the success of the fund, it has been increased to Australian $ 100 million. R&D programmes in the areas of biotechnology and other disciplines are supported with 30% of fund each. Other 40% of the fund is deployed in addressing grand challenges in the areas of agriculture, energy and environment, health care, cyber security etc. The level of engagement of R&D groups in both countries under AISRF is impressive so far.

35. Indian beam line in Japan

Indian scientists have been seeking access to beam lines in synchrotron facilities. They have been accessing such facilities through global competition. Although the Indus 2 facility is currently operational with 2.5 GeV range, there have been shortages of access to the facility on account of the stability of the beam. A decision was taken to build Indian beam line in the facility in Japan with same specifications as the Indus 2 and increase access of Indian scientist to the global facility. DST has now hired an exclusive beam line for Indian scientists in the synchrotron facilities in Japan. The facility is fully operational. Indian post doctoral fellows have been appointed. Access to the facility is currently being managed by SINP.

36. Beamlines in Petra III

While the access to Synchrotron in Japan provides access to 2nd generation 2.5 GeV facilities, for material sciences access to next generation facility with different beam line energies would be necessary. DESEY Petra III facility is considered one of the top end facilities in the world. After extensive negotiations, India has been able to arrive at an attractive deal. Access to total of 15 beam lines of widely differing energy levels has been gained a period of 5 years. The total access to the Petra III facility would amount of 1.3 beam line for the whole year. A national user meeting has been organized. Total of about 250-300 users have already been identified. This facility will open up access to advanced global facilities for Indian scientists.

37. Devasthal Telescope

A National facility of 3.6 meter class optical telescope is being established at ARIES, Nanital at a cost of Rs 180 crores. This facility will be the most powerful telescope in Asia in this class of telescope. In the establishment of the telescope, collaboration has been obtained from Belgium which has contributed 2 million Euro. Telescope has been designed indigenously and reviewed by an Expert team at several stages. Commissioning of the facility is expected to be completed by 2012.

38. Thirty Meter Telescope (TMT)

Currently there are three parallel efforts to build extremely large optical telescopes in the world. In view of the relatively advanced status of India in the field of astronomy and astrophysics, all three major consortia have approached India for the technical and financial participation. DST constituted a national advisory committee under the Chair of Dr Kasthurirangan and with Dr J Narlikar, Dr Govind Swarup and Dr T Padamanabhan as members. After extensive national consultation, it was decided that it was in the national interest to join the 5-member consortium involved in the establishment of Thirty Meter Telescope in Hawaii as an observer. IIA was commissioned to prepare A Detailed Project Report, which was discussed further at the national level committee. India has now joined TMT as an observer. India derives the advantage of being able to gain access to technology for adaptive optics and show case strength in designing and fabricating segmented mirrors. Apart from the access to technology in areas with strategic interest, astronomers from India would gain observational time proportional to the financial investments made by the country. India is expected to finalise decisions and confirm participation by May 2012.

39. Center-State Technology partnership

The Government of India has initiated a special mechanism for linking State Center partnership in several areas. Annual conferences of chief secretaries of states are being held in the first week of February. In these annual conferences a session is specifically scheduled to show case technology assets created and available with various institutions under the administrative control of ministries in the central sector. New mechanisms have been developed for promoting state centre technology partnerships. The Department of Science and Technology has taken measures to strengthen the State Science and Technology council mechanism for the promotion of outreach of technology assets available with central sector. State specific technology deployment plans are being developed under the emerging state-centre technology partnerships. DST is spearheading the development of such plans as well as in the implementation of technology deployment plans. Preparation of state specific technology deployment plans for Kerala and Tripura has already been initiated.

40. Technology portal and Compendium

Technology compendium and a live technology portal have been launched. Technology assets available with various departments of sciences have been compiled into a compendium and a live portal which could be continuously updated has been designed, developed and launched. These data bases make it possible for states to select specific technologies of interest to serve the public and social good and implement the use of technologies. Special funding mechanisms are being developed during the 12th plan period for supporting the proof of benefits of applications of technologies to various state governments. It is hoped that the continuously updatable data base would create hitherto untapped opportunities for applications of technologies emanating from public funded research.

41. Science, Technology and Innovation policy

Science and Technology policy enunciated in 2003 by the Government of India has now been revised to include the innovation component of national policy of science and technology sector. The policy has been drafted and is ready for national consultation and adoption by the Government of India.

Indian science vision has been promulgated by the Scientific Advisory Council to the Prime Minister. There is now growing aspiration in the national science and Technology sector to seek global eminence and leadership in some select areas. India offers also an opportunity to gain niche status in development of affordable innovations for serving national and global good. Science Technology and Innovation policy of the country will convey the national posture and position. It is expected that the new policy will pave a new path forward.

42. Promotion of PPP for R&D and Clean Energy

The Prime Minister's council for Trade and Industry has constituted total of five sub committees for developing concept and white papers. One of the subcommittees has addressed specifically issues concerning the promotion of Private Public Partnership for R&D and Clean Energy. DST has played the role of convenor to this sub committee. The Sub committee has made some specific recommendations and new paradigms for promotion of academy-research-industry partnerships. Some of the key recommendations are listed here.

1. **To Develop a holistic approach to funding socially relevant projects**
    - Institute a new policy paradigm to treat the entire domain of R&D for public and social good in the public and private sector as connected for Governmental grants
    - To launch schemes to support R&D consortia in five major research areas viz. agriculture and food security, water, affordable health care and clean energy
2. **Enhance public funding of R&D and Improve policy environment to private sector engagement into R&D**
    - To deploy technology cess funds to catalyse PPP
    - To improve financial audit system to suit R&D
    - Undertake a world class R&D cluster
    - Create a competitive grant system of Rs 1000 crores for R&D in private sector
    - Establish a PPP fund of Rs 5000 crore
    - Implement a mission for affordable innovations
    - Make public investments into private sector venture funds for R&D and innovations
    - Leverage National Science and Engineering Research Board for servicing the programmes launched under PPP

- Create a regulatory and policy environment to support application of indigenous R&D

3. **Broaden the horizon to facilitate the interactions of R&D professionals**
    - Reward systems for professionals for commercialization of patents
    - Mobility of R&D professionals between public and privates sector R&D
    - Encourage scientists in public sector in entrepreneurship with seed/ commercialization grants
    - Encourage scientists in public domain to focus on patentability
    - Encourage private sector to create R&D related jobs
4. **Implement multiple mechanisms to encourage PPP**
    - Establish Technology observatory under PPP
    - Provide for 1:1 investment of public and private funds for
        - Clinical trials
        - Capacity building
        - Challenge awards
        - Leverage PPP for reduction of subsidy burden
        - Develop new relationship based model
        - Set up joint centres in clean energy with global alliances
        - Strengthen ongoing alliances in PPP
5. **Proposed next steps**
    - Commission a scoping study of best global models
    - Convert the sub-committee into standing apex board for dynamically revising parameters

They have been accepted by the Prime Minister's council on Trade and Industry already. Implementation measures are underway.

43. <u>Drug and Pharma Research Programme for Neglected diseases</u>

Drug and Pharma Research Programme is an initiative to promote research and development in a nationally important area. The scheme was originally initiated with a fund of the size Rs. 150 crores. Interest accrued from the fund was deployed to promote R&D in drug and pharma sector. On account of the need and demand, the scheme was converted into one with annual budget allocation. Several Public Private Partnerships have been promoted in R&D for Drug and Pharma sector under the scheme. Total of 14 national facilities in public funded research institutions by way of grants and 23 projects under PPP model through soft loan have been promoted. In order to promote research in the development of drug discovery for treating neglected diseases like Kalaazar, Malaria, etc., cabinet approval for providing grant to private sector R&D was obtained. The scheme has led to total of 9 molecules under different phases of clinical trials. Three, four and two drugs are under first, second and third phase clinical trials currently based on the support extended under the scheme.

44. Facility for Anti proton and Ion Research

A policy decision has been taken at the highest level that India could join an international consortium in building Facility for Anti-proton and Ion Research. India after due processes has joined the 13-member research consortium as a full member and agreed to participate through an investment of 36 million Euros with 27 million Euro worth of contributions in kind. Components of interest to India for designing and fabricating for contributing in–kind have been identified. Cash contribution of 9 million Euro has already been made. Project Director has been appointed and Bose Institute has been named the implementing organization. This National project is being implemented jointly between the Department of Atomic Energy and Department of Science and Technology. The Department plans to support research in nuclear and accelerator physics in the university sector as a part of FAIR initiative.

45. Grand Alliance Initiative with MHRD

The benefits of synergising programmes of the Ministry of Science and Technology with those of Ministry of Human Resource Development in areas of research and development have long been felt. There has been no institutional mechanism for such collaborative effort between the two ministries. Grand Alliance Initiative has now been formulated between the two ministries and formal MoU signed. A joint council has now been formed under the co-chairs of the two ministers. Understanding for joint funding, joint appointments, rejuvenation of research in the university sector etc has been developed under Grand Alliance Initiative.

46. Vetting Images and Geospatial Information for Licensing

Many service providers display aerial and satellite imageries of locations and facilities within Indian boundaries compromising national security and sensitivity considerations. This has been a matter of grave concern to the country. The Department has been directed to draft a bill which will protect the national security and prevent the service providers from displaying in public domain areas with national sensitivity. The Department has now proposed a licensing process after vetting images and Geospatial Information for sensitivity to national security matters. A bill for "Vetting Images and Geospatial Information for Licensing" (VIGIL) for National Security has been drafted and submitted for approval.

47. Modified Flexible Complementing Scheme

Schemes for career advancement of scientists and engineers engaged in management of science have remained a subject of discussion among the policy bodies. Administration of science differs in texture and content from administration of justice, law and order and finance. A special breed of scientists and engineers are required for administration and management of science. The Government has introduced a scheme called "Flexible Complementing Scheme for providing of in situ promotion to administrators and managers of science. The scheme has been challenged by non-science related administrative groups. The Department has now been assigned the task to review the scheme and modify the scheme introducing rigor in implementation. The Department in consultation with other science departments prepared a modified Flexible Complementing Scheme. The DoPT has now obtained ACC approval for implementing the scheme under modified parameters.

48. Institute for Advanced Studies and Science and Technology

The Government of India under Assam accord had agreed to assume responsibilities to provide funds and administrative governance for the Institute for Advanced Studies and Science and Technology, Guwahati. The Department of Science and Technology has now discharged the responsibility by taking over IASST as Grant-in-Aid institution of Government of India. IASST is now provided annual grant for R&D and management support. Efforts are underway to streamline administrative governance and focus research and development activities in some lead areas.

49. National Innovation Fund

A National Innovation Fund has been created by the Department of Science and Technology. This is a fund created jointly with NASSCOM, ICICI Knowledge Park and Bharati Airtel. The fund size is Rs 48 crores. The focus of the fund is investment into start-up companies owning Intellectual Properties. Sectors identified for support are a) pharma, b) auto infotronics, c) telecom, d) medical devices and e) intelligent transport system

50. National Centre for Himalayan Glaciology

The Department of Science and Technology was assigned the task of establishing National Centre for Himalayan Glaciology. Himalayan glaciers playing a critical role in the water cycle of Indian subcontinent, scientific assessment and understanding of processes leading to glaciations in the Himalayan region have gained paramount importance. A National nodal centre for Himalayan Glaciology has been established at Wadia Institute for Himalayan Geology. Efforts are underway to establish National institute in Uttarakhand with regional centres in Himachal Pradesh, Sikkim and Jammu and Kashmir. Establishment of National Centre for Himalayan Glaciology is now a part of the National Mission for Sustaining Himalayan Ecosystem under National Action Plan for Climate Change.

51. National Centre for Molecular Materials

The Department has gained the approval of the cabinet for establishment of National Centre for Molecular Materials at Thiruvananthapuram. All Governmental processes have been completed. Processes for registration of the society and gaining land allocations from the state Government are underway.

52. Institute for Nano Science and Technology

The Government has approved the establishment of Institute for Nano Science and Technology in Mohali. Land of 30 acres has been obtained. This institute is being co-located with Indian Institute of Science Education and Research, Mohali. A society has been formed and the necessary approvals for creation of posts and Director have been obtained. The institute is expected to start functioning soon.

53. North East Centre for Technology Applications and Reach

The Ministry of Science and Technology made a commitment to the states in the North East Region in 2009, that a nodal centre for technology outreach would be established in the NER. State-Centre Technology partnerships are being built as a strategic process following discussions at Annual Conference of the Chief Secretaries of various State Governments. Taking into account of the one of the objectives of the Government of India to main stream developmental processes in North Eastern Region, the Department of Science and Technology has developed a proposal to establish a North East Centre for Technology Application and Reach (NECTAR). The proposal is currently under processing. The proposed centre would strive to connect technology assets emanating from various scientific departments and their institutions to the developmental processes of state Governments of the North East Region.

54. Building Educators for Science Teaching

The Ministry of Science and Technology has entered into a MoU with Ministry of Human Resource Development and launched a Grand Alliance Initiative. Under the initiative, a proposal is being mooted to launch a programme for motivating teachers engaged in primary and secondary school as well as tertiary education in teaching of science. Scientific Advisory Council to PM has proposed a National Mission on Teaching and Teachers. Building Educators for Science Teaching (BEST) is one of the major programmes being envisaged by the Department of Science and Technology for the 12th plan initiative. It is proposed to develop a pilot programme during the current financial year.

Annexure 2

Salient Findings and Recommendations of the Professor Kalyan Sinha Committee

1. FIST - Impact Analysis

1.1 Summary

There is a marginal increase in recruitment at all levels, viz, teaching assistant, lecturers, readers and professors. The most significant increase was at the level of lecturers in universities. Also this was more prominent in life sciences, physical sciences and chemical sciences.

Substantial increase was observed in the number of research publications in SCI journals and books (taken together) as well as non SCI journals and conference proceedings (taken together) in respect of life sciences, physical sciences, chemical sciences and engineering technology in the post FIST period. However, no such appreciable increase was seen in earth sciences and mathematical sciences, possibly because of the very small number of responding beneficiaries in these disciplines.

An absolute increase was observed in the number of lectures given in each of the categories “plenary”, “invited” and “contributed”. This was true across all disciplines. The increase in the number of “Invited Lectures” for the post-FIST period was statistically significant in all the subjects except Earth Sciences and Mathematical Sciences. The increase was not statistically significant for “Plenary Lectures” in any of the subjects while for the “Contributed Papers” category the increase was statistically significant only for Life Sciences, Engineering & Technology and Earth Sciences.

The number of students enrolled in the M Tech programme in engineering and technology was higher in the post-FIST grant period in comparison to the pre-FIST period. There was no significant change in MSc. and MPhil enrolment across all the six disciplines. On the other hand, there is an appreciable increase in the number of students enrolled for PhD. in life sciences, physical sciences and chemical sciences.

For most of the courses and in all subjects, there does not seem to be any appreciable change in the number of degrees granted in the post-FIST period in comparison to the pre-FIST period. There was, however, statistically significant increase in the number of M.Sc. and Ph.D. degrees granted in Life sciences.

Marginal increase in the number of students qualifying for NET and GATE examinations in the post-FIST period in Life Sciences, Physical Sciences and Chemical Sciences was observed.

The quantum of FIST grant used for purchase of books is highest in Earth Sciences. Also, for Earth Sciences, almost two-thirds of the total expenditure on books bought for the Library is from FIST grants.

For Chemical Sciences the expenditure on books for Library was almost equally divided between FIST and non-FIST grants.

The amount of FIST grants used for purchase of Laboratory equipment in “Life Sciences”, “Physical Sciences” and “Engineering Sciences” was approximately one-third of the amounts spent by the relevant departments on laboratory equipment using other sources, while for “Chemical Sciences” it was slightly more than half. The situation was re- versed for “Earth Sciences” and “Mathematical Sciences” where the FIST grant expenditure for laboratory equipment was roughly double that of expenses on laboratory equipment from other sources.

There was a significant increase (more than double) in the number of users from industry who made use of the Laboratory/Library resources in Engineering departments which were purchased using FIST grants while only a marginal increase was seen in “Chemical Sciences”.

The number of users from research institutes who used Laboratory/Library resources in engineering departments doubled in the post-FIST period. In “Life Sciences” there was a marginal increase in the number of users in this category. In “Chemical Sciences” this number remained more or less the same.

All disciplines showed a marginal increase in the number of users from Universities who used the infrastructure purchased using FIST grants.

The equipments purchased from FIST grants were in use for most of the time in most of the departments. In almost half the responding departments the down-time of the equipments was reported to be zero.

There was a significant increase in the funding received from sources other than FIST in “Engineering Sciences” and “Physical Sciences” and a decrease in “Life Sciences” in the post-FIST period.

The number of projects undertaken was substantial only in “Life Sciences”, “Chemical Sciences” and “Engineering Sciences”. The majority of projects were of duration “1-3 years”.

In “Life Sciences” and “Chemical Sciences”, the majority of projects undertaken were using equipment purchased from FIST grants while in “Engineering Sciences” the majority of projects undertaken did not use equipment purchased from FIST grants.

Only the “Engineering departments” were generating funds via industrial consultations. The amount generated showed more than 3-fold increase in the post-FIST period compared to the pre-FIST one.

Most of the respondents gave a high rank to the FIST scheme.

Annexure 3

Major Highlights of the Nano Mission

Capacity-building in this upcoming area of research is of utmost importance for the Nano Mission so that India emerges as a global knowledge-hub in this field also. For this, research on fundamental aspects on Nano Science and training of large number of manpower are receiving prime attention. The Nano Mission is also making efforts towards development of products and processes for national development, especially in areas of national relevance like safe drinking water, materials development, drug delivery, etc. For this, it is forging linkages between educational and research institutions and industry and promoting Public-Private-Partnership. The Nano Mission is also synergizing the efforts being made by various agencies towards promoting Nano Science and Technology. International collaborations are also being entered into, wherever required. Major highlights of activities from the NSTI and the Nano Mission are summarized below:

1. Infrastructural Facilities

- ❖ A dedicated Institute of Nano Science & Technology at Mohali.
- ❖ An Ultra High Resolution Aberration-Corrected Transmission Electron Microscope costing Rs. 32.62 Crores at the International Centre for Materials Science, JNCASR, Bangalore as a National Facility.
- ❖ Established 3 Accelerator-based Research Facilities at IIT-Kanpur, Kurukshetra University, Kurukshetra, and University of Allahabad, Allahabad.
- ❖ Set up 12 Units/Core Groups on Nano Science having sophisticated state-of-the-art facilities across the country.
- ❖ Apart from specific application focussed Seven Centres for Nano Technology, a Centre of Excellence on Computational Materials Science at the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bangalore.
- ❖ Established an India-Japan beam-line at the Photon Factory, KEK, Tsukuba, Japan. Access to all the beam-lines at the PETRA-III Synchrotron Radiation Facility and FLASH facility at DESY, Hamburg, Germany is expected to be funded shortly.

2. Other activities

- ❖ In order to utilize the existing expertise in research and educational institutions towards developing products and processes of direct interest to industries, Nano Mission has promoted Joint Institution-Industry Linked Projects. In many of these activities, the industrial partners have also invested financially into the projects. These activities will help us to simultaneously leverage the scientific knowledge-base existing in our research and educational institutions and the commercial vision of our industry to generate competitive technologies leading to products and devices. Six such projects have received financial support so far for work related to Nano fillers for tyre application, nano-textiles, nano materials, drug delivery, etc.

- Post Graduate Programmes (M.Sc/M.Tech.) in 16 Institutions/Universities across the country.
- Institution of attractive Post-Doctoral fellowships through Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bangalore.
- Funding of around 235 individual scientist-centric research projects on fundamental scientific aspects of Nano scale systems.
- Support to International/National Conferences, Seminars, Workshops etc. extended.
- The process of laying down a Regulatory Framework for Nanotechnology in India has been initiated in consultation with concerned Ministries.

Annexure 4

Key recommendations emerging from various discussions: Stake Holder Priorities and Perceptions

The Stakeholders of Department of Science and Technology are:

- Government
- Scientific Institutions
- Educational Institutions and Universities
- Indian Institutes of Technology
- Autonomous Institutions funded by DST
- States and State Councils for Science and Technology
- Industry
- Private Entrepreneurship
- Non-Government Organizations

DST is seen as a funding agency with a significant national share in Extra Mural Research Funding in non-strategic sector. DST is valued by the scientific community for its robustness decision fairness. The stakeholders' aspirations from DST desire speed in functions and delivery.

1. Aspirations of the stakeholders

Several consultation meetings were held between the Department and representatives of different stakeholders and their aspirations were captured. An elaborate process was adopted in securing inputs from various stakeholders. The open strategic document was posted on the web site and suggestions from the stakeholders were solicited. Finally all the key aspirational recommendations of the various stakeholders are listed here:

- Proactive step for bridging the gross asymmetries in the S&T strengths of different states in the country.
- Strengthening of State S&T council, mechanisms for delivering science to the people and leveraging their strength in implementation of national and state level S&T programmes.
- Enhancing the Technology profile of DST in promotion of design and innovations and technologies for manufacturing.
- Open-ended research promoted by DST in diverse areas is a good policy and needs to be continued.
- Nurturing every bright spot wherever available and Preservation of the time tested peer review system of Programme Advisory Committees/Science Engineering Research Council.

- Some of the fundamental research could be "oriented fundamental research" aiming at solving some national problems like TB, water, energy, etc.
- A special drive for promotion of drug discovery.
- Enhancement of instrumentation capabilities in non-strategic sectors; start high tech projects like synchrotron in the non-strategic sector with the help of the strategic sector.
- Continued promotion of research in areas where other S&T Departments are not engaged.
- Some duplication in R&D efforts by various departments is not only unavoidable but also desirable." Deliberate and conscious duplication " is essential and it is inherent part of the R&D process and DST should remain a promotional agency for research in all areas of science, technology and innovation in all S&T areas.
- Strengthening of Technical /scientific monitoring mechanism of funded projects and a network –centric approach and hosting of the project completion reports on the website.
- Science academies could be leveraged for policy formulation and even implementation of specific programmes.
- Increase in the number of socially relevant mission mode projects like the ones on potash project and the solar energy programme initiated by DST should be.
- Creation of a network of institutions based in rural areas to reach the fruits of S&T to the people.
- Research in important developmental areas like water, food, health care etc. should aim at the best possible technologies for solving problems and synergizing the R&D strengths available in the country.
- Building human capacity, both in numbers and quality, is of utmost importance. Institutions in the country at large should be involved in this exercise. Mentoring also play a very important role. One could launch a mentoring programme for under graduate students in engineering.
- Building leadership in science and technology is an important priority.
- Improvement in R&D infrastructure is required. Industry could be leveraged by starting PPP labs inside industries. Industry could also create widespread instrumentation and diagnostic facilities.
- Policy advocacy for increasing the R&D expenditure to 2% of GDP and for increasing the investments of the private sector from the present 25% to at least 50%.
- New PPP models for promotion of research and development are required.

- S&T also needed to show up as a distinct element in the contribution to the rise of GDP.
- Leveraging well designed global partnerships in R&D and encouraging measures for fostering innovation ecosystem, entrepreneurship and venture capital culture.
- Industry and government are need to work together to improve the eco-system for R&D inside the industry.
- Our engagement with the third world needs further push. The least –developed countries in the third World looked up to India for their S&T empowerment.
- Inputs to changes in governance structure of S&T systems in the country.
- For creating newer demands on S&T, one could go to the Panchayat level. One could have a Standing Committee on S&T in Panchayat Raj Institutions.
- Enabling individual innovations to solve grass roots problems should be continued and efforts should be made to bring such people to the centre stage. Attempt should be made to create institutional structure around such innovators. The innovation policy should focus on radical innovations.

2. Priorities

The Department of Science and Technology, after consultations with its stakeholders and assessing its own weaknesses and strengths, has identified the following priorities for the Strategic Plan for the 12th Five years Plan;

- To Stimulate the private sector engagement into R&D through various policy initiatives and developing new PPP models for the promotion of research
- To rejuvenate research in universities for increasing their share of scientific publications in SCI journals to 50% by 2020
- To Set- up a number of test beds for convergent technology solutions to water related challenges, energy and agriculture related problems
- To mount a mission for biomedical devices and instrumentation for increasing access of biomedical technology products to people
- To improve attraction of talent to careers with research and expanding the base of Full Time Equivalent R&D Professionals by 25% from its current levels within the next five years
- To position programmes for orienting main stream basic research the national priorities in the R&D on food and nutrition security,

affordable health care, energy and environment security, home land security and sustainable water supply

- To position better instruments and delivery mechanisms for outreach of technologies for civil society needs from non-strategic and strategic R&D sector
- To establish systems for building both institutional and human capacities for a sustainable leadership pipeline for the S&T sector
- To formulate policies and programmes for promoting innovation ecosystem
- To improve significantly the international competitiveness of the Indian R&D sector from its current levels
- To develop suitable measurement indicators to measure the contribution of S&T to GDP of the country.
- To double the levels of International S&T Cooperation and promote strategic international alliances in areas of mutual interest
- To position programmes for increasing the participation of women in science and overcome the leaky pipelines through promotional measures such that the share of women investigators in Extra Mural Research increases by 35% from the current level within 5 years
- To strengthen state-center technology partnerships in at least five states through planned interventions to connect technology deployment with per-capita income of select districts
- To position socially oriented interventions for rural and weaker sections of the country and establish systems to measure the social outcome of such interventions

Annexure 5

Review of the ongoing programmes of DST and suggested some revisions and modifications

The Sub-Groups have recommended for continuation of all on-going programmes/schemes with the following suggestions/modifications for improving their performance.

Table 3 Sub-Groups - Review

Sub-Group	Review of Ongoing programmes
Sub-Group I **for Formulation of policies relating to Science and Technology**	• **Need for a vibrant Science, Technology and Innovation Policy of India.** • **Strengthening of innovation ecosystem**
Sub-Group II **for** **Strengthening Basic research and Expanding R&D base** **-Human Capacity**	**The Sub-Groups have recommended for continuation of the following on-going schemes:** ❖ **Individual Scientist centric R&D Projects (SERC Projects)** ❖ **Core Groups /Nationally Co-ordinated Programmes (IRPHA)** ❖ **BOYSCAST Scheme** ❖ **Swarnajayanti Fellowships** ❖ **Ramanna Fellowships** ❖ **J C Bose Fellowships** ❖ **Ramanujan Fellowships** ❖ **Seminar Symposia Scheme** ❖ **International Travel Support Scheme** ❖ **INSPIRE Scheme** ❖ **Nano Mission** ❖ **Cognitive Science Research Initiative Mega Facilities for Basic Research** ❖ **Training Programmes** **The following three existing schemes may be reinvented in a modified form as per suggestions made by the Sub-Group contained in Chapter 8 of the Report during the 12th Plan to make them even more**

	effective and fruitful ❖ **Fast Track Scheme for Young Scientists** ❖ **Women scientists Schemes** ❖ **SERC Schools** **Suggestions;** ❖ **Operation of highly stabilized schemes of DST should be entrusted to Special Purpose Vehicles like Science and Engineering Research Board or outsourced to other institutions and research organizations enjoying sufficient functional autonomy and a long term financial and administrative decision making set-up.** ❖ **IT Tools must be effectively utilized for managing these schemes at the earliest to curtail turn-around time for approval and sanction.** ❖ **It may be useful to grant a total amount of manpower and the choice of research personnel to be employed may be left to the PI and the grantee institution.** ❖ **Five Autonomous institutions of DST have been doing very good work in basic research and must be enabled to further strengthen their profiles.**
Sub-Group III **for** **Strengthening Basic research and Expanding R&D base** **-Institutional Capacity**	**The Following successful programmes/schemes have been recommended for continuation during 12th Plan:** ❖ **FIST** ❖ **PURSE** ❖ **CURIE** ❖ **SAIF** ❖ **Special Programme for region or State like North East Region, J&K and Bihar** ❖ **Mission Mode Programmes** ❖ **Solar energy research initiative** ❖ **Service providing activities like Patent Facilitating Centres** **After the review of ongoing programmes, the Sub-group has made specific recommendations that the focus of SAIF in future could be stressed on less-**

	endowed institutions and regions. **The sub-group has also made an observation that the future focus in Nano mission could involve stress on applications and technology.** **Suggestions;** ❖ **Currently, applications of scientific discoveries in solving socio economic problems and addressing national challenges are limited. Academy, research and industry partnerships are few. Public funding of research systems in the private sector is not common. Participation of states in research and development is relatively small and the deployment of technologies developed in public funded laboratories of the central government by states is also limited. It is essential to devise such policies and schemes which promote active engagement of university and private sector into R&D and states into absorption of R&D outputs and deployment of indigenous technologies.** ❖ **There is need to increase the investments into infrastructure strengthening in public funded academic institutions engaged in basic research.** ❖ **While basic research would need necessarily an input led growth path, differences in approach through output directed investment model would be required for connecting knowledge and wealth generating activities of the country.** ❖ **Current individual investigator centric models need to be expanded for consortium funding system.** ❖ **Possibilities of funding Indian basic research with other nations with control of intellectual Properties through International S&T Co-operation.** ❖ **Offer new schemes to institutions aspiring to gain listing among the top 300 universities in the world by making higher investment with changed governance structure.** ❖ **Investment in long term goal oriented basic research in national priority areas such as water, energy, affordable health care etc. as**

	well for impact making discovery research
Sub-Group IV for Implementing Technology Development Programs	**The following successful programmes have been recommended for continuation during 12th Plan:** ❖ **National Spatial Data Infrastructure (NSDI)** ❖ **Innovation Clusters** ❖ **Security Technology Initiatives** ❖ **Water Technology Initiatives** ❖ **Winning, Augmentation and Renovatio (WAR) for water programme** ❖ **Solar Energy Research Initiatives** ❖ **Climate Change Programme** ❖ **Enlargement of Drug and Pharm Research Programme** ❖ **Technology System Development Programme (TSDP)** ❖ **Instrumentation Development Programme** ❖ **National Programme on Carbon sequestration Research** ❖ **National Accreditation Board for Testing and Calibration** ❖ **Good Laboratory Practices** ❖ **Survey of India** ❖ **Advanced Centre for Powder Metallurgy and New Materials** ❖ **Agarkar Research Institute** ❖ **Shree Chita Tirunal Institute for Medical Science and Technology** **After a critical review of the work on technology development support by DST during the last twenty years, the Sub-group has observed that the existing model of support to technology-led start ups has not yielded optimum results. The Sub-group calls for a bold approach for making a difference. They suggest a Technology platform model for conversion of R&D results into commercial outcome.** **Suggestions;** ❖ **Demonstration and promotion of the use of spatial data management technologies for micro level planning under diverse terrain**

	conditions. ❖ **Establishment of critical number and carefully sized test beds for providing techno-commercial viabilities of technologies selected from technology compendium and portals to enroll the academy research partnership and develop policy support mechanisms for addressing the subsidy burden in areas like fertilizers and energy needs.** ❖ **To establish credible number of innovative technology deployment clusters in the areas like water technology and prove sustainability through appropriately developed revenue models.** ❖ **To create and establish knowledge network and institutional capacities in the areas like climate change and clean energy.** ❖ **To promote R&D in areas like Drug and Pharmaceuticals and biomaterial devices and technologies for affordable health care.** ❖ **Technology development will need to have a recipient industry with the appropriate "Go to market "strategy for realization of its value.**
Sub-Group V **for** **Societal interventions of S&T**	**The following Programmes/Schemes have been recommended for continuation during 12th Plan:** ❖ **Science and Society Programmes** ❖ **Science and Technology for Women** ❖ **Scheduled Cast Sub-Plan** ❖ **Tribal Sub-Plan** **After a review of the ongoing programmes, the sub-group has observed that a focus on scaleable innovations leading to social and financial impact in rural areas is necessary in future programmes. The sub-group suggests prioritization on taking prototypes to market and technology solutions for large scale dissemination.** **Suggestions for Social approaches;** ❖ **To provide healthcare facilities in the villages-telemedicine technology, integration for rural health practitioners, diagnostic tools** ❖ **Drinking water : Potential for use of herbs for**

	purification ❖ To encourage innovation and entrepreneurship: Leveraging grassroot innovations documented by NIF. ❖ Creating market for rural products like Vyapar sewa portal.
Sub-group VI for S&T co-operation / Partnerships and Alliances	The Sub-Groups have recommended for continuation of all on-going programmes/schemes. The sub-group observes that the number and size of R&D projects under Public-Private Partnership models are low and prevailing situation does not promote viable partnerships and emergence of an innovation ecosystem. Suggestions; ❖ Both bilateral and multilateral co-operation needs to be selective, output oriented and driven strategically. ❖ Develop holistic approach to funding socially relevant R&D in India in both private and public sectors as one continuum. ❖ Strengthen ongoing alliance initiative in PPP on R&D and clean energy both on national and international levels. ❖ Expand the Technology Business Incubator (TBI) network substantially in the country through competitive support model, participation of State Governments and appropriate Public-Public and Public-Private partnerships ❖ Innovation clusters could be scaled up in consultation with the National Innovation Council. ❖ Strengthen various State S&T Councils ❖ Provide adequate fund for the PAN-INDIA programs in DST that can be taken up jointly in key sectors along with other ministries/departments under the STACs. ❖ Strengthen existing institutions, field groups, science based voluntary organizations, etc. involved in research and application of grass root innovative S&T solutions.

Annexure 6

Formation of Working Group: The composition and the Terms of Reference

The Steering Committee on Science and Technology for the formulation of Twelfth Five Year Plan in its first meeting held on 5th April, 2011 under the Chairmanship of Dr. K. Kasturirangan, Member (Science) decided to constitute a number of Working Groups and Task Forces to comprehensively address various tasks assigned to the Steering Committee. The Planning Commission then constituted Working Groups for various S&T sectors and Ministries/Departments. It has been decided to constitute a '**Working Group for the Department of Science and Technology'** under the Chairmanship of Dr. T. Ramasami, Secretary, DST with Sh. Neeraj Sharma, Advisor, DST as Member Secretary. The composition and Terms of Reference of the Working Group are as under:

Table 4 Composition of the Working Group

Sr. No.	Name & Designation	
1.	**Dr. T. Ramasami, Secretary, DST**	**Chairman**
2.	Dr. Ajay K Sood President Indian Academy of Sciences Bangalore-560 080	**Member**
3.	Dr. M. Barma, Director Tata Institute of Fundamental Research Mumbai-400 005	**Member**
4.	Prof. P. Balaram Director Indian Institute of Science Bangalore - 560 012	**Member**
5.	Dr. E. D. Jemmis, Director Indian Institute of Science Education and Research Thiruvananthapuram - 695 016	**Member**
6.	Prof. Dinesh Singh Vice Chancellor, Delhi University Delhi-110 007	**Member**
7.	Ms. Naina Lal Kidwai Chairperson, HSBC, New Delhi	**Member**

8.	Mrs. Chanda Kochhar Managing Director & CEO ICICI Bank Ltd. ICICI Bank Towers, Mumbai	**Member**
9.	Dr. C.V. Natraj 120, Adarsh Vista Basavanagara Bangalore-560037	**Member**
10.	Prof. Mihir Kanti Chaudhuri Vice-Chancellor Tezpur University, Sonitpur, Napaam, Assam -784028	**Member**
11.	Professor Devang V. Khakhar Director Indian Institute of Technology Powai, Mumbai-400 076	**Member**
12.	Prof. L S Shashidhara Professor and Coordinator, Biology Indian Institute of Science Education and Research (IISER), Pune-411 021	**Member**
13.	Prof. Indranil Manna, Director Central Glass and Ceramic Research Institute 196 Raja S C Mullick Road, Kolkata-700 032	**Member**
14.	Dr. Bimal K Roy Director Indian Statistical Institute 203 Barrackpore Trunk Road, Kolkata – 700 108	**Member**
15.	Prof. Govind Swarup National Centre for Radio Astrophysics (NCRA) Pune University Campus, Post Bag 3,	**Member**

	Ganeshkhind P.O., Pune 411 007	
16.	Mr. K. Ahmed Indian Institute of Entrepreneurship Guwahati-29	**Member**
17.	Dr. Ashok Jhunjhunwala Department of Electrical Engineering IIT Madras Chennai - 600 036	**Member**
18.	Dr. S. Basheer Professor in IP Law National University of Juridical Sciences Kolkata – 700 098	**Member**
19	Prof. Milan K Sanyal Director Saha Institute of Nuclear Physics Sector 1, BLOCK-'AF', Bidhannagar Kolkatta 64	**Member**
20.	Shri Chandrashekhar Dasgupta Distinguished Fellow The Energy Research Institute (TERI), India Habitat Centre, Lodi Road, New Delhi-110003	**Member**
21	Dr. Neelima Jerath, Executive Director Punjab State Council for Science & Sacred Heart School, Sector-26 Chandigarh-29	**Member**
22.	Mr. Kiran Karnik Former President, NASSCOM Q2A, Hauz Khas Enclave, New Delhi-16	**Member**
23.	Dr. B. Purnaiah Head, International Studies Division, Department of Atomic Energy Anushakti Bhawan, CSM Marg,	**Member**

	Mumbai- 400 001	
24.	Dr. Anil K. Gupta Director Wadia Institute of Himalayan Geology, 33 GMS Road, Dehradun – 248 001	**Member**
25.	Sh. B Muthuraman President Confederation of Indian Industry, CII Headquarters, New Delhi-110003	**Member**
26	Mr. Harsh Mariwala, President Federation of Indian Chamber of Commerce and Industries (FICCI), New Delhi-110 001	**Member**
27	Mr. Dilip Modi, President The Associated Chambers of Commerce and Industry of India, ASSOCHAM Corporate Office, Kailash Colony, New Delhi – 110 048	**Member**
28.	Sh. A.K. Verma, Adviser (S&T), Planning Commission or his Nominee Yojana Bhavan, Sansad Marg, New Delhi 110001	**Member**
29.	Financial Advisor, DST	**Member**
30.	Sh. Neeraj Sharma, Adviser, DST	**Member Secretary**

Terms of Reference

- To review and assess the performance and role of the Department at the end of the Eleventh Five Year Plan, Identify priorities of the Department for the Twelfth Five Year Plan and suggest measures including policy initiatives for enabling India to emerge as a major global technological power by 2025.
- To suggest plan programmes for the Department by adopting a ZBB approach and keeping in view the priorities and goals for the Twelfth Five Year Plan as well as the agenda for the Decade of Innovations during 2010-20.

- To define deliverables as well as goals for the Department for the Twelfth Five Year Plan period as well as Annual Plans, both in terms of tangible and non-tangible outputs and formulate guidelines for deployment of resources for relating inputs to the specified goals.
- To suggest an optimum outlay for the Department, comprising of the on-going commitment and new programmes proposed to be undertaken.
- The Chairman may co-opt any other member.
- The expenditure towards TA/DA in connection with the meetings of this Working Group in respect of Official Members would be borne by their respective Ministries/Department of Science and Technology, as admissible to class-I officers of the Government of India.
- The report of the working Group would be submitted to the Steering Committee on the S&T for the formulation of Twelfth Five Year Plan by 15th July, 2011.

In this regard, the first meeting of the Working Group to discuss 12th Five Year Plan of the DST was held on 10th May, 2011 under the Chairmanship of the Secretary, DST. Secretary, DST welcomed the members of the Working Group and explained the purpose and objectives of the meeting. The Secretary outlined six objectives and functions of the Department, viz. (i) Policy Formulation, (ii) Strengthening Human Capacity in R& D, (iii) Strengthening Institutional Capacity in R&D, (iv) Technology Development Programmes, (v) Societal Intervention of S&T, and (vi) Co-operation/Partnerships & Alliances. Secretary also briefly talked about and instrument called the Results Framework Document (RFD) through which the Department's performance is being monitored by the Cabinet Secretariat. With this brief introduction, Secretary then requested, Sh. Neeraj Sharma, Advisor, DST to introduce the approach plan of the Department for preparing 12th Plan programmes. Sh. Sharma presented some of the 11th Plan programmes, objectives and functions and highlighted the approach for the 12th Plan programmes. He also highlighted the key aspirations of the stakeholders, prospective key deliverables and broad budget proposals for the Department for the 12th Plan period.

The Working Group further divided the work of developing the Department's 12th Plan proposal among six Sub-Groups, one for each of the six activities and functions mentioned above.

Annexure 7

Formation of Sub-Groups of the Working Group: The composition and the Terms of Reference

In the first meeting of the Working Group for the Department of Science and Technology to discuss 12th Five Year Plan of the DST held on 10th May, 2011 at Technology Bhawan, New Delhi under the Chairmanship of the Secretary, DST, it was decided vide O.M No. 1/2/2011-PC dated 06-06-2011 to constitute the following sub-groups to examine contents of the Plan Document and submit its report to the Working Group for its consideration within six weeks:

Table 5 Working Group

Sr. No.	Objectives of the Sub-groups	Chairman	Convenor
1	Formulation of policies relating to Science and Technology	Prof. Milan K Sanyal	Dr. Akhilesh Gupta
2	Strengthening Basic research and Expanding R&D base -Human Capacity	Prof. P. Balaram	Dr. Praveer Asthana
3	Strengthening Basic research and Expanding R&D base -Institutional Capacity	Prof. Mihir Kanti Chaudhuri	Dr.A.Mukhopadhyaya
4	Implementing Technology Development Programs	Dr. C.V. Natraj	Dr. G. J. Samathanam
5	Societal interventions of S&T	Prof. Ashok Jhunjhunwala	Dr. Vinita Sharma
6	S&T co-operation / Partnerships and Alliances	Dr. B. Purnaiah	Dr. Arabinda Mitra

Accordingly, the composition of the six subgroups based on the objectives of the Department along with the terms and conditions are as under:-

1. **Formulation of policies relating to Science and Technology**

   1. Prof. Milan K Sanyal (SINP, Kolkata) **Chairman**
   2. Dr. A. K. Sood (IAS, Banglore) **Member**
   3. Dr. Krishan Lal (INSA, New Delhi) **Member**
   4. Dr. Satyajit Rath (NII, New Delhi) **Member**
   5. Dr. Renu Swarup (DBT, New Delhi) **Member**

6.	Dr. V. K. Gupta (CSIR, New Delhi)	**Member**
7.	Dr. V. Bhaskar (DIPP, New Delhi)	**Member**
8.	Dr. S. Bhasheer (NUJS, Kolkata)	**Member**
9.	Dr. H. R. Bhojwani, (MHRD, New Delhi)	**Member**
10.	Dr. D. Yogeswara Rao, (IICT, Hyderabad)	**Member**
11.	Dr. Praveen Arora (DST, New Delhi)	**Member**
12.	Dr. Akhilesh Gupta (DST, New Delhi)	**Member Convener**

Terms of Reference

- To recognise policy gaps in building academy-research-industry collaborations.
- To suggest commissioning of preparation of study reports, if any.
- To enlist policy instruments suiting the aspirations of the stake holders along with inter-se priorities, if any.
- To advise policy directions for increasing the private sector investment into R&D.
- To advise policy instruments for enhancing the absorption capacity for larger investment into R&D.
- To advise measures for de-bureaucratization of science sector.
- To suggest policy instruments and framework for creation of an innovation ecosystem.
- To review quantitative deliverables proposed by the Department in the area and suggest alternative targets, if any
- Any other priorities of choice of the Committee

For the consideration of the committee

- Suggestions of possible study reports for strengthening the 12th plan proposals
- Suggestions on the timely implementation methodologies for 12th plan targets
- Suggestions of consultation processes

2. Strengthening Basic research and Expanding R&D base-Human Capacity

1.	Prof. P. Balaram (IISc Bangalore)	**Chairman**
2.	Prof. L S Shashidhara (IISER, Pune)	**Member**
3.	Prof. Devang V. Khakhar (IIT Mumbai)	**Member**
4.	Prof. Dinesh Singh (Univ. of Delhi)	**Member**
5.	Prof. G. Rangarajan (IISc, Banglore)	**Member**
6.	Dr. Sibaji Raha (Bose Institute Kolkata)	**Member**
7.	Prof. S.C. Lakhotia (BHU, Varanasi)	**Member**
8.	Dr. R. Luthra (CSIR, New Delhi)	**Member**
9.	Prof. Giridhar Madras (IISc, Banglore)	**Member**
10.	Dr. P. Prakash (UGC, New Delhi)	**Member**
11.	Dr. Pratishtha Pandey (DST, New Delhi)	**Member**
12.	Dr. Praveer Asthana (DST, New Delhi)	Member Convener

Terms of Reference

- ❖ To recognize potential areas of gaps in human capacity in the form of both quality and quantum needs.
- ❖ To examine various means of strengthening human capacity in a pragmatic time frames and suggests some possible approaches.
- ❖ To review some ongoing measures and suggest means of further strengthening useful measures.
- ❖ To suggest road map for expanding the R&D base without loss of quality.
- ❖ To suggest possible means of promoting private sector participation in capacity building for R&D in industrial sector.
- ❖ To suggest some innovative ways of building human capacity for research and development in a time bound manner.
- ❖ To review quantitative deliverables proposed by the Department in the area and suggest alternative targets, if any.
- ❖ To suggest indicative of budgetary needs for the objective.
- ❖ Any other priorities of choice of the Committee.

For the consideration of the committee

- ❖ Suggestions of possible study reports for strengthening the 12^{th} plan proposals
- ❖ Suggestions on the timely implementation methodologies for 12^{th} plan targets
- ❖ Suggestions of consultation processes

3. Strengthening Basic research and Expanding R&D base- Institutional Capacity

1. Prof. Mihir Kanti Chaudhuri (Tezpur University) **Chairman**
2. Dr. Archana Bhattacharya (IIG, Mumbai) **Member**
3. Prof. Seyed. E. Hasnain (IIT Delhi) **Member**
4. Prof. Sanjay Puri (JNU, New Delhi) **Member**
5. Prof. V. K. Singh (IISER, Bhopal) **Member**
6. Prof. Ashutosh Sharma (IIT Kanpur) **Member**
7. Prof. Manoj Mishra (Lucknow University) **Member**
8. Dr. George John (DBT, New Delhi) **Member**
9. Prof. Ranjan K Mallik (IIT Delhi) **Member**
10. Dr. Nisha Mendiratta (DST, New Delhi) **Member**
11. Dr. A. Mukhopadhyaya (DST, New Delhi) **Member Convener**

Terms of Reference

- To recognize potential areas of gaps in institutional capacity in priority research areas.
- To examine various means of strengthening institutional capacities in a pragmatic time frame and suggest some possible approaches.
- To review some ongoing measures and suggest means of further strengthening useful measures.
- To suggest road map for rejuvenation of research in university sector.
- To suggest possible means of promoting private sector participation into R&D in industrial sector.
- To suggest some innovative ways of building institutional capacity for research and development in a time bound manner.
- To review quantitative deliverables proposed by the Department in the area and suggest alternative targets, if any.
- To suggest indicative of budgetary needs for the objective.
- Any other priorities of choice of the Committee.

For the consideration of the committee

- Suggestions of possible study reports for strengthening the 12th plan proposals
- Suggestions on the timely implementation methodologies for 12th plan targets
- Suggestions of consultation processes

4. Implementing Technology Development Programs

1.	Dr. C. V. Natraj (Banglore)	**Chairman**
2.	Mr. Agnideep Mukherjee (ASSOCHAM, New Delhi)	**Member**
3.	Mr. Malikarjun Javali (CII, New Delhi)	**Member**
4.	Dr. Dipanjan Banerjee (FICCI New Delhi)	**Member**
5.	Dr A R Upadhya (NAL, Bangalore)	**Member**
6.	Dr. G. Sundararajan (ARCI, Hyderabad)	**Member**
7.	Dr. T. S. Rao (DBT, New Delhi)	**Member**
8.	Dr. Bhaskar Ramamurthi (IIT Madras)	**Member**
9.	Dr. A. K. Jindal (Tata Motors, Pune)	**Member**
10.	Mr. K Ananth Krishnan (TCS, Chennai)	**Member**
11.	Dr. Pradeep (TRDDC, Pune)	**Member**
12.	Dr. Ajay Mathur (BEE, New Delhi)	**Member**
13.	Dr. J. Gururaja (Bangalore)	**Member**
14.	Dr. P. K. Ghosh, (CSMCRI, Bhavnagar)	**Member**
15.	Dr. Shashikant Kadam, (Piramal Healthcare)	**Member**
16.	Dr. Sanjay Bajpai (DST, New Delhi)	**Member**
17.	Dr. G. J. Samathanam (DST, New Delhi)	**Member Convener**

Terms of Reference

- To scope key sectors of priorities for technology development and deployment.
- To suggest means and mechanisms for building technology partnerships among key stake holders.
- To suggest best mechanisms for promoting development of convergent technology solutions for some key challenges of India.
- To suggest some limited number of technology mission mode programmes of national importance.
- To suggest some innovative methods of selecting technology priorities complete with techniques for deriving bench marks.
- To review quantitative deliverables proposed by the Department in the area and suggest alternative targets, if any.
- To suggest indicative of budgetary needs for the objective.
- Any other priorities of choice of the committee.

For the consideration of the committee

- Suggestions of possible study reports for strengthening the 12th plan proposals
- Suggestions on the timely implementation methodologies for 12th plan targets
- Suggestions of consultation processes

5. Societal interventions of S&T

1.	Prof. Ashok Jhunjhunwala (IIT Madras)	**Chairman**
2.	Prof. Anil Gupta (NIF, Ahmedabad)	**Member**
3.	Dr. B. Mishra (NEHU, Megalaya)	**Member**
4.	Dr. P. G. Rao, (NEIST, Jorhat)	**Member**
5.	Dr. Arvind Gupta (IUCAA, Pune)	**Member**
6.	Dr. Narender K. Sehgal (Vigyan Prasar, New Delhi)	**Member**
7.	Dr. Raghunandan (CTD, New Delhi)	**Member**
8.	Shri Darshan Shankar (FRLHT, Bangalore)	**Member**
9.	Shri R. S. Hiremath (Flexitron, Bangalore)	**Member**
10.	Shri L. Kannan (Vortex Engineering, Chennai)	**Member**
11.	Ms. Suma Prashant, (RTBI, Chennai)	**Member**
12.	Ms. Bindu Ananth, (IIT-Madras Research Park, Chennai)	**Member**
13.	Ms. Ujjwala T Tirkey (DST, New Delhi)	**Member**
14.	Dr. Vinita Sharma	**Member Convener**

Terms of Reference

- To design innovative ways and means of delivering S&T needs of the target populations.
- To examine various models for developing demonstration programmes for Rural India and suggest best course models.
- To design schemes and programmes for delivering budgetary targets (5%) to the target population.
- To suggest new schemes for improving gender parity in R&D sector.
- To design and suggest schemes for R&D for women and child health.
- To review quantitative deliverables proposed by the Department in the area and suggest alternative targets, if any.

- To suggest indicative of budgetary needs for the objective.
- Any other priorities of choice of the committee.

For the consideration of the committee

- Suggestions of possible study reports for strengthening the 12th plan proposals
- Suggestions on the timely implementation methodologies for 12th plan targets
- Suggestions of consultation processes

6. S&T co-operation / Partnerships and Alliances

1.	Dr. B. Purnaiah (DAE, Mumbai)	**Chairman**
2.	Dr. Neelima Jerath (S&T Council Punjab)	**Member**
3.	Dr. C T S Nair (KSCSTE, Thiruvananthapuram)	**Member**
4.	Dr. A. Amudeswari (CEFIPRA, New Delhi)	**Member**
5.	Dr. Anjan Das (CII, New Delhi)	**Member**
6.	Dr. Anita Mehta (S N Bose NCBS, Kolkata)	**Member**
7.	Dr. S. Natesh (DBT, New Delhi)	**Member**
8.	Dr. Jagdish Chander (DST, New Delhi)	**Member**
9.	Dr. Arabinda Mitra (Indo-US S&T Forum)	**Member Convener**

Terms of Reference

- To study the existing models of building international S&T and Centre-State partnerships and alliances.
- To suggest best course models for developing partnerships with other socio-economic ministries.
- To propose means of selecting strategic alliances for India for building S&T cooperation.
- To suggest some possible means for promotion of Private-Public Partnerships.
- To recognize best means of strengthening of S&T council mechanisms and designing competitive grant models for states for deployment of technologies.
- To design modalities for developing partnerships and alliances suited for developing R&D infrastructure for mega science.
- To review quantitative deliverables proposed by the Department in the area and suggest alternative targets, if any.

- To suggest indicative of budgetary needs for the objective.
- Any other priorities of choice of the committee.

For the consideration of the committee

- Suggestions of possible study reports for strengthening the 12th plan proposals
- Suggestions on the timely implementation methodologies for 12th plan targets
- Suggestions of consultation processes

Secretary, DST in a meeting with member conveners of the subgroup, has asked all six member convenors to include objective-wise programmes, initiatives, activities, and autonomous institutions of DST in their reports as given in the Table 6;

Table 6 Sub-Groups - Programmes

Sr. No	Objectives	Details of initiatives
1	**Formulation of policies relating to Science and Technology**	National Science and Technology Management Information System, Technology Information Forecasting and Assessment Council
2	**Strengthening Basic Research and Expanding R&D base-Human Capacity**	SERC, SERB, INSPIRE, Women Component, Fellowship Schemes, IACS, IRHPA, Mega facilities for basic research, Training Cell, Gender Initiatives, Cognitive Science Research Institute, Bose Institute, Centre for liquid Crystal Research, Jawaharlal Nehru Centre for Advanced Scientific Research, S.N. Bose National Centre for Basic Sciences, Nano Science and Technology Mission
3	**Strengthening Basic Research and Expanding R&D base – Institutional Capacity**	FIST, CURIE, PURSE, SAIF, Special Programme for NE, J&K and Bihar, NATMO, Patent Facilitating Centre, Nano Science and Technology Mission Aryabhatta Research Institute of Observational Sciences, Birbal Sahni Institute of Palaeobotany, Wadia Institute of Himalayan Geology, Raman Research Institute, Institute of Advanced Study in Science and Technology, Indian Institute of Astrophysics, Indian Institute of Geomagnetism, Solar Energy Research Initiative
4	**Implementing Technology**	Drugs and Pharmaceuticals, Instrumentation Development, National programme on Carbon

	Development Programmes	Sequestration Research, Technology Development Board, Solar Energy, Security Technology, Water Technology, NRDMS, Survey of India, Good Laboratory Practice, National Accreditations Board for Testing & Calibration Laboratories, Shree Chitra Tirumal Institute for Medical Sciences and Technology, International Advanced Research Centre for Powder Metallurgy& New Materials, Climate change and Adaptation Programme, Agharkar Research Institute, PPPs.
5	**Societal Interventions of S&T**	Science for Equity, Empowerment & Development, National Mission on Bamboo Applications, Mission for Geospatial Application, National Innovation Foundation
6	**S&T Cooperation/ Partnerships and Alliances**	S&T Entrepreneurship Development, International S&T Co-operation, National S&T outreach State Science and Technology Programme, Vigyan Prasar, Joint Technology projects with other Socio-economic ministries, NCSTC, Innovation Clusters

In the meeting, it has been decided to prepare and submit the sub group reports for 12th plan of DST in a common broad structure/format as;

1. Introduction and background
2. Overall objectives
3. XI plan achievements including review and phasing out/ merging of any programmes, if required
4. Changing national scenario and the role of DST
5. Consolidation of successful ongoing schemes
6. Trajectory & selection of new paths and programmes
7. New approaches for the XII plan
8. Selection of XII plan targets

Annexure 8a

Recommendations of the Sub-Group of the Working Group

on

Formulation of Policies relating to Science & Technology

REPORT OF THE SUB-GROUP ON FORMULATION OF POLICIES RELATING TO SCIENCE & TECHNOLOGY OF THE 12TH PLAN DOCUMENT OF DEPARTMENT OF SCIENCE AND TECHNOLOGY

1. GENISIS

1.1 Background

The Department of Science & Technology (DST) is in the process of formulating its 12th Five Year Plan document. Keeping in view the aspirations of key stakeholders, the task of formulating the document has been divided into 6 broad functions/ objectives. These are:

- Formulation of Policies relating to Science & Technology;
- Strengthening Basic research and Expanding R&D base - Human Capacity;
- Strengthening Basic research and Expanding R&D base - Institutional Capacity;
- Implementing Technology Development Programs;
- Societal interventions of S&T Strengthening; and
- S&T co-operation/ Partnerships and Alliances.

DST vide Order No 1/2/2011-PC dated 06-06-2011 has notified various sub-groups and outlined broad objectives, terms of references and tasks assigned to these sub-groups.

SUB-GROUP ON "FORMULATION OF POLICIES RELATING TO SCIENCE AND TECHNOLOGY" – CONSTITUTION AND BROAD OBJECTIVES

1.2 The sub-group on "Formulation of policies relating to Science and Technology" was set up by DST with following composition of members:

1	Prof. Milan K Sanyal	Saha Institute of Nuclear Physics, Kolkata	Chairman
2	Dr. A. K. Sood	Department of Physics, Indian Institute of Science, Bangalore	Member
3	Dr. Krishan Lal	National Physical Laboratory, New Delhi	Member
4	Dr. Satyajit Rath	National Institute of Immunology	Member
5	Dr. Renu Swarup	Department of Biotechnology, New Delhi	Member

6	Dr. V. K. Gupta	Council of Scientific & Industrial Research, New Delhi	Member
7	Sh. V. Bhaskar	Department of Industrial Policy and Promotion (DIPP), New Delhi	Member
8	Dr. S. Basheer	National University of Juridical Sciences (NUJS), Kolkata	Member
9	Dr H.R.Bhojwani	Ministry of Human Resource Development, New Delhi	Member
10	Dr D. Yogeswara Rao	Indian Institute of Chemical Technology (IICT), Hyderabad	Member
11	Dr. Praveen Arora	Department of Science & Technology, New Delhi	Member
12	Dr. Akhilesh Gupta	Department of Science & Technology, New Delhi	Convener

1.3 Following terms of references have been outlined for the Sub-group on "Formulation of policies relating to Science and Technology":

To recognise policy gaps in building academy-research-industry collaborations;

- To suggest commissioning of preparation of study reports, if any;
- To enlist policy instruments suiting the aspirations of the stake holders along with inter-se priorities, if any;
- To advise policy directions for increasing the private sector investment into R&D;
- To advise policy instruments for enhancing the absorption capacity for larger investment into R&D;
- To advise measures for de-bureaucratization of science sector;
- To suggest policy instruments and framework for creation of an innovation ecosystem;
- To review quantitative deliverables proposed by the Department in the area and suggest alternative targets, if any; and
- Any other priorities of choice of the Committee.

The sub-group is also expected to consider the following:

- Suggestions of possible study reports for strengthening the 12th plan proposals;
- Suggestions on the timely implementation methodologies for 12th plan targets; and
- Suggestions of consultation processes.

2. CHANGING NATIONAL SCENARIO AND THE ROLE OF S&T

2.1 Directions from the Approach Paper on S&T prepared by Planning Commission

Planning Commission vide Chapter X of the Approach paper prepared for the formulation of 12th Plan Document has come up with an approach paper on Science and Technology. A brief outline of this approach paper is given in the following paragraph.

2.1.0 As the Indian economy and society grow and modernize, the Indian Science & Technology and Innovation landscape also has to change to meet the magnitude of demands being made. This landscape should take care of new responses to risk averse nature of the society, delivery models for innovative deployment of technologies, business models for financing deployment of innovations and adjustments in governance and management models for supporting strategic goals of innovations. Current practices and policies do not promote, to desirable extent, demand for innovations especially in the formal sector. This calls for a well enunciated Science, Technology and Innovation policy, which is supported by an ecosystem that addresses the national priority for inclusive and accelerated growth. Whereas most global models of innovation are focused on process of innovation, India needs a country specific innovation model which lays emphasis on purpose as well as process of innovations. We need to adopt a people centric pursuit that focuses on affordable innovations to ensure that benefits of innovations reach as many people as possible.

2.1.1 There are wide ranging areas that would require breakthrough innovations and significant S&T inputs – from energy to water management, to farm production, to medical research, to waste disposal, to health care, to communications and so on.

2.1.2 Significant changes will have to be brought in the current interaction of publicly-owned S&T establishment with industry, both in public and private sector. This should result in a significant enhancement of the private sector R&D expenditure, which is presently estimated at around 25 per cent of national R&D expenditure to at least 50 per cent in the Twelfth Plan. The industry, both public and private, would also need to be incentivised to invest at least 2% of their sales turnover in R&D.

2.1.3 PAN India mission mode projects addressing National needs and priorities should be launched, through extensive participation of stake holders, in the areas of Health, Water, Energy, Food and Environment security, with the objective to achieve the goals and targets in a defined time frame.

2.1.4 We must expand the scope of our dialogue with both advanced and emerging economies; in the sphere of defining S&T focus areas and avenues for exchange of information and purposeful collaboration..

2.1.5 The energization of S&T activities cannot be de-linked to the expansion and deepening of basic science teaching and research in our scientific centres of learning. Therefore, the creation of greater infrastructure and more project-related funding for expanding the quality of basic science teaching and basic science research is, in the ultimate analysis, a prior condition for the expansion of the scope of S&T intervention in the development of the wider economy and society.

2.1.6 The institutional concepts which were initiated in earlier Five Year Plans, like the Inter University Centres and Inter Institutional Centres for enhancing research and educational linkages for Universities, are to be expanded further to cover many other inter disciplinary research areas such as Earth System Science, Life Sciences, Computational Science, Cognitive Science etc.

2.1.7 Enterprise of innovation for wealth creation in the country needs to be strengthened and scaled up many fold from the current levels.

3. Report of the Sub-Group

INTRODUCTION

One of the important functions identified for the Department of Science and Technology is to develop and deliver public policy support for the promotion of research and development in the country. Whilst S&T sector seems to have registered phenomenal growth in terms of investment and S&T outputs in some emerging economies in Asia, the rates of growth of S&T output indicators are not in tune with the desirable rates of changes in case of India. There are valuable and useful lessons to be learnt from the experience of countries like China, Korea for growing science and technology in the country and for linking knowledge to wealth generation through commercialization of technologies. Most of the dramatic developments in the emerging economies in the S&T sector have been supported by policy inputs.

India needs a forward looking Science, Technology and Innovation Policy framework for defining the R&D thrust and programmes envisaged for implementation during the 12th plan period.

The sub-group met twice on 17th June and 21st July, 2011 and deliberated extensively on various issues. These included, XI plan achievements including review of programmes, consolidation of successful on-going programmes, approach for the XII Plan, policy perspectives for XII Plan, likely deliverables and some specific policy measures. These are presented in the following paras.

XI PLAN ACHIEVEMENTS INCLUDING REVIEW AND PHASING OUT/ MERGING OF ANY PROGRAMMES, IF REQUIRED

4. Progress/ achievements made against the targets of 11th Plan period

Sr. No.	Target	Achievements
1.	Number of policy systems supported	❖ A total number of 16 policy systems have been supported

2.	S&T Innovation Policy	❖ Draft Policy has been prepared for National Consultation
3.	Data Sharing Policy	❖ Draft National Policy for Data Sharing and Accessibility has been prepared
4.	MoST-MHRD Grand Alliance Initiative	❖ Strengthening R&D in Universities and Academic Institutions ❖ Memorandum of Understanding between the two ministries has been signed in January, 2011
5.	Tax Exemption to Incubators	❖ 30 STEPs/TBIs have been recognized for availing tax exemptions

5. NEW APPROACHES FOR THE XII PLAN

Need for a vibrant S&T and Innovation Policy of India

India enunciated Science and Technology Policy in 2003. Since then the role of innovation as a part of the Research and Development system has grown considerably. India needs a carefully developed Science, Technology and Innovation Policy. With 2010-20 having been declared a "Decade of Innovation" by the Government of India, an integrated Science, Technology and Innovation Policy has become essential.

In order to bring in vibrancy in the Science, Technology and Innovation the following key factors are need to be addressed:

- ❖ Increasing the R&D expenditure to 2% of GDP
- ❖ Doubling the R&D Investments of the private sector from the present level
- ❖ Improvement of R&D Infrastructure in institutions as well as industries
- ❖ New PPP models for R&D

In addition an innovation ecosystem is very essential to derive the enhanced outputs commensurate to the investments in Science, Technology and Innovation. Some major policy interventions considered necessary for creating such a viable Innovation ecosystem are associated with aspects like

- ❖ R&D investments related,
- ❖ Knowledge flows related,
- ❖ Strategy related,
- ❖ Process and bureaucracy related,
- ❖ Personnel policy,
- ❖ Financial and risk averseness related,

- Engagement of private sector into R&D related,
- Promotion of Public-Private Partnership in R&D related ,
- Incentive systems for R&D professionals related
- Mobility of S&T professionals related

Some of these specific policy interventions that could enhance the vibrancy in the Science, Technology and Innovation sphere are given in the Annex –II.

6. GENERAL PHILOSOPHY OF THE SUB-GROUP DELIBERATIONS

The sub-group in its second meeting held on 21st July extensively debated various issues. The general philosophy and specific observations of the sub-groups are summarised below:

i. It was recognised that the task of formulating S&T policies for next 5 years needs careful planning and visionary approach keeping in view changing national scenarios and aspirations of stakeholders

ii. The approach and trajectory of the S&T policy formulation should match with the Approach Paper prepared by the Planning Commission

iii. The future S&T landscape must address societal needs and demands for new delivery models for innovations especially in the formal sector.

iv. There is an urgent need for a well enunciated Science, Technology and Innovation policy, which is supported by an ecosystem that addresses the national priority for inclusive and accelerated growth.

v. India needs a country specific innovation model which lays emphasis on purpose as well as process of innovations. This would need a people centric pursuit that focuses on affordable innovations to ensure that benefits of innovations reach at the grass root level.

vi. In order to achieve breakthrough success in the S&T and Innovation, the private sector participation and investment is essential. It is high time that India must quickly ramp up the investments into science, technology and innovation sector. There is need to set up large funds to create breakthrough research. It should be recognised that the Science and Technology is a growth sector which can not afford to have stability.

vii. The total investment into R&D is presently at less than 1% of GDP which needs to be increased to 2%. If we were to increase to say 1.45-1.5% of GDP by end of 12th plan we would need to invest at least US $ 135-150 billion dollar over a period of five years after adjusting to purchase power parity. It is a desirable goal if through various policy mechanisms we are able to stimulate the investment of private sector from the current 0.24% to at least 0.48% by the end of 12th plan period. It will be good for the country if the private sector is able to invest about US 35-40 billion during the 12th plan period. To enable this to happen, we would need appropriate policy instruments.

viii. If large investments into science sector were to be justified, we would need some mega and big ticket projects which would catch the imagination of not only the country but also the world. We need big ideas as well as strengthening of R&D infrastructure of the entire R&D systems in the country.

ix. We need to encourage private sector to develop a medium and long term priorities and aims to emerge as global leadership in technology at least in some select areas. While we have the strength of young people, we do not have the benefit of systems that leverage the untapped potentials of our people. There is need to bring greater synergy between knowledge and wealth creation sectors. While research should lead to new discoveries, technology must provide new solutions to national problems of water, agriculture, energy and environment, health care related challenges. Innovation should provide this country global leadership.

x. There is also a need to bring a paradigm shift in our mindsets of developing "*policy for science'* to developing *"science policy for nation*". There is a need to identify certain key socio-economic related problems of national relevance to which scientists can be challenged to find viable solutions. This call must be global so that scientists abroad can also participate in this grand challenge programme. The programme like setting up of "Grand Challenge Awards" can be put in place. We need to facilitate such interventions through new policy mechanism.

xi. There is also need to build an evidence based system for national S&T policy based on national indicators. It must be recognised that the scientific facts are not established by consensus but through objective methodology.

xii. There is need to position India at the apex level of global knowledge. This would need assigning national priorities and perspective into our policy process. Most of our policies are inspired by other countries. We may need global reference but we need to have our own national perspective for measurement of output of scientists which may not necessarily be based on H-index.

xiii. We also need a policy framework to encourage research in colleges/universities so that people who are employed in R&D can be increased.

Detailed comments and suggestions provided by the members of the Sub-group are summarised in Annex-III.

7. SELECTION OF XII PLAN TARGETS

Policy perspectives for 12th plan period

Following are a few among a number of policy perspectives which could become part of 12th Plan document goals and targets for DST. The list is not an exhaustive one but contains certain indicative perspectives:

a. Stimulation of private sector engagement for investment into R&D: From the current 0.24% to about 0.5% level

b. Public-Private Partnerships for promotion of R&D and Clean Energy: New policies for relationship for co-investment

c. Enlarging Research in the University Sector: Through new Private-Public and Public-Public partnerships

d. Expanding research in the Technology areas: Through technology partnerships with Socioeconomic ministries

e. Policy for investing into R&D through Indians abroad: For contractual R&D and Diaspora recruitment

f. Stimulating states for investments into deployment of technologies: Under state-center technology partnership models

g. Revisions of Existing policies: S&T policy for including innovation

h. Quadrupling Full time Equivalent R&D personnel through multiple mechanisms: Tapping all possible sources of Indians

i. Data Sharing and Access Policy: For proactive transparency

j. Global Scale Innovation clusters: For R&D for five areas of strategic knowledge domains

k. Enlarging coupling between technology and manufacturing and trade and Technology: Evidence based selection of sectors for early impact

l. Performance related Investment Strategy: For Global positioning of India

Some indicative 12th plan deliverables on policy formulation from DST

a. Introduction of at least 4 major Bills in the parliament on S&T related aspects

b. Framework preparation and formulation of about 16 Policy documents

c. Complete Implementation of all 11th Plan policies

8. THE WAY FORWARD

The sub-group felt that the formulation of S&T and Innovation Policy for the country is an involved process which needs much wider circulation and consultation amongst all stakeholders including S&T professionals, scientists, managers, policy makers, industry and public at large. The draft report therefore needs to be circulated amongst all such stakeholders and also be kept in public domain for comments. The Department of Science & Technology is in the process of finalising its S&T and Innovation Policy. The inputs received from stakeholders would be of great value for enunciating a vibrant policy. The sub-group observed that the Public-Private-Partnership framework suggested by the sub-committee of the PM's Council on Trade and Industry could a useful instrument in creating a new environment for encouraging private sector participation in the S&T sector.

ACKNOWLEDGEMENTS

The Sub-group "Formulation of Policies relating to Science & Technology of the 12th Plan Document" are thankful to the Department of Science & Technology for having entrusted with the responsibility of suggesting policy formulation for S&T and innovation. We are particularly grateful to Dr T.Ramasami, Secretary, DST for his constant guidance, encouragements and invaluable inputs to the sub-group for the preparation of the report. We thankfully acknowledge inputs/ comments/ suggestions provided by the members of the Sub-group in particular Dr D.Yogeswara Rao, Dr A.K.Sood, Dr Krishan Lal and Dr H.R.Bhojwani.

Annex-I:

Approach Paper on S&T prepared by the Planning Commission

Chapter X

SCIENCE AND TECHNOLOGY

1. *Creation of an Innovation Ecosystem*

- As the Indian economy and society grow and modernize, the Indian Science & Technology and Innovation landscape also has to change to meet the magnitude of demands being made. This landscape should take care of new responses to risk averse nature of the society, delivery models for innovative deployment of technologies, business models for financing deployment of innovations and adjustments in governance and management models for supporting strategic goals of innovations. Current practices and policies do not promote, to desirable extent, demand for innovations especially in the formal sector. This calls for a well enunciated Science, Technology and Innovation policy, which is supported by an ecosystem that addresses the national priority for inclusive and accelerated growth. Whereas most global models of innovation are focused on process of innovation, India needs a country specific innovation model which lays emphasis on purpose as well as process of innovations. We need to adopt a people centric pursuit that focuses on affordable innovations to ensure that benefits of innovations reach as many people as possible. Building Global Innovation and Technology Alliances with strategic partners could form an integral part of this pursuit. New structures and mechanisms like: Competitive Innovation clusters, National Innovation Fund under a PPP model, Promotion of Venture capital industry, Open Source Innovation Policy for social inclusion, IP acquisition by the government for non-exclusive licensing for public and social good sectors of research and development and promotion of innovation culture in centres of excellence merit attention for building such alliances. Innovation ecosystem would also require readjustments in the mindsets of educational system, financial institutions, R&D entities as well as the governance system. We also need to migrate from defensive decision syndrome to trust based decision logic and risk averse to risk prepared social behaviour.

1.1. *Aligning S&T to developmental needs*

- There are wide ranges of areas that would require breakthrough innovations and significant S&T inputs – from energy to water management, to farm production, to medical research, to waste disposal, to health care, to communications and so on. Enrichment of knowledgebase, which is harbinger to technology development, must also continue to get adequate priority.

- In order to play a productive and appropriate role to service these national needs, the S&T system will have to do the following:

- Undergo a paradigm shift from the current input driven model to an output directed development path strategy. This would involve communicating with user segments in various parts of Indian society and industry and work towards finding solutions and applications that correspond to such felt needs. Not only is this a vitally important transition for re-orienting the direction and priorities of S&T activities, it is also necessary to open up new funding avenues for public and private agencies, clearly expecting and securing benefits from their association with the S&T sectors;
- Review existing framework and programmes in the context of their contemporary relevance and optimise on resources;
- Create a framework that takes into account the entire life cycle of ideas beginning with discovery/creation to commercialization, extension and value addition. It is success in this area alone that can stimulate appropriate innovation across the wider system. To achieve this, current institutional structures and mechanism would require:
    - A holistic approach to public funding of R&D for socially relevant projects and treat the entire knowledge domain of R&D as connected;
    - Much larger base of full time researchers and flexibility in hiring them;
    - Greater autonomy to work in a clearly defined charter ;
    - More flexibility to the younger generation of scientists to pursue their ideas and greater mobility between industry, academia and R&D institutions;
    - Enhanced scope and process of inter-institutional and international collaborative research;
    - Significant participation of socio-economic Ministries & States in technology deployment process;
    - A culture of world class publicly owned and privately/autonomous managed S&T institutions;
    - A well crafted strategy for Technology acquisition in high-tech areas;
    - Significant changes in HR, financing, procurement policies and importantly a transparent performance appraisal system.

- Significant changes will have to be brought in the current interaction of publicly-owned S&T establishment with industry, both in public and private sector. This should result in a significant enhancement of the private sector R&D expenditure, which is presently estimated at around 25 per cent of national R&D expenditure to at least 50 per cent in the Twelfth Plan. The important elements which may play the catalytic role in achieving this outcome are: first, leveraging the Government grants and other forms of financing, to secure private financial flows and support around a demand driven R&D development path. The industry, both public and private, would also need to be incentivised to invest at least 2% of their sales turnover in R&D. The second is developing a workable protocol for facilitating interaction amongst these players. This would cover a range of issues, from the nature of testing to that of the regulatory framework and the facilitation of FDI in related R&D activity.

- FDI in R&D by MNCs, such as GE, Motorola, Texas Instruments, CISCO, Dupont, Honda etc. has created enclaves of world class technological development and have helped in creation of a pool of highly skilled scientists and technologists through setting up of their R&D Centres in India, Large Indian companies may be encouraged to establish similar centres. Many of them are now global companies with large interests worldwide in metals, engineering, energy, medicine, etc and they have the organizational and financial capacity to recruit top-class S&T personnel from across the world. In this way the current S&T divide between us and the advanced economies can be partially bridged. Government can play a facilitating role to enable these centres to come-up.

- The innovative component of several technologies that have been developed by the three strategic Departments viz. Atomic Energy, Space, and Defence Research and Development, for their own respective needs could trigger unique mechanisms for encouraging innovation and ensuring the right impact on social, industrial, and strategic sectors in the Twelfth Plan. Therefore, there is a need to create mechanisms for flow of technologies from the strategic sector to non-strategic sectors and vice versa for social and public good applications.

- PAN India mission mode projects addressing National needs and priorities should be launched, through extensive participation of stake holders, in the areas of Health, Water, Energy, Food and Environment security, with the objective to achieve the goals and targets in a defined time frame.
- We must expand the scope of our dialogue with both advanced and emerging economies; in the sphere of defining S&T focus areas and avenues for exchange of information and purposeful collaboration. To make this dialogue more meaningful, it has to be mediated through a framework that takes into account the realities of strategic national interest and the diplomatic charter. Collaboration at the level of academic research etc is an activity that will in any case carry on, but it should not be confused with the Government sponsored dialogue with S&T establishments of our key counterparts in the rest of the world. Meaningful dialogue pre-supposes the achievement of a certain level of technical competency, such as in our participation in ITER. The XIIth Plan must identify half-a-dozen areas where our key technological competency can

allow us to conduct this dialogue at the level of peers and permit participation in international projects. This will also place us in a better position to carry forward S&T dialogue with other developing nations.

- The energization of S&T activities cannot be de-linked to the expansion and deepening of basic science teaching and research in our scientific centres of learning (universities and teaching institutes). It is hard to envisage how basic scientific research can be carried forward if the leading centres of science teaching do not have an active role in this process. Therefore, the creation of greater infrastructure and more project-related funding for expanding the quality of basic science teaching and basic science research is, in the ultimate analysis, a prior condition for the expansion of the scope of S&T intervention in the development of the wider economy and society.

- Finally, the institutional concepts which were initiated in earlier Five Year Plans, like the Inter University Centres and Inter Institutional Centres for enhancing research and educational linkages for Universities, are to be expanded further to cover many other inter disciplinary research areas such as Earth System Science, Life Sciences, Computational Science, Cognitive Science etc. during the Twelfth Plan to bring about functional connectivity across universities and domain institutions. This would also overcome regional disparities in the quality of education/research.

1.2. ***Institutions for Innovation***

- Enterprise of innovation for wealth creation in the country needs to be strengthened and scaled up many fold from the current levels. Whereas many current schemes are focused on scouting and supporting innovations, scaling up of the successful innovations many-fold would require support of venture financing and risk capital on the one hand and greater level of partnership between public funded institutions and private sector R&D, National Innovation Fund, Research Parks in R&D institutions, Technology Business Incubators in academic institutions for scaling innovation sector many fold will form part of innovation strengthening of S&T sector.

Annex-II

SUGGESTED MAJOR POLICY INTERVENTIONS IN THE CONTEXT OF PROPOSED NATIONAL SCIENCE, TECHNOLOGY AND INNOVATION POLICY

1. Proposed National Science, Technology and Innovation Policy

India enunciated Science and Technology Policy in 2003. Since then the role of innovation as a part of the Research and Development system has grown considerably. India needs a carefully developed Science, Technology and Innovation Policy. With 2010-20 having been declared a "Decade of Innovation" by the Government of India, an integrated Science, Technology and Innovation Policy has become essential.

Some major policy interventions considered necessary for the emergence of a viable Innovation ecosystem are associated with aspects like –

a) R&D investments related,
b) Knowledge flows related,
c) Strategy related,
d) Process and bureaucracy related,
e) Personnel policy,
f) Financial and risk averseness related,
g) Engagement of private sector into R&D related,
h) Promotion of Public-Private Partnership in R&D related ,
i) Incentive systems for R&D professionals related
j) Mobility of S&T professionals related and

(a) R&D investment related

In India, investment into R&D has never exceeded 1% of GDP with Government's share of ~75%. In contrast, R&D investment in China is already at 1.7% of its GDP with the share of industrial sector being ~66%. China is targeting to increase R&D investments to 2.5% of GDP by 2020. Patent filings per billion dollars of GDP are at about 2.0 for India while the corresponding figure for China is more than ten times higher.

Currently in India, more than 80% of the industrial sector does not invest in R&D. Doubling of Indian R&D investments from less than 1% of GDP is possible only when private sector investment in R&D also increases significantly. While the focus of the public-funded R&D system is on publishable results, the private sector seeks commercialisable intellectual properties.

Policy instruments are needed for increasing the Gross Expenditure on Research and Development though a more direct and stronger participation of the private sector into R&D coupled with significant increase in the number of R&D related jobs in the private sector. Higher investments into R&D should also be supported by policy measures to right size of the R&D base and increase absorption capacity for larger investments.

(b) Knowledge flow related

Current flows of knowledge into the manufacturing system involve mostly transactions of knowledge for money. New policy paradigms and instruments are essential for correcting deficiencies of knowledge flow, in the mind-to-market chain, by promoting long term PPPs and relationships amongst Academia-Research-Industry-Government-Society.

(c) Strategy related

Current Indian policies treat the R&D sector in segregated compartments. The knowledge domain of the R&D sector under public and private sectors are considered as discrete units working independent of each other. Deployment of public funds into private sector R&D units and private sector funds into the public funded research is inadequate.

Within the current policy regime and mindsets, the potential benefits of affordable innovation created within the entire knowledge domain of R&D, combining private and public sector efforts as one, cannot be easily tapped. A change in the policy paradigm for treating the entire R&D sector in the country as one and developing PPPs for R&D to promote public and social good are important new strategies.

There are some useful global models for promoting PPPs in the R&D sector. Good global models could be adapted to suit the requirements of the country for positioning suitable policy instruments.

(d) <u>Process and Bureaucracy related</u>

A growth sector like research and development suffers from slow responses of systems of bureaucracy globally. In democratic and emerging economies like India, concerns have been raised about the level of bureaucracy in management and administration of science. In matters of personnel and administrative management, new tools and principles need to be discovered and positioned through policy instruments for fostering the R&D sector.

(e) <u>Personnel policy related</u>

Global competitiveness of Indian industry and trade demands also competitiveness of the Indian Science, Technology and Innovation system. Right sizing the R&D base is essential. The personnel policy of the Government is well designed to suit the linear processes associated with administrative functions. System driven functions permit a person-neutral approach for personnel management. Technical and science related functions do not lend themselves to people- and expertise-neutral and personnel policy management. Induction based rather than vacancy-filling models are essential for R&D functions. A personnel policy system based on job requirements of R&D functions needs to be designed, developed and positioned.

(f) <u>Financial audit and Risk averseness systems related</u>

Innovations, by definition are first applications of hitherto untested concepts and are generally associated with risks of failure. The current financial audit systems do not promote exploration of risky innovations. Readjustments in the financial audit system for not treating honest and grand failures in R&D as negative developments are necessary and they should make provisions for failed experiments. The current financial audit processes promote risk averseness in R&D systems. Incremental rather than leap-frog innovations should form the major thrust of innovation system of the country.

Expenditure control mechanisms suited best for fiscal control of administrative costs dose not suit the growth sector like R&D. A mind set for planned investments into expected returns is essential. The Indian S&T sector has sought a well designed financial audit discipline and system for long. An audit system based on objectives and processes rather than compliance to procedure may seem necessary. A global study of financial audit system suited to R&D sector in the country will be valuable. A new policy paradigm for financial audit and manpower induction systems will be valuable.

(g) Engagement of private sector into R&D related

The essentiality of enhancing considerably the engagement of the Indian private sector from the current level of about 0.26% of GDP to at least 0.50% of GDP by the end of 12th plan has been emphasized. Such a quantum increase is possible only when sufficient number of jobs is created in the private sector for R&D. Further, the private sector would invest into R&D only when it is able to realize the economic potentials of the investments in the form of market advantages. Korea was able to increase the share and quantum of private sector investment into R&D in a relatively short time. Study of the policy provisions leveraged by Korea for increasing the private sector engagement into R&D would be valuable. Suitable policy instruments for growing research into the private sector should form a priority for the 12th plan programmes of India.

(h) Promotion of Public-Private Partnership in R&D related

Private Public Partnership is a relatively powerful instrument for promotion of R&D, which has not yet been fully tapped. A suitable and forward looking policy instrument would be useful for not only increasing the investment into R&D but more so for converting R&D outputs into measurable economic and social outcomes. The current asymmetry prevailing among public funded R&D and national manufacturing systems is more likely to be bridged through PPP than any other paradigm. A sub-committee of PM'S council for Trade and Industry has made some important recommendations for promoting PPP in R&D which rely on a forward looking policy framework.

(i) Incentive systems for R&D professionals related

Research and Development systems in the country are focused on discoveries leading to high peer recognitions rather than development of commercialisable Intellectual products. This is partially on account of cultural preferences among the R&D professionals as well as inadequate demand pull for R&D outputs into the manufacturing systems. Indian psyche responds enthusiastically to stimulants based on incentive systems. Currently, such stimulants are favouring publications and discovery oriented research. Suitable incentives would need to be positioned through policy framework to support industrial research and commercialization of Intellectual Properties. Such systems should also increase the public accountability of the science sector through appropriate measurement and reporting systems. Implementation of Performance Related Incentive System would depend heavily on the public policy support for providing financial incentives for higher performance in applications of research outputs.

(j) Mobility of S&T professionals related

Cultural changes in the R&D landscape of the country are necessary for promoting an innovation ecosystem. This would call for intermixing of professionals engaged into the R&D and manufacturing systems seamlessly. The current policy systems do not permit free mobility of R&D professionals among various streams of the knowledge sector.

Joint appointments between academic and research as well as research and industry could address some of the gaps prevailing in the R&D sector. However, it is necessary to address issues like conflict of interest in the implementation of such policy tools. A carefully assessed and enabling policy tool for promoting the mobility of scientists within the knowledge to wealth creation sector would form the next best step forward.

2. Policy for Partnerships and Strategic Alliances

Partnerships and strategic alliances form powerful tools in modern global R&D and innovation systems. Well enunciated policy framework for developing partnerships and alliances would form a strong 12th plan priority.

2.1 International S&T cooperation

Three pillars of International S&T cooperation are a) technology diplomacy, b) technology synergy and c) technology acquisition. Policy instruments to support all three pillars based on national priorities should be carefully developed based on strategic partnerships and alliances.

2.2 State-Centre partnerships

Technology partnerships between centre and state Governments for deployment of technologies for development and delivery of public and social goods offer new and powerful tools for accelerating the phase of development. A stated policy for centre-state technology partnership could form a new 12th plan perspective.

2.3 Partnerships with community based organizations for Deployment

Technologies require referencing to the social contexts in which they are applied. Social referencing technologies to the contexts in which they are applied are best accomplished under a partnership between technology owners/ sources and community based organizations with local presence. The current policy framework may need readjustments for promoting partnerships between public funded bodies and community based organizations.

3. Scientific Assessment for Policies for Regulatory processes

The sub-group may also take into account of the policy gaps that merit actions from the three departments under the Ministry of Science and Technology as a collective exercise. The role of scientific assessment for development of policies for regulatory frame work is critical. Products and services based on new technologies like biotechnology and nano technology etc, while offering new opportunities for accelerated development, are likely to be associated with un-assessed safety risks. Sound appraisal of risks associated with products of new and emerging technologies like GM food, nano technology etc should be based on scientific methodologies. Regulatory mechanisms should be based on public policy instruments developed on the basis of sound scientific principles. The role S&T sector in designing appraisal processes and policy guidelines for regulatory bodies should be addressed during the 12th plan period.

4. Identification of priorities for Designing policy instruments

While there may be several needs for policy instruments to bring about desirable directional changes in the Indian R&D system, it is necessary to prioritize among the various needs for time scheduling the delivery of policy instruments. The sub-group may be requested to study the gap areas of policy space for R&D, list the policy needs and indicate a priority ordering of the various policy related work items.

Annex-III

SUMMARY OF SPECIFIC INPUTS/ COMMENTS/ SUGGESTIONS PROVIDED BY THE MEMBERS OF THE SUB-GROUP

Some of the members of the sub-group have provided invaluable inputs and suggestions for formulation of S&T polices for the 12th Plan. While efforts have been made to include majority of these suggestions into the report, a detailed elaboration of these inputs and suggestions are being provided separately here as annexure. These inputs have been duly acknowledged in the report.

1. Enhancing the Reach and Effectiveness of PPP Programmes

1.1 Realizing that technological innovation is the key determinant for global competitiveness of Indian industry, the Government of India has established several R&D support programmes at national level along with number of policy measures. Chief among them are Pharmaceutical R&D Programme (DPRP), Home Grown Technology Programmes (HGT), and Sectoral Mission Programmes of TIFAC, Technology Development Board (TDB), New Millennium Technology Leadership Initiative (NMITLI) of CSIR, Small Business Innovation Research Initiative (SBIRI) and Biotechnology Industry Partnership Programme (BIPP) of DBT, Technopreneur Promotion Programme (TePP) and Technology Development and Demonstration Programme (TDDP) of DSIR and others.

1.2 The general perception of the industry about the effectiveness of these programmes is that they have not achieved the success to the desired extent due to inadequate fund allocation (less than Rs 300-500 crores / annum for all programmes put together), long processing time, lack of remedial action on earlier project failures, ineffective implementation, relatively lower priority assigned to Technology Development by the R&D institutions and suboptimal participation of private sector companies. Since the PPP is the best option available for enhancing the reach of Government R&D programmes to a larger number of companies in general and small and medium scale companies in particular, there is a need to remodel the PPP programmes of the country. Some suggestions are presented below:

1.2.1 The current practice of government department wise allocation of funds for specific PPP programmes or schemes that support collaborative research with industry may be transformed fully or partly into a Unified Revolving Technology Innovation Fund

(URTIF) with an initial contribution of Rs 10,000 crores for utilization, similar to a single window dispensation;

1.2.2 The various funding departments of Government of India can formulate appropriate umbrella programmes either individually or jointly with other departments and draw funds from the unified revolving fund;

1.2.3 An Oversight Committee with wider industry representation may be put in place to oversee the programme implementation.

1.3 The Departments have to compete to utilize URTIF funds. There may not be any upper or lower limit for the fund utilization as long as the funds are claimed within a particular bandwidth. The main focus of the above programme is to encourage innovative technology development preferably through a public-private partnership (PPP) mode.

1.4 The URTIF may be administered by the Department of Science and Technology under the overall guidance of an Apex Committee comprising Principal Scientific Advisor to Government of India as the Chairman, Secretary, DST as the Convenor, two secretaries of scientific departments and two secretaries of Socio-economic ministries as members. The committee among others provide (i) overall guidance to the management of fund and its effective utilization (ii) provide broad framework of guidelines for implementing the individual programmes / schemes (iii) set the performance criteria and critically review once in 5 years, the performance of the schemes / programmes that draw funds from URTIF and rank them, (iv) close at least 30% of the programmes / schemes once in five years from the bottom of the performance rank and (v) decide on the cases where writing off the recoveries / loan etc., becomes necessary. DST may have to create a separate wing may be created to manage the fund. The recoveries of the funds from various partners, if any shall be managed by this wing.

1.5 The programmes / schemes under URTIF could support three types of projects and these are:

1.5.1 Proof of concept projects – Industrially relevant projects under this category, can be submitted by the industry, research institutions, educational institutions (both public and private), universities, SIROs, and other organisations engaged in R&D activities either individually or jointly. Support to the projects will be provided as grant up to a maximum of Rs.50 lakhs.

1.5.2 Intermediate stage projects including prototype / semi-pilot scale process and product development: These projects are beyond the proof of concept stage and will have compulsory industry involvement. Projects can be submitted by industry either on its own or jointly with institution(s) engaged in R&D activity. The cost of project under this category will be shared equally between industry and government. The benefits of IP generated in the project will also be shared equally with first right of refusal for commercial exploitation resting with the industry partner. Industry shall pay royalty to the government for exploiting the IP. The project costs will be limited to a maximum of Rs 5 crores. In case of failure of a project, both parties shall write off their respective costs on receiving approval from the Apex Committee.

1.5.3 Technology development projects including pilot plant and market seeding: These projects will only come from industry with or without external R&D institutional participation. The industry under this category can get funds as loan at simple interest rate of 2%, payable over a period not exceeding 7 years from the date of completion of the project. The project costs will be limited to a maximum of Rs.20 crores. The cluster based R&D programmes will also be eligible for above type of support.

These measures are expected to bring in uniformity and flexibility in R&D funding policy and thrust to innovation development and commercialization of the resultant technologies.

2. Addressing the MSME Sector

2.1 ***Establishing R&D and Innovation Support Centres (RDISC) at MSME Clusters****:* MSMEs due to their size and low profitability are not in a position to undertake R&D activities at a globally competitive level. Nonetheless, these companies form an important segment of national economy as they provide large employment and contribute significantly to GDP. Therefore it would be the responsibility of State to support these companies to enhance their R&DI to position competitively in the global market place. It is felt that a cluster based R&D access system is well suited to them. Accordingly it is suggested to establish RDISCs equipped with most modern facilities at select locations to cater to a group of MSMEs. Public-Private (75:25) Investments are recommended for establishing these facilities. The RDISC will provide R&D infrastructure to SMEs at an affordable cost on shared resource ownership concept. A suitable model could be evolved to operationalize the centres with participation of the industries from the cluster. **These centres will carryout application oriented R&D activities in specified S&T areas that are relevant to the cluster.**

The projects undertaken by RDISC may be shared on a 70 : 30 ratio, where the 70% of the cost will come from the URTIF or associated schemes and the rest to come collectively from the beneficiary industries. As an incentive, the staff working in RDISC may be permitted to retain a percentage of the external funding as salary plus. In addition the centres shall provide the following R&D services to the cluster:

- Centralized analytical and testing Facilities for characterization and performance evaluation of products;
- Multipurpose pilot plant facilities for scale-up studies;
- Patent facilitation services
- Library services including on line access facilities;
- Modular research laboratory workspaces which can be leased to SMEs for a specified period for concept proving in process / product oriented research

The proposed centres hold the key to the success of R&D capacity building in MSME clusters since they provide access to state of art R&D and support facilities to a large number of MSMEs.

2.2 **Alignment of Government Policies for encouraging and enhancing innovation in SME sector:** The Governments of South East Asian countries viz. China, South Korea and Taiwan have played a significant role in creating an innovation eco-system for expanding the technological capabilities of SME sector. Towards this, the governments of these countries are aligning their S&T Policies dynamically to suit broader industrial goals, specifically SME sector. Some of these are:

- Facilitated and funded technology imports through hard currency for specified Export oriented sectors;
- Assisted development including reverse engineering of equipments / machinery to move away from exclusive dependence on imports. Also encouraged deployment of innovations as well as national capabilities to expand the technical superiority of such developments;
- Encouraged and promoted Foreign Direct Investment flows into SME sector for technological up gradation and modernization. Also aligned the policies for attracting Foreign Direct Investment into SME sector;

- Promoted partnership between government, universities, R&D institutions and private sector industry, particularly SME sector to develop innovations;
- Facilitated development of Technology parks to promote new start-ups.
- Supported SMEs to develop their own Brands for product marketing rather remain as simple intermediaries supplier through technological upgradation;

Whilst the government of India has taken several initiatives in the recent past to enhance the innovation quotient among the diverse industry sectors, there is no specific scheme that focuses on the SME sector. Further, as the R&D intensity in the SME sector is being low, these industries can not compete with established industries in drawing the benefits of the government promoted R&D schemes. It is suggested that a special scheme exclusively focussing on the SME sector may be mounted on the lines of DBT-SBIRI programme for areas other than Biotechnology. The scheme may cover some of the above aspects.

3. <u>Enhancement of R&D Intensity by Industry</u>

The R&DI activities in Indian companies with annual turnover in excess of Rs 100 crore have not kept pace with their level of annual earnings. However to stimulate the investment in R&DI of Indian industry there is a need for providing fiscal incentives backed by policy measures at individual unit level. It is suggested that for every rupee invested by a company:

(i) with a turnover up to Rs. 100 crores on R&DI, at least Rs 0.3 to be made available from URTIF as a funding support to that industry to take up R&D projects at its In-house unit;

(ii) with a turnover beyond Rs. 100 core on R&DI, the company may be permitted to draw a minimum of Rs. 0.3 from the URTIF to support directed research at public or privately funded R&D and academic institutions as well as universities;

Besides enhancing the industry – academia interaction, this measure will promote industry oriented applied research in Indian R&D and academic institutions. It will also promote patenting of IP jointly developed by them with industry.

4. <u>Forging and Nurturing Industry –Academic Linkages</u>

The current level of industry – University / academia / R&D institutions linkages in Indian chemical sector is very disappointing, although such relationships are necessary in generating industrially relevant knowledge at affordable cost. However there are several institutional bottlenecks in forging such relationships and these obstacles need to be overcome in the larger interest of the nation and competitiveness of the Indian industry in the global arena. It is suggested that a Mission mode programme may be evolved by Ministry of Science and Technology for evolving various country specific industry – academic linkage models. Such models may include (a) an appropriate IPR sharing and technology transfer mechanisms, (b) the policy changes required at university level (c) mandatory involvement of faculty beyond the age of 45 years, (d) incentives and revenue sharing for faculty in industry oriented R&D**.**

In addition, necessary measures may be taken (i) to recognise R&D reports of industry oriented work as academic outputs for consideration of appointment or promotion of faculty, (ii) sharing of contract research fee and royalties pertaining to industry projects. These measures will go a long way in encouraging applied research by Academic & R&D institutions. It may be mentioned that the short term temporary mobility from Research and Academic Institutions and University to industry and vice versa is permitted by Government under 'mobility scheme' in 2009.

The active association of Ministry of HRD with the proposed programme will be most desirable.

5. Technology Innovation Centres in Frontier Areas

The basic objective of this recommendation is to provide necessary driving forces for development of highly innovative technologies in frontier areas which can provide global leadership to India. The proposed Technology Innovation Centres (TIC) has to be equipped with state of the art facilities with the highly qualified faculty usually sourced nationally or internationally at competitive salaries. These centres are different from the full fledged research institutions, in the sense that they concentrate on a specific subject and pools together all the resources that are needed to develop commercially viable technologies in the frontiers of science. Many developed countries have adopted this kind of model to build new knowledge so that it could be advantageously leveraged to the benefit of the nation. For example, UK has identified high value manufacturing, energy and resource efficiency, transport systems among others for setting up such TICs. It is suggested that India could consider to set up such centres initially in 5 subject areas in the XII Five Year Plan. Identification of the areas could be through extensive consultations with experts and stake holders in the concerned fields. These centres could ideally be located in the premises of the existing R&D or academic institutions or universities. They should have freedom to acquire IP from various sources including abroad in the chosen areas and leverage its own IP for cross licensing in the interest of the nation. For making centres to be efficient and effective, a good governance system could be evolved by a competent group of experts. As a rule, these centres should be provided government support to take care of the salaries, maintenance of facilities and replacement of equipments and the centre should be asked to earn for its research activities. As an incentive to the staff, they may be permitted to retain a percentage of the external funding as salary plus. This measure is expected to position Indian industry and India as a whole advantageously in developing technologies in emerging scientific areas.

6. Foreign Direct Investment as a Vehicle for Innovation

India, as a nation, has limited experience in introducing globally competitive technologies / products. Indian industry can gain significantly if national S&T Innovation policies are more strongly linked to FDI policies being pursued by the Government of India. It will eventually enhance the chances of knowledge alliances between Indian industry and global R&D / academic / industrial institutions in emerging S&T areas for development of new products and technologies.

Given the fact that Science, Technology and Innovation (STI) are at the centre stage of socio-economic development world over, it would be imperative for Indian government to factor innovation policies into FDI policy. Technology intensive, pharma and biotechnology components of Indian chemical industry have undergone much higher level of R&D globalization as compared to others in India. Therefore, a STI driven FDI policy is most desirable to deliver financial benefits to Indian chemical sector in terms of state of art equipments, transfer of new application knowledge, novel research methodologies, new R&D subcontracting opportunities and host of other high-tech benefits. The transnational R&D spin off effects can result in transfer of technologies from MNCs to local firms, new opportunities to setup ventures by the former MNC employees and opportunities to acquire new skills and knowledge from global technology supplier agencies. The spill over effects may contribute to the emergence of a new class of world class entrepreneurs in the host country. The INAE team, therefore, recommends the formulation of a STI driven FDI policy by the commerce Ministry in consultation with the Ministry of Science and Technology under the new context of global FDI regime.

7. Technical Audit as opposed to Financial & Procedural Audit

Various departments under the Government are subjected to scrutiny at different levels, from internal audit to CAG audit. The current audit practices mainly focus on procedures rather than on the outputs and outcomes. Further, such audits are more concerned on whether the money has been spent in accordance with rules and procedures and less with what has been achieved and gained by spending that money.

The scientific departments of Government too are subjected to similar audits, even though these are not very relevant to the kind of activities the departments perform. Besides delays in implementation, over emphasis on the procedural issues take away considerable energy, time and enthusiasm of the scientists. The very nature of these audits makes scientific departments to think in terms of less objective procedures, approvals and other secondary issues at the cost of achieving scientific and technical objectives of the programme. Further, the approach of the auditors seems to be based on mistrust and is thus focused on finding faults rather than performing an advisory role. More often than not, auditors are not knowledgeable about scientific and technical subjects and as a result it becomes difficult to make them understand about the significance of the R&D activities. Consequently, there is an unwarranted fear of audit in the mind of scientific workers, which often freezes them into inaction.

Therefore, in order to reduce the bureaucratic delays and make scientific departments to concentrate more on achieving scientific objectives of research programme, it is suggested that audit of scientific departments may be emphasized on **Technical Performance Audit.** Further, the scientific departments will be benefited if the audit is of an advisory nature. While, the technical audit could be conducted by a team of acknowledged experts in the field, CAG audit could be limited only to financial aspects.

8. <u>Macro protection</u>

The scientific departments functioning under overarching government rules are averse to taking risks. The prevailing situation has arisen due to lack of suitable macro-protection measures for those who take decisions involving risk. However, for these organizations which should be primarily focused on innovation driven S&T, this culture is inimical. It may not be out of place to mention that such protections are provided to Indian administrative service cadres. Quite often, decision takers are afraid of taking decisions, fearing possible harassment as a consequence. Thus, there is a sense of insecurity among the concerned scientists/ officials.

If India is to emerge as a formidable knowledge power the confidence building among those who take risk, perform and deliver is an absolute necessity. Thus there is growing feeling that it is necessary to provide suitable macro-level protection to those staff/scientists who take risks to perform/discharge their duties. As one of the measures towards building a fearless environment, the process of vigilance in S&T departments should be internalized. A senior scientist with rich knowledge of Research and Technology management may be placed as the in charge of vigilance in scientific departments. Further, it is suggested that a high level committee headed by a senior level scientist may be constituted by the Secretary of the concerned department to guide the Vigilance Office. Such measures would lead to the much needed confidence building in scientific departments and R&D agencies and would progressively imbibe and build the culture of risk taking for innovative driven S&T.

9. Devolving of Powers

The present set up of scientific organizations in the country has a well-structured hierarchical system that is derived from the days of the colonial rule which was based more on mistrust. It was often felt and even talked about the need to reform the structure by devolving of powers for improving their efficiency and effectiveness. But very little has been done. The failure appears to be due to 'mindset' rather than due to lack of diagnosis of the problem.

Because of the historical background of our system, the powers are concentrated with a few. Further a dichotomic situation existed in scientific departments where the scientists are responsible for delivery without any powers and the administration enjoying all the powers are not accountable for neither delivery nor performance of the department. Perhaps, it did not matter earlier as it was performing under a sort of protected and isolated economy and the size of the organizations and their budgets and activities were relatively much smaller. With the advent of globalization of economy and the consequent changes that are sweeping the nations, the speed and timeliness of decision-making has become critical to working and overall performance. The wish to become competitive globally cannot be fulfilled by thinking wisely, but it depends more on acting wisely. For this to be achieved, it is important to empower the people, and make them mature and responsible to take timely decisions in the larger interest of the nation. Thus, it is suggested that devolving of certain powers down to the bench level scientist and up to the level of section officer are imperative to liberate them from the shackles of present mechanism where even for small items they would have to get involved in very time consuming and sometimes suffocating procedures of seeking approvals.

10. New Procurement Procedures for Scientific Departments

Procurement activity is very vital for timely execution of any project or programme or for maintaining and running a facility. The effect of procurement on the outcome is more pronounced in case of scientific projects, as considerable money (at times more than two-third of the project cost) and time is spent in procuring necessary equipment, consumables, spare parts, software etc. Often delays in procurement become a limiting factor in effective and efficient implementation of the project. It is experienced that the existing government procedures for procurement are lengthy, cumbersome time consuming and laden with considerable bureaucratic delays. Even a small deviation in the procedures invites adverse remarks and some time leads to vigilance cases and unnecessary harassment. For fear of repercussions, concerned staff often delays in taking decisions leading to delays in procurement, which ultimately effect project implementation. Safety of the service and reputation comes in the way of timely procurement, as delayed procurements are not considered to be of much consequence.

The situation gets compounded due to technical ignorance of Purchase officials, as many of them are with non-technical background. Thus, the procurement procedure often becomes a major stumbling block in timely execution of project and consequently achieving of project objectives.

It is thus felt that procurement systems should be streamlined and bureaucratic hurdles be removed to facilitate timely procurements for timely execution of projects. Some of the measures, among others that could be considered are: delegating powers for procurement to the Principal Investigators of the project for items within certain limits and a committee of scientists and technologists beyond that limit; enhancing tendering process(es) limits and limiting the procedure to specific purchases; procurement of off the shelf items without going through the tendering process; allowing rate contracts for all the foreseeable procurement items; doing away with the obligation of lowest quotations etc. Further, minimum qualification for Procurement Officers in scientific and technical departments/institutes may be raised to graduate and post-graduate levels in science and engineering coupled with degree or post-graduate diploma in materials management. The existing staff could be encouraged to obtain such additional qualifications.

11. Creation of a Global Technology Acquisition Fund

With trade barriers among countries fast disappearing, the concept that knowledge and IP could be acquired apart from being invented is gaining currency. As a strategy, the country needs to encourage its industry to aggressively undertake such technology acquisition. Government may create a US $ 2 billion Global Technology Acquisition Fund and park the funds with a progressive financial institution. The support could then be provided to Indian firms for acquisition of technology intensive foreign firms. After due diligence by the financial institutions support could be provided through an equity or a loan. Further, the funds can be used to support Indian companies/organisations to acquire IP to early stage innovations from overseas and value add in India using resources available within India. Such value additions can be done through public-private partnership models between research/academic institutions and industry.

12. Off-shore acquisition of early stage knowledge/ IP

Many private organizations across the world today consider it rather unwise to attempt self-sufficiency in technology development, particularly in an era, where the R&D costs and risks are increasing rapidly and ideas flow freely across the geographical boundaries. With trade barriers among countries fast disappearing the concept that Knowledge and IP could be acquired rather than invented is gaining currency. As a part of the global innovation strategy, several companies world over are aggressively scouting for new ideas irrespective of their point of origin. Yet another PPP that could be considered is off-shore acquisition of early stage knowledge/IP, which could then be incubated in India for further development in technologies/products. Government could set aside a specific fund for Indian Industry as well as venture capital supported companies to avail such funds for acquisition of IP/knowledge either in association with Indian research institutes or alone.

13. Country specific Technology Parks

Innovation chain is increasingly becoming transnational. As a result boundaries are disappearing, distances are no longer a barrier and knowledge sharing is becoming easier. Companies world over are outsourcing the knowledge for technology development and associated services. They have no hesitation in reaching out to those knowledge pastures which can deliver in time. In this changing paradigm, those countries which have enabling mechanisms and are open to benefit sharing will be benefited maximum.

In this context India can explore setting up of country specific industrial technology development parks, which will be beyond national technology incubation centres. The park would work in a novel way for industrial technology development based on the concept/ idea and specific hardware as well as software from either side. Thus, on one hand the industrial enterprises of that country, besides Indian enterprises could set up facilities in the park to draw upon the well trained manpower and on other hand the specific country in question could provide knowledgeable human interface for technology development. Thus, these parks are as much about knowledge networks of the two countries as providing hardware and software for industrial technology development. In addition it would facilitate knowledgebase of a given country on tap. Such an endeavour would create in addition to a local specific state-of-the-art park facility, a virtual laboratory drawing upon both countries knowledge pool for developing industrial technologies. The endeavour could lead to a unique knowledge based partnership between the two countries.

14. Techno-Fund for Manufacturing Sector

The new challenges in the post liberalization and post WTO regime meant that new strategies had to be developed to face global competition including the use of technology as an instrument of growth, job creation as well as leadership position. Further, most of the industries in manufacturing sector are in small and medium category and lack capacity, both in terms of financial and R&D, to face global challenges. They need to be nurtured through handholding for enabling them to reach the level of global competitiveness. It must be recognized that in the post WTO era, the only legitimate government support permitted to industry is that for R&D. GOI can thus consider and create a "Techno-Fund for Manufacturing Sector". This fund could support R&D activities for incremental improvements, new technology developments as also cost saving measures related activities. Further, the R&D activities under the said fund could be taken for individual companies or for a group of companies in a cooperative mode. This fund could be modelled on the lines of New Millennium Indian Technology Leadership Initiative (NMITLI) and in public-private partnership mode. The innate effort as part of overall strategy for the fund would be to work out a variety of approach to position the manufacturing sector competitively.

15. Some miscellaneous comments/ suggestions

- Under Bureaucracy related, it is absolute essential to reduce the bureaucracy to the minimum. At present, even after scientific evaluation and peer review process, the hurdles put in by the financial section are a road block. The Financial bureaucracy should be rationalized and integrated in the decision making process right from the beginning.

- The easy mobility of scientists amongst academic institutes, universities, industrial labs and Policy making bodies should be ensured. At present the hurdles in this mobility are enormous. Joint appointments should be encouraged, taking care of responsibility sharing and conflict of interests.

- Participation of State Science bodies has to be strengthened million fold!! State bodies are poor cousins which are sidelined at present. This has to change.

- The role of science academies should be enhanced in policy making and involving them in crucial decision making.

- We should emphasize on development of products as a part of engineering training and education and with the ultimate goal of preparing persons who are equipped for solving problems being faced by the society.

- We should stress on development of advanced facilities within the country and also preparation of a wide variety of special materials which should be available freely for research and development work.

- A number of centres with advanced facilities should be set-up all over the country, so that all researchers have access to these irrespective of their quality of infrastructure of their own university/institute.

- The entire focus of investment in S&T should not be limited to only "the fashionable areas", but a substantial amount should be invested in non-glamorous areas which lead to increased inherent strength in research and development in the country.
- The main focus should be on developing at least 3-4 major products, which will have impact on the society, for example, low-cost high-efficiency solar cells or fuel cells.
- There is a serious need for having inter-ministerial efforts on tackling societal problems like water, sanitation and quality education.
- All our international activities must be linked to national priorities and in this perspective DST and INSA can be good role models.
- S&T should be a part of Indian diplomacy, particularly while dealing with countries of similar and lower levels of development.
- Special efforts are needed to link our S&T system with the developing world, particularly the African continent and the South African region. This will be of immense benefit in the long-run.
- While the efforts are being made to bring greater transparency and de-bureaucratization of S&T funding system under SERB system, there is also need to formulate some guidelines for the code of conduct for scientists and engineers working in the S&T set up in the government.
- Under National Action Plan on Climate Change, considerable efforts are being made by the Government to address adaptation and mitigation issues relevant to the Indian scenarios. It is also widely believed that the solution to the problems of climate change lie in Science, Technology and Innovation. The new S&T policy therefore must provide focus on promotion of appropriate 'technology for green India'.
- There is need to enlarge the opportunities for meaningful employment of Scientists in the non-publically funded sector in the changing S&T landscape in the country.
- The easy mobility of scientists especially women amongst academic institutes, universities, industrial labs and Policy making bodies should be ensured. At present the hurdles in this mobility are enormous. There is need to launch special schemes for mobility of women scientists. Similarly, Joint appointments should be encouraged, taking care of responsibility sharing and conflict of interests.
- Participation of State Science bodies need considerable strengthening. Special efforts are needed to encourage state governments to actively participate in the national schemes and programmes..
- The Science academies can play significant roles in policy making process. There is greater need to involve them in national decision making process.

Annexure 8b

Recommendations of the Sub-Group

on

Strengthening Basic Research and Expanding R&D base-

Human Capacity

Chapter 1

INTRODUCTION AND BACKGROUND

Broad directives from the Planning Commission

This report is a part of the exercise undertaken by DST to formulate its proposal for the 12th Five-Year Plan.

The exercise was started by the Planning Commission sometime back. An Approach Paper was first prepared. The Planning Commission, after due deliberations, shared National concerns and expectations from the science and technology sector. The three fundamental concerns that have been expressed are how to connect a) public funded R&D systems with the industry for mutual advantages b) subsystems of public funded research in strategic and non-strategic sectors for transformational changes and c) states with indigenous R&D systems for gainful deployment and absorption of technologies.

The Planning Commission has advised that, during the 12th plan period, a tangible and traceable impact of the R&D sector on the developmental economics and quality of life of people of India be made. It has further suggested that some of the 11th plan programmes could be redesigned to test as “proof of concepts” on which the 12th plan programmes are developed. It has advised the scientific departments to learn from the recent experience of the country in various sectors and develop a plan for the S&T sector which feeds into the national goals for economic and social development. It has reemphasized the obligation of the S&T sector to develop socially relevant objectives for some of the leading programmes during the 12th plan in order to justify large public investments into the sector.

Recommendations of the Expert Group

The Planning Commission constituted an Expert Group to further develop the Approach Paper and make more focused suggestions to various sectors of S&T and various Ministries/Departments for preparing the country's 12th Plan proposal for the S&T sector.

The Expert Group has proposed a two-pronged approach, namely,

a) To provide grass root solutions; and

b) Achieve highest scientific excellence and gain global leadership in some areas in science.

The Expert Group has recommended —

- A shift of focus from IP generation to global leadership in S&T both at organizational and individual levels
- Learning from lessons from past real life examples which proved the benefits of futuristic Planning and concerted efforts leading to desired results and qualitative differences, even in scientifically intricate areas. Focus on radical but participative transformation which is multifaceted and multidirectional.
- Enabling structural changes for rebuilding and transforming existing institutions,
- Setting up of newer world class publicly owned and privately managed institutions,
- Expanding human capacity through creation of trained HR in trans disciplinary areas,
- Putting in place high class instrumentation facilities and commercialization/ delivery setups(with specialized mechanisms)
- An approach which emphasised upon the outcome based and time targeted deliveries in planning the S&T agenda for the country and
- Emphasis on grass root level solutions and highest achievements in basic, directed and applied research creating thus global niches with national spotlight.

The Expert group proposed

- Some missions in Public-Private-Partnership (M-PPP)" mode
- "Translational Research" aiming development of products and solutions which are cutting edge on one end and nationally relevant on the other,
- Involvement of the stake holders from very beginning and
- Time targeted delivery of project outputs

The Expert Group has identified the following priorities for 12th Plan programmes —

- Enhancing Academia – Research Institution - Industry interaction through an enabling environment and appropriate policy intervention,
- Building and harnessing a pool of talent in terms of budding scientists enlarging the size of catchment areas for innovation and

- Study of new paradigms being created by other emerging economies for suitable adoption by Indian R&D system.

The Expert Group has emphasized the need for:

- A well thought out, enabling and orchestrated strategy for building up the 12th Five Year Plan,
- A participative approach for building the strategy and building ownership across the diverse stake holder profile.

The Expert Group has recognized the following aspirational goals for the country:

- India should become a highly energy efficient nation;
- Provide to its 800m million people an enabling environment for generating income over US$ 10 per day
- Become most affordable healthcare providing nation
- Emerge an entrepreneur centric country (having highest number of entrepreneurs) with highest number of highly technically qualified S&T persons leading & involved in building world class micro, small and medium scale enterprises;
- A destination for Highest S&T output per dollar of investment. Not only in quantitative measure but also in quality manner;
- A Food Surplus nation through desired technological intervention;
- A nation where population's "Nutrition Level" is higher than global average;
- A nation which employs water efficient technologies, potable water is available to all & natural water resources are enriched employing innovative mechanisms;
- Strategic sector to become technology & product supplier rather than importer; and
- Emerge as the Highest "Happiness Index" country.

The Expert Group has also identified some priority themes for the 12th Plan. They are:

- Increasing the outlay for Science and Technology sector to match the global trends
- Setting up a number of mission mode programmes and Technology Missions

- Development capacity for designing and developing research instruments
- Special mechanisms for support of centers of excellence and outstanding schools
- Focus on oriented basic research for meeting the national priorities on food and nutrition security, affordable health care, energy and environment security, home land security and sustainable water supply
- Consolidating the benefits of R&D outputs from both strategic and non-strategic sectors
- Building both institutional and human capacities as well as leadership for meeting the needs of the Indian science and technology sector and
- Balancing between the social contract of science and need to emerge global leader in some knowledge domains of science through excellence

Recommendations of the DST Working Group

The Planning Commission then constituted Working Groups for various S&T sectors and Ministries/Departments. A Working Group for drafting a 12th Plan proposal for the Department of Science and Technology was also formed. The Working Group noted that DST's activities and functions could be broadly classified into the following six areas —

1. Formulation of policies relating to Science and Technology
2. Strengthening Basic Research and Expanding R&D base-Human Capacity
3. Strengthening Basic Research and Expanding R&D base-Institutional Capacity
4. Implementing Technology Development Programs
5. Societal interventions of S&T
6. S&T co-operation / Partnerships and Alliances

Developing further on the ideas and directives of the Planning Commission and the Expert Group, the DST 12th Plan Working Group felt that the country was faced with the following challenges while making plans for the 12th Plan period:

- Inadequate linkages among academy, research and industry,
- Ageing Institutional Framework,
- Weak innovation ecosystem to convert ideas into programmes and into useful acceptable products and process,

- Low base of full time equivalent scientists per million population and S&T manpower base,
- Balancing between basic research and well directed and focused research.

The Working Group felt that there had to be some paradigm shift in the 12th Plan and the planning process needed to be output-led. It would be useful for DST to fix priorities for the 12th Plan keeping in view the objectives of its various functions. In particular, it would be important to focus on the following:

- Undertaking oriented research for providing vital inputs in all aspects of development particularly in socially relevant sectors such as agriculture, education, health care, food, energy, water, minerals etc.
- Serving as an instrument for rapid economic development by providing technological inputs to the industrial sector on forms of innovation.
- Building both institutional and human capacities as well as leadership for meeting the needs of Indian Science and Technology Sector.
- Creating knowledge-society by way of Research Publications and IPR generation through appropriate research programmes.

The Working Group further divided the work of developing the Department's 12th Plan proposal among six Sub-Groups, one for each of the six activities and functions mentioned above.

The Sub-Group on "Strengthening Basic Research and Expanding R&D base-Human Capacity"

The Sub-Group formed by DST to look at (in short) Human Capacity Building has the following composition —

1.	Prof. P. Balaram (IISc Bangalore)	Chairman
2.	Prof. L S Shashidhara (IISER, Pune)	Member
3.	Prof. Devang V. Khakhar (IIT Mumbai)	Member
4.	Prof. Dinesh Singh (Univ. of Delhi)	Member
5.	Prof. G. Rangarajan (IISc, Banglore)	Member
6.	Dr. Sibaji Raha (Bose Institute Kolkata)	Member
7.	Prof. S.C. Lakhotia (BHU, Varanasi)	Member
8.	Dr. R. Luthra (CSIR, New Delhi)	Member
9.	Dr. P. Prakash (UGC, New Delhi)	Member
10.	Prof. Giridhar Madras (IISc, Bangalore)	Member
11.	Dr. Pratishtha Pandey (DST, New Delhi)	Member
12.	Dr. Praveer Asthana (DST, New Delhi)	Member Convener

CHAPTER 2

OVERALL OBJECTIVES

The Terms of Reference of the Human Capacity Building Sub-Group, as assigned by DST, is as follows —

- To recognize potential areas of gaps in human capacity in the form of both quality and quantum needs.
- To examine various means of strengthening human capacity in a pragmatic time frames and suggests some possible approaches.
- To review some ongoing measures and suggest means of further strengthening useful measures.
- To suggest road map for expanding the R&D base without loss of quality.
- To suggest possible means of promoting private sector participation in capacity building for R&D in industrial sector.
- To suggest some innovative ways of building human capacity for research and development in a time bound manner.
- To review quantitative deliverables proposed by the Department in the area and suggest alternative targets, if any.
- To suggest indicative of budgetary needs for the objective.
- Any other priorities of choice of the Committee.

The DST Order desired that the Sub-Group studied the following suggestions and included it suitably in its Report —

- Suggestions of possible study reports for strengthening the 12th plan proposals
- Suggestions on the timely implementation methodologies for 12th plan targets
- Suggestions of consultation processes

The Sub-Group met two times and had detailed discussions on the overall HR scenario for basic research, various ongoing programmes of DST and other agencies and their strengths and weaknesses and then made concrete suggestions on modifications in/strengthening of existing programmes as well as some new programmes. Those proposals are given in the succeeding chapters. Needless to say, the Sub-Group seriously kept in view the overall national goals laid down by the Planning Commission and the Expert Group and the DST goals as listed by the DST Working Group.

CHAPTER 3

XI PLAN ACHIEVEMENTS INCLUDING REVIEW AND PHASING OUT/ MERGING OF ANY PROGRAMMES, IF REQUIRED

(*)[1] Funding situation for S&T saw worsening during mid-1990's with GERD dipping to 0.70 % of GDP during 1994-96 period. It was in the 9th Plan period (1997-2002) that the R&D funding in the country started looking up and the R&D landscape started changing. The Government further consolidated these efforts during the 10th and 11th Plan periods. In particular, efforts have been made to maintain a Composite Annual Growth Rate of 25-26 % since 2004. However, as a general feature, it can certainly be said that the planning so far has been input-led. In other words, in the context of human capacity building for basic research, the basic requirements of the scientific community in the research and higher educational institutions in terms of discipline-wise needs were met to ensure competitiveness at the international level. What has not been asked so far are the following: (a) what should be the knowledge output (publications, patents etc.) from the country in a particular year; (b) what is the number of manpower in each class (faculty, students, R&D professionals, technical support manpower etc.) required for achieving the desired output; (c) how can we consciously take steps to generate this manpower considering the contrasting factors prevalent in the country; (d) how can we improve the quantity and quality of knowledge-output from the existing manpower in the basic research sector?

The Indian S&T sector, however, despite the absence of conscious output-led planning, has responded very favourably to the increased R&D funding in the 10th & 11th Plan Period. As a result of this, India has registered an annual growth rate of scientific publications at ~12 % as against the global average of ~ 4%. The Global Research Report brought out by Thomson Reuters in October 2009 has brought out the increasing growth trends in publications. So far, there seems to be a clear correlation between investments and, at least, basic research outputs from the country. Several reports containing global R&D trends bring out positive trends in S&T output indicators for India during the last three years.

DST Programmes

DST has been the major scientific agency for supporting basic research for close to four decades. It has consistently accounted for ~ 50% of EMR funding in the country. The Science and Engineering Research Council (SERC), established as part of DST in 1974, has provided the umbrella for supporting basic research by DST. DST has promoted basic research based on the following fundamental principles:

- Recognize the centrality of an individual scientist in basic research; support should therefore be across institutions, agencies and other such institutional barriers. Building Human Capacity is thus central to achieving excellence in basic research.

- Recognize that failure in achieving a pre-determined objective is an essential part of basic research as one operates in a completely uncharted territory at the very frontiers of knowledge; failure in achieving pre-determined objectives in such projects also generates valuable knowledge.

- Recognize that changes in research methodology from a pre-determined path during the course of investigation is also an inherent part of basic research for reasons similar to the one mentioned in the earlier point above. It is also quite often that one hits upon a bright idea and an entirely new domain during the course of an investigation which was started for a different purpose and proves to be very interesting and some time path-breaking and the scientist, driven by his curiosity, starts traveling on that path.

- Recognize that basic research is essentially curiosity-driven and knowledge-centric; support should therefore be based on the novelty and quality of scientific questions being asked and outputs should be judged basically by the knowledge-capital that gets generated out of the investigations like number and quality of peer-reviewed research papers, number of Ph.D.'s, post-doctoral fellows and technical manpower trained, patents obtained etc. Reasonable diversions and variations from original objectives in basic research projects is an inherent part of basic research.

- As frontiers in science advance at a very fast pace, as the knowledge is very specialized and as the challenges of traversing unknown territories in basic research are known only to actual practitioners in science, support and judgment about the output should only be based on scientific peer review.

- Provide necessary research facilities and manpower to enable the individual scientist to carry out his investigations.

- Recognize that basic research is a universal enterprise and recognition in basic research comes after tough and thorough international peer review. Naturally, a scientist, more than anything else, longs for and values international recognition. At any given time, there may be a large number of scientists researching on exactly the same problem and hence competition and rivalries are intense and speed of getting results is of utmost importance.

In the intervening period since 1974, changes have continuously taken place in the basic research enterprise. Some of the notable ones are:

- Basic research has increasingly become multi-disciplinary.
- Because of the complexity and sophistication of investigations, basic research has increasingly become a group activity, often involving multiple institutions in the country as well as abroad.
- Basic research has increasingly required more sophisticated (and hence more expensive) equipment and research tools.
- Internet has revolutionized the manner and speeds in which scientific information travels and is shared across the world.

In addition to these global developments, there have been some national realities to contend with while promoting basic research. For example,

- Small number of researchers in any given field.
- Relatively scarce resources for establishing research facilities before the 10th Plan.
- Loss of attraction among young students to pursue scientific research as a career.
- Diversity in the quality of educational institutions and the resulting students.
- Lack of sound broad-based Ph.D.-level training except in some institutions.

DST has shown considerable dynamism in adjusting to the evolving national and international realities and has come up with newer and newer programmes and instruments to enable the scientists to remain competitive in basic research.

A brief account of the DST programmes for building human capacity for basic research in the 11th Plan is given below. More structured details are available in Appendices xx-yy.

Individual-Scientist centric R&D Projects (SERC Projects): These projects, granted to individual scientists from any institution belonging to any organization and any discipline has been the mainstay of basic research promotion by DST. These are scientifically judged by Programme Advisory

Committees (PACs) and SERC, both consisting of the most eminent researchers of the country. This mode of support has been hailed by the scientific community as the lifeline of basic research in the country. These projects greatly aid in building human capacity for basic research, by (i) enhancing the research profile of the investigators; (ii) training doctoral students; (iii) training post-doctoral and technical manpower; (iv) way of increased interaction among researchers in the country and dissemination of the new knowledge that is generated. This programme of DST continued during the 11th Plan quite strongly. Out of the 4600 projects received, 2075 projects were funded with an average funding of about Rs.30 lakh per project for a 3-year project. An average of 4 research papers per project was produced.

Concerns: (i) long time taken in according financial sanction to a project, most of the time rendering the objective obsolete; (ii) increased restrictions by way of budget head-wise definitions; (iii) long time taken in hiring manpower and procuring equipment; (iv) lack of appreciation in Finance and Administration of both agencies and grant-receiving institutions about the inherent uncertainties of basic research and the resulting requirement of budgetary flexibilities.

Core Groups/ Nationally Coordinated Programmes (IRHPA): To promote intensive research in upcoming areas of basic research, DST extended support to core groups of competent scientists in existing institutions. During the 11th Plan, 15 such projects were funded out of 20 such projects that were received. These have helped nucleate or strengthen research in important areas such as Structural Biology, Micro-molecules, Neurosciences, Research in Oncology, High Magnetic Field Low Temperature Physics, Ferroelectrics, Display Technologies, Theoretical Condensed Matter Physics, Catalysis, Green Chemistry, Micromachining and Combustion Engineering in the country.

Concerns: Similar to the R&D projects.

Fast Track Scheme for Young Scientists: This scheme, built upon the earlier Young Scientists Scheme, continued in the 11th Plan period also. This provides fellowship (currently Rs. 35000/- per month consolidated) and modest research support in the form of a 3-year project (currently up to a maximum amount of Rs. 23 lakh (including the fellowship) to young post-doctoral investigators below the age of 35 years (with 5 years relaxation for women/SC/ST/OBC candidates). These projects have in-built portability, i.e. these can be easily transferred from one institution to another, keeping in view the needs of its target group. This is a very popular and sought after scheme of DST and has served the community well. During the 11th Plan, 1800 projects were funded out of 4000 projects at an average cost of Rs.15 lakh per project for 3 years. The number of publications per project per year is 1.2.

Concerns: (i) long time taken in sanctioning of projects; (ii) release of second and subsequent installment of grants.

BOYSCAST Scheme: This scheme, introduced in 1986-1987, continued in the 11th Plan period also. This is designed to send regular S&T personnel working in educational and research institutions for doing post-doctoral work in good institutions abroad in areas of national importance. Such scientists, after their stint abroad, have been able to strengthen research activities in their parent institutions. During the 11th Plan period, 323 Fellowships were awarded out of 940 applications that were received. Every BOYSCAST Fellow, on an average, was able to publish one paper during his stint abroad.

Swarnajayanti Fellowships: Started in 1997-98, this is the most prestigious fellowship scheme for scientists below the age of 40 years. Apart from the salary they draw, they get a fellowship amount of Rs.25,000/-. per month. The project value depends on the overall merit of the proposal and the research requirements. The project is granted for a period of 5 years. The recipients of this fellowship are some of the most outstanding scientists in the country. The scheme continued during the 11th Plan. Till now 87 Swarnajayanti Fellowships have been have been given, out of which 55 Fellows have received the prestigious Bhatanagar Prize subsequent to their getting the Swarnajayanti Fellowship. Each fellow publishes about 15-20 papers in 5 years.

Concern: The time taken in sanctioning of the grants.

Ramanna Fellowships: This scheme was designed to reward excellent performance in a basic research project funded by DST by awarding a succeeding 3-year project with a small honorarium for the PI and a flexible budget. The qualification criteria were recently made slightly more stringent by DST. During the 11th Plan, 100 such Ramanna Fellowships were granted.

Concerns: The time taken in sanctioning of the grants.

JC Bose Fellowships: This fellowship was instituted in 2006 to recognize (on search-cum-selection basis) outstanding researchers holding regular positions in educational and research institutions in the country and grant them a monthly fellowship in addition to their salary (presently Rs.25,000 p.m.) and a liberal research grant of Rs.10.0 L per year for 5 years with flexibilities to spend it for various research requirements including one international travel per year for self for attending international conferences. About 25 JC Bose Fellows are supported every year. The JC Bose Fellows have been able to publish, on an average papers with IF ranging from 26.309 to 3.295 in Physical Sciences, from 1.304 to 0.382 in Mathematical Sciences, 34.480 to o.040 in Chemical Sciences, 4.157 to 0.782 in Earth and Atmospheric Sciences, 8.379 to 0.592 in Engineering Sciences and 42.198 to 4.380 in Life Sciences

Concerns: Time taken in sanctioning of the grant and subsequent annual installments.

Ramanujan Fellowships: These fellowships, also instituted in 2006, aim at attracting outstanding scientists, mainly from abroad, to work in leading laboratories in the country. Each fellowship currently carries with it a fellowship amount of Rs. 75000/- p.m. and a liberal and flexible Contingencies grant of Rs. 5 lakh per year for 5 years. About 15 Ramanujan Fellows are supported every year.

Concerns: Time taken in sanctioning of the grant and subsequent annual instalments.

Women Scientists Scheme: This scheme was started in 2002 as a re-entry scheme for women who have training in science but who get out of mainstream science because of family and motherhood responsibilities. This scheme has three components, WOS-A, B and C. WOS-A deals with women scientists in basic and applied research. Such women scientists receive 3-year research projects after peer-review once they submit a project with a scientist mentor from an institution. These projects have in-built portability to accommodate movement of such women scientists. This scheme naturally accommodates break in career of women scientists because of family and motherhood reasons. Currently, this scheme is open to Ph.D. or equivalent candidates up to 50 years of age and M.Sc. or equivalent candidates up to 35 years of age. The support is granted in the form of research projects of 3-year duration up to a maximum cost of Rs. 23 lakh. This includes the fellowship amount for the woman scientist (currently Rs. 35,000/- p.m. for Ph.D. category and Rs. 20,000/- p.m. for M.Sc. category). In the 11th Plan, 733 women scientists received such support out of 2356 applications received. On an average, these projects have resulted in 500 papers in refereed journals. During this period, 30% recipients of such projects got permanent positions and resumed their scientific career. Considering that this community had decoupled from the R&D system, this scheme has led to a net gain in the research workforce of the country.

Concerns: (i) Time taken in sanctioning of the grant and subsequent annual installments; (ii) difficulty in transfer of projects from one institution to another; (iii) very strict selection criteria not commensurate with the limitations of the target group; (iv) still poor catchment area.

SERC Schools: This concept of 3-4 week intensive classroom teaching on advanced topics in various subjects for doctoral students was started more than 25 years back. In several subjects like Theoretical High Energy Physics, these Schools have continued uninterruptedly for the past 26 years. The courses are meticulously planned and delivered by the best researchers and teachers in the country and the students (~ 50 per School) are selected from across the country. In experimental disciplines, hands-on training on model experiments is also given. These Schools have been hailed unanimously as the single most successful experiments in training of young quality manpower in the country. In many disciplines, most of the faculty appointed in some of the best institutions in the country in recent times have attended one or more such Schools. They all acknowledge the positive role these Schools played in shaping their research careers and enhancing their research capabilities. During the 11th Plan, 100 such Schools were organized in different disciplines.

Concerns: (i) delay in sanctioning of grants; (ii) reduction in each grant, not commensurate with the increased costs; (iii) conservative viewpoint adopted regarding payment of honorarium to lecturers who have to spend considerable time.

Seminar Symposia Scheme: This has been a very popular scheme of DST which enables organization of national and international conferences in the country by extending partial financial support. This has greatly helped in increasing interaction among scientists, training of scientists and establishment of networks. During the 11th Plan, 2000 conferences were supported with an average grant of Rs.1.9 lakh per event.

Concerns: Delay in sanctioning of grants.

International Travel Support Scheme: This is another very popular and long-standing scheme of DST through which scientists and doctoral students are supported to attend conferences and schools abroad. DST used to sanction partial travel support earlier, but from 2009-2010, the scheme extends full travel support. During the 11th Plan, 5800 candidates were supported out of 14,600 applications at an average cost of Rs. 50,000/- per travel.

Concerns: (i) delay in sanctioning of grants; (ii) delay in settlement of travel claims.

INSPIRE Scheme: This has been a flagship scheme of DST in the 11th Plan. This is the largest- ever scientific manpower attraction and nurture scheme anywhere in the world. This targets students from the age of 10 and nurtures them till 32 yeas of age. This scheme has four components –INSPIRE Award, INSPIRE Internships, INSPIRE Scholarships, INSPIRE Fellowships.

During the 11th Plan so far, the number of candidates receiving support under different components of INSPIRE are as follows: INSPIRE Award- 409831, INSPIRE Internship- 67949, INSPIRE Scholarships- 5640, INSPIRE Fellowships- 1092 have been given.

Nano Mission: Nano Mission is another flagship programme launched by the Government in the 11th Plan. This was built upon the earlier Nano Science and Technology Initiative (NSTI) of DST. It is an umbrella programme to support R&D in Nano Science and Technology in a comprehensive fashion. During the 11th Plan so far, 153 individual-scientist centric projects and 6 Units on Nano Science were supported. These projects are still ongoing. Analysis of some of the completed projects funded earlier reveals that (i) each individual-scientist project resulted in 10 papers in refereed journals with an average impact factor per paper of 2.1, ¼ patents, 2.5 Ph.Ds and 2 other technical manpower; (ii) each Unit/Centre resulted in 10.5 papers in refereed journals with average impact factor per paper of at least 2.1, 4 patents, 9 Ph.Ds, 39 other technical manpower. Under Nano Mission, in 11th Plan, M.Sc. (Nano Science) has been funded in 3 institutions and M.Tech. (Nano Tech) has been funded in 14 institutions. 143 M.Tech.'s and 23 M.Sc.'s have already been produced out of these programmes. The Nano Mission has also developed Model M.Tech. Syllabus which has been uploaded on the website for possible use by any institution. 30 attractive post-doctoral fellowships have been granted. In addition, 3 Advanced Schools, 2 International Conferences, 3 National Meetings and a number of other topical conferences have also been supported during 11th plan period. As a result of the Nano Mission initiatives, and the NSTI earlier, a community of about 1000 researchers has been built in the country.

Concerns: Delay in sanctioning of grants and subsequent installments.

Mega Facilities for Basic Research: This is another flagship programme launched by the Government in the 11th Plan. This programme was launched to create Mega Science facilities and launch Mega Science programmes in and out of the country to improve access to such state-of-the-art facilities for the Indian scientific community, especially from the academic sector. Under this programme, initiatives taken in 11th Plan are - Funding for the CMS, ALICE and LHC Grid projects at the Large Hadron Collider at CERN, Geneva has been continued. India is participating in Facility for Antiproton and Ion Research (FAIR) at GSI, Darmstadt, which is going to be a multi-faceted accelerator facility. It will enable Indian scientists to carry out experiments in particle physics including quark gluon plasma, nuclear structure physics and nuclear astrophysics using radioactive ion beams, atomic physics, etc. India has committed to contribute at least 3 % of the construction cost, mostly in kind. Seed Funding for R&D and prototyping work for the FAIR project have been provided to several groups. India has decided to join the Thirty Metre Telescope (TMT) project at Mauna Kea, Hawaii as an "Observer". During the "Observer" period, the Indian astronomy community is developing a Detailed Project Report and exploring possible in-kind contributions from the Indian institutions and the industry. Another project for setting up a twin beam line for macromolecular crystallography and high pressure physics at the Elettra Synchrotron Radiation Facility at Trieste, Italy has been initiated. The process of site-selection for the India-based Neutrino Observatory (INO) has also been completed. The process for financial sanction of the project has been initiated jointly by DAE and DST.

Most of these projects, except the LHC related projects are still in initial phase. During the 11th Plan so far, the India-CMS project has resulted in xx Ph.Ds and 70 papers in refereed journals; and the India ALICE/STAR project has resulted in xx Ph.Ds and yy papers in refereed journals.

Concerns: Delay in sanctioning of grants and subsequent instalments.

Cognitive Science Research Initiative (CSI): CSI, started in the year 2008, is to revolutionize research in various fields, such as: a) the nature and origins of mental disorders, of physiological, social and neuro-chemical origins; b) design of better learning tools and educational paradigms; c) search of better software technologies and artificial intelligence devices; and d) streamlined social policy formulation and analysis. This Scheme has three components: i) Major coordinated projects; ii) Individual Research Projects; and Post Doctoral Fellowship Program. Proposals received under Individual Research Projects category covers Psychology, Linguistics, Social Engineering, Education, Neurology, Bio Engineering, Biotech, Computer Technology and Artificial Intelligence. Department has supported 69 individual projects out of 226 applications received. Post Doctoral Fellowship under CSI, started in the year 2009, is granted in the form of research projects with the fellowship of Rs 35,000/- per month and research grant of Rs 1.00 lac per annum. Seven (7) PDFs have been supported last year against 28 proposals received. Two (2) coordinated projects have been supported; one on "language and cognition" with 27 PIs and the second on "cognitive networks" with 12 PIs. The first project is entitled "Language and brain organization in normative multilingualism" and the cost of the project is ` 4,64,50,200/- . This project addresses the relationship between language and cognition as human capacity with a special emphasis on the linguistic and cognitive diversity of India. The second project entitled "Generativity in cognitive networks" and the cost of the project is ` 17,37,05,000/-. This project deals with the study of manner in which mental functions emerge from interconnected neural architectures and focused on the integration of mental functions emerge from interconnected neural architectures and confused on the mental functions like emotion, thought and social cognition as well as evolution of these functions across evolutionary time. In addition to this, the Department has supported 6 Schools and 5 Conferences exclusively in Cognitive Science. On an average, the supported projects have resulted in 140 papers in refereed journals and 46 students have been registered for PhD.

Concerns: (i) Lack of trained man power, (ii) poor understanding of the subject, and (iii) inadequate budget.

Training Cell: The Department in close consultation with the Department of Personnel and Training and Planning Commission conducts training programmes for scientists and technologists working in Govt. sector. Targets under the Scheme are Scientists/Technologists working in the Department & Ministries of Central Govts., Public sector Units, Govt. Aided Research Institutes, Govt. Research Laboratories and Scientists/ Technologists working in State Governments. The Scientists and Academicians from Central and State Universities, Educational Institutions & Colleges, engaged in R&D in any discipline of Science & Technology, are also target under the scheme for one week and two weeks training programme. Scientists having completed minimum two years of service in Group 'A' and having two years of service left are eligible for the programmes. During the XI Plan period, 173 training programmes were conducted by Training Cell, Department of Science and Technology and about 4046 personnel were trained.

Autonomous Institutions

Indian Association for the Cultivation of Science: IACS is the oldest scientific research institute in India. The main focus of IACS is on basic research in four umbrella areas. The areas are as follows: Molecular Science, Material Science, Theoretical Science, and Biological Sciences. IACS has about 1850 papers in last 5 years and 415 in 2010. The total IF generated by IACS is 5021 in last 5 years (2006-10) and is 1083 in 2010 alone. The total number of citations in 33,330 in last 5 years and is 8078 in 2010 alone. The citations per crore is 155 in one year (2010) for IACS. During the last five years the PhD produced is 193 in last 5 years and 39 in last year. This is about 0.5 per faculty per year. Currently there are 80 faculty members in IACS. The current h-index of IACS is 82 and eleven faculty members have h-index> 25.

Bose Institute, Kolkata: Major Research programmes in last 5 years have been on i) Improvement of Plants :Biotechnological, Genomic and Proteomic Approaches, ii) Protein Structure, Function and Engineerin iii) Molecular Medicine, Microbial Genomics and Infection Biology and iv) Basic and Applied Problems in Physical and Environmental Sciences. The institute has 730 publications in last 5 years and 1620 Impact Factor Aggregates in last 5 years. The citation frequencies till 2009 are average of 2.5 per paper. The total number of faculty with H-Indices above 25 is 4. 13 Patents during the last

5 years have been filed/ granted. The Post Graduate and PhDs trained in last 5 years are 105 and 200 respectively.

Centre for Soft Matter Research: Centre for Soft Matter Research is formerly called Centre for Liquid Crystal Research. The main objective of the Centre is to focus on basic science and to develop a bias towards technology, in line with the international trends on Soft Matter including liquid crystal materials. The centre is engaged in research and development on a variety of liquid crystal materials and other soft materials like gels and polymers. This is the only centre in the country devoted to research and developments in liquid crystals and other soft matter. The total number of publication in last 5 years is 127 and 7 PhD produced, and 1 Indian patent filed and granted.

S N Bose National Centre for Basic Sciences, Kolkata: *T*he institute has 30 regular faculties, 130 students and about 20 post doctoral researchers; the centre has become a premier hub in Physics in some focused research areas. In last 5 years, the faculties have produced 720 publications in major referred journals which are an average of 4.8 papers per faculty per year. This is significantly better than which is average of 4.8 papers per faculty per year. The main activities are focused in four major areas i) Physics of Nanomaterial ii) Advanced Computational Materials iii) Interface of Biology and Condensed Matter Physics iv) Collective Behavior in Quantum and Classical condensed state and v) Theoretical work in Black Holes

Chapter 4

CHANGING NATIONAL SCENARIO AND THE ROLE OF DST

*2 The 12th Plan period, 2012-17, present before the planners a very different landscape of the country. The single greatest change that one finds in that country is on the path of robust economic growth, which is expected to be ~8-9 % during the 12th Plan period. India's foreign exchange reserves are also recording impressive growth. So, considerably more resources, both in Rupee and FE terms, are available for deployment.

In the context of S&T, there is another feature of our growing economy which should be a matter of pride and satisfaction. Emergence of knowledge economy has freed economic prosperity from capital resources and, after a long time, given hope to countries like India to secure for its large population a level of economic prosperity, hitherto unimaginable, based on the knowledge-resources of its young population. The dream of the country, as mentioned in the Scientific Policy Resolution of 1958, is getting realized only now. However, in the globalized economic world order, this also means that we need to maintain an edge in knowledge and technology generation.

In the context of national economic scenario, we must remember that the per capita income, despite impressive GDP figures, remains low. Increased availability of information, on the other hand, has increased aspirations of all sections of the population for better development and better standards of living.

So, both continued economic growth and increasing aspirations of our large population demand that the knowledge sector must deliver for economic and social well-being of the people. In the context of S&T, it means that Science must latch on to technology properly and Technology must pull Science strongly. This connectivity has traditionally been poor in India. Some sectors like biotechnology and drugs and pharma have, however, proved then the country's R&D system can respond quite well to increased demand from the technology and market side. It may be noteworthy in these context that —

(a) Private pharmaceutical companies in India have been registering an increase in R&D investment since 2000 at the rate of ~ 35% per year.

(b) Currently, about 14% of India's net domestic product (GDP-depreciation) is composed of knowledge intensive products, though much of it from the services sector. And, growth in knowledge-intensive production surpasses that of the economy overall.

(c) Although manufactured exports are still dominated by low-tech products, the share of high-tech products has doubled in the past 20 years. India has become the world's largest exporter of IT services since 2005 and exports of aerospace products have been increasing at a rate of 74% per year, compared to 15% for world exports of these products.

(d) India is acknowledged to have considerable technological capability in the design and manufacture of spacecraft and is acknowledged to be a global leader in remote sensing. In terms of Space Competitiveness Index, India ranks higher than South Korea, Israel or Brazil.

(e) India has been ranked in a recent US study as the second major country with manufacturing competence. This study has ranked India ahead of Korea, USA, Japan and many other countries. This study also predicts that India will close the gap with China within the next ten years.

It is clear that for India to acquire and retain a competitive edge in the global knowledge economy and to accrue for its people the benefits of development at increasing pace, human capacity needs to be built—both in number and in quality — for strengthening basic research expanding the R&D base. It is still true that new scientific ideas hold primacy over anything else in a competitive knowledge-generation environment. It is the originality of scientific ideas which ultimately leads to competitive, and at times even disruptive, technologies for the benefit of the society. Basic research, however, needs to be strongly coupled in the 12th Plan through structured mechanisms so that the knowledge-capacity gets translated into knowledge-products thereby strengthening the knowledge-economy and leading to a vibrant knowledge-society.

Human capacity building is also required now for some other self-explanatory, obvious and urgent reasons as mentioned in brief below.

*3

- India's growing young population implies higher enrolment ratio in the higher education sector in the years to come. The country is seeing a very rapid expansion in the higher education sector (both private and public) because of this. And, that requires quality teachers and researchers to continuously train good R&D personnel to feed into the industry, education and R&D sector.

- While large number of science and engineering graduates and post-graduates are being produced, the quality of their education is not up to the mark. In this rapid expansion phase, the quality of teaching has greatly suffered at the college/university level.

- The actual number of FTE involved in R&D is woefully small, around 1,50,000 in such a large country. In the context of basic research, this gets reflected in the small number (about 30,000) of refereed research papers produced by a country of our size and population. While this number has increased in recent times and growing at a good pace with increased share of papers from the university sector, the fact remains that the contribution from the university sector (which should ideally drive basic research) is still small. And, the large population of college teachers is still out of the R&D sphere.

*4 Despite impressive number of R&D labs being opened and operated in the country by multinational companies, R&D in industry as a whole is very minimal. The demand for qualified research professionals by R&D systems in industry is dominated by these multinational companies. This promotes production of Intellectual Properties (IPs) for international companies for exploitation abroad.

*5 DST, being the largest extramural basic research funding agency across agencies, institutions and disciplines, is uniquely placed to push the manpower development agenda for S&T in the 12th Plan. DST can target the entire manpower chain feeding into the national R&D system and launch and/or catalyze promotional programmes to build human capacity for basic research and expand R&D base in a holistic manner. Needless to say, DST will collaborate with all concerned national and international agencies in achieving this target. This will be obvious from the list of programmes being proposed for the 12th Plan and given in Chapter 8.

Chapter 5

CONSOLIDATION OF SUCCESSFUL ONGOING SCHEMES

In view of the current national scenario regarding manpower development for basic research, and based on the near-manifest consensus among scientists in the country, it is proposed to continue the following very successful schemes of DST in the 12th Plan also:

- Individual-Scientist centric R&D Projects (SERC Projects)
- Core Groups/Nationally Coordinated Programmes (IRHPA)
- BOYSCAST Scheme
- Swarnajayanti Fellowships
- Ramanna Fellowships
- JC Bose Fellowships
- Ramanujan Fellowships
- Seminar Symposia Scheme
- International Travel Support Scheme
- INSPIRE Scheme
- Nano Mission
- Cognitive Science Research Initiative
- Mega Facilities for Basic Research
- Training Programmes

The concerns expressed about the operation of these schemes are very similar and the following recommendations are being made by the Sub-Group for addressing the same:

- Operation of these highly stabilized schemes of DST should be entrusted to Special Purpose Vehicles like the Science and Engineering Research Board or outsourced to other institutions and organizations enjoying sufficient functional autonomy and a long-term financial and administrative decision-making set-up.

- IT tools must be effectively utilized for managing these schemes at the earliest to curtail the turn-around time for approvals and sanction.

- Needless duplication of paperwork, like submission of quotes for equipment prior to sanction to the funding agency and again during purchase, may be dispensed with.

- It may be useful to grant a total amount for Manpower and the choice of research personnel to be employed may be left to the PI and the grantee institution. This will considerably simplify the process at the agency-end.

The 5 autonomous institutions of DST have been doing very good work in basic research and must be enabled to further strengthen their profiles.

The Sub-Group recommends that the following 3 existing and successful schemes of DST be re-invented in a modified form during the 12th Plan to make them even more effective and fruitful:

- Fast Track Scheme for Young Scientists
- Women Scientists Scheme
- SERC Schools

This has been explained in Chapter 8 below.

Chapter 6

NEW APPROACHES FOR THE XII PLAN

*6 When we plan for human capacity building for basic research in India, we need to bear in mind the following realities:

- India is indeed a land of diversity. This diversity is everywhere, even among the quality and competence level of institutions, especially those in the higher education sector. It is important that we devise schemes to raise the research and teaching competence level of all classes of institutions (increase in level being different for different classes of institutions) so that the overall competence level in the country gets enhanced. The real problem of India is not so much of excellence, but the fall in average level of competence. The excellence over the years has become too peaked around some individuals and institutions. It is only when the average competence level rises that the ambience for creative excellence will get built.

- There is a very large population of scientists and teachers in the university/colleges who are inactive in research. Even drawing a small fraction of this population into active research will result in increasing some of the output parameters mentioned above.

- Increased opportunities for post-doctoral research in good institutions will help in improving upon the Ph.D. training of researchers.

- With graduate courses becoming a common feature of Ph.D. training now, and UGC making it compulsory for all Ph.D. granting institutions, it can be hoped that the doctoral training will become stronger and broad-based in the years to come, enabling the students to venture outside the narrow domains of their Ph.D. problem. This could be supplemented with SERC-School like courses which have been very successful so far.

- The culture of high-end R&D in the industry is missing. So, teaching and research institutions remain the only employers of R&D personnel. Students, therefore, get drawn to other avenues of employment in the industry because of better employment and career prospects.

- We seem to be selling R&D career to our youngsters on the possibility of Nobel prizes. Most of research all over the world is honest incremental addition to knowledge. It is only when the universal body of knowledge advances to a certain level and phenomena emerge which cannot be easily explained that some visionary in science comes up with a revolutionary idea. It is this sequence which throws up Newton's and Einstein's. We need to right-sell the R&D career based on the creative adventure that it offers as opposed to routine application of knowledge and even drudgery that they may encounter in other professions if they crave for creativity. And, of course, when consumerism is the social norm today, we need to make a R&D career reasonably well-paying and monetarily attractive. We cannot expect only the R&D personnel to behave as hermits in a society which is increasingly becoming money-driven.

- As a corollary to the preceding problem, the long time taken in starting a R&D career usually dissuades young persons from taking it up. Most Indian researchers come from middle-class or poor background and an early stable job is an important factor for them in making a career choice. We also have to remember that India does not have a social security cover like many western nations and a job is a matter of livelihood security.

*7 The approach for building human capacity for strengthening basic research and expanding R&D base should include the following —

1 Spot, attract, nurture and encourage sparks and talent for scientific research from under-graduate to post-graduate and doctoral studies through a life-long learning approach;

2 Reduce the artificial divide between educational and research institutions in India by promoting inter-institutional collaborative research projects;

3 Special promotional efforts for improving quality of science education right from the school level ;

4 Special promotional efforts for R&D in areas of national interest and gap areas for basic research in various disciplines;

5 Focused efforts to promote oriented basic research in sectors of national importance such as food and nutrition security, affordable health care, water, energy and environment security, etc.;

6 Promote multidisciplinary research wherever required;

7 Leverage international collaboration, wherever required; especially in areas requiring use of mega research facilities;

8 Promote collaboration between universities, research institutions and industry so that research output and innovations can be effectively commercialized and transformed into marketable products and services for last mile benefits;

9 Enable universities to create industry-ready talent pools, with practice-relevant skills;

10 Use universities expertise to upgrade industries talent;

11 Encourage universities to help solve specific operation-related problems of Industries

12 Synergize the expertise in universities and research institutions—in areas such as manufacturing, ICT and industrial management to enhance industrial productivity and efficiency;

13 Develop industry-relevant curriculum and research programme in universities and research institutions;

14 Develop enabling mechanisms for supporting R&D in private sector through public funds if the ultimate outputs relate to public and social good like job creation, food-energy-environment security and affordable health care.

*8 Participate effectively in global consortia for building mega research facilities for basic research. In absolute terms, reasonably large resources are now available in the national R&D system. In most developed economies, the R&D funding is shrinking. Coupled with India's credibility in basic research, this favorable condition has made global consortia engaged in building mega research facilities approach India for partnership. India very effectively participated in such global consortia in the 11th Plan period. In the 12th Plan, emphasis should be on choosing such projects based on our national strengths, importance of the expected science outcome and spin-offs in terms of advanced instrumentation and technologies for the Indian industry. Such investments now should be more consciously made based on our requirements and based on principles of joint funding and sharing of Intellectual Property.

Chapter 7

SELECTION OF XII PLAN TARGETS

*9 ***Relevant Parameters***

The road-map for 12th S&T Plan indicates that the 12th Plan should be an output-driven plan. When it comes to human capacity building for basic research, the output parameters that will be relevant are:

- Number of papers in refereed journals every year
- Number of papers per scientist
- Total Impact Factor of published papers every year
- Impact Factor/crore of EMR funding
- Impact Factor/scientist/year
- Number of Ph.Ds produced
- Number of Ph.D.'s produced per scientist/year
- Number of Master’s level thesis/project produced
- Number of UG projects guided
- Number of inter-institutional papers published in refereed journals
- Number of new faculty from universities/colleges who join the list of authors of refereed papers every year
- Number of technical/lab personnel trained

The number of inter-institutional papers may serve as a measure of establishment of research networks. Number of new authors from universities/colleges will indicate that larger number of teachers is being drawn into the research stream.

And, the relevant output parameter for human capacity building for expanding the R&D base is the FTE personnel engaged in R&D.

Available values of some important parameters

Values of not all the output parameters mentioned above are readily available. However, values of some important parameters are indeed available which can provide the basis for arriving at reasonable targets for the 12th Plan. Those are as follows:

Table		
Parameter	**Value (Year)**	**Source**
No. of research papers/year	36,261 (2008)	**UNESCO**
No. of Ph.D.'s in scientific subjects	7,000 (2008)	**NSTMIS, DST**
No. of colleges	31,324 (2010)	**NSTMIS, DST**
No. of universities	493 (2010)	**NSTMIS, DST**
No. of faculty in colleges/universities	5,88,334 (2009)	**NSTMIS, DST**
No. of FTEs of R&D personnel	1,54,840 (2005)	**NSTMIS, DST**
No. of Science Ph.D.'s among FTEs of R&D personnel	**19,546 (2005)**	**NSTMIS, DST**

Available trends/correlations

- India's share of publications globally is ~ 3%.
- India's share of FTE R&D professionals is ~ 1.9%.
- There seems to be a direct correlation between IF/crore and investment made as part of EMR projects. It is as follows –

IF/crore ~ 6.3 with 13 lakh/year for 3 years

IF/crore ~ 7.5 with 25 lakh/year for 3 years

IF/crore ~ 11 with 50 lakh/year for 3 years

- Currently, 3500 scientists supported per year with EMR grant of Rs. 13 lakh/scientist.
- Share of publications from the university sector has increased from 15% in 2000 to 31% in 2009.
- Number of scientific papers correlates directly with number of Ph.D. students. For India, publications/Ph.D. student is ~ 4.2 – 4.5.

The 12th Plan Targets

Human Capacity for Basic Research

When it comes to human capacity building for Basic Research, some basic parameters can help us lay down the targets for the 12th Plan.

(i) First and foremost is the number of research papers. The number of world publications has grown from 733305 in 2002 to 986099 in 2008 growing at an average rate of 34.5%. If we were to assume that this would grow at the same average rate till 2017, then the number of world publications will be 1555090 in 2017.

***Target 1*: India's share of world publications will be increased from the present 3% to 5%.**

This would imply that India should have 77755 papers in 2017, i.e. an increase of 4610 papers/year on an average which implies ~12% increase on an average.

(ii) The number of Science Ph.D.'s among FTE R&D professionals in the country is ~ 20,000. It will be a safe assumption that it is this population that produces research papers. That would imply that each such scientist is producing 36261/20000=1.8 ~ 2 papers per year. This seems to be a reasonable number per scientist. This, in turn, would imply that we must add 4585/2=2293 ~ 2500 new scientists/year till 2017 (headcount) if we are to achieve the publication targets.

***Target 2*: 2500 new researchers will be added to the research pool every year till 2017.**

Under INSPIRE, 1000 Ph.D. students will be added every year. Assuming that every student takes 4 years to complete Ph.D., about 250 scientists will get added every year. Again under INSPIRE, 1000 PDFs/Faculty will be added. So, INSPIRE alone will add 1250 new scientists every year. This implies that we shall have to bring 1250 new scientists into active R&D every year if we are to meet the publication target.

(iii) 1250 new scientists would have to come from the EMR project route. This is the national requirement. Keeping DST share at 50%, DST EMR schemes must add ~ 700 new PIs every year.

***Target 3*: 700 new investigators will receive EMR projects from DST every year till 2017.**

(iv) In this context, it will be useful if every scientist in the autonomous institutions of DST gets at least one EMR project so that the basic calculational parameters are straightforward apart from the other competitive academic advantages.

***Target 4*: Every scientist in the autonomous institutions of DST will obtain at least one EMR project.**

(v) The Strategy document and other plan documents for DST so far say that number of Ph.D. students should be raised to 10,000 per year.

***Target 5*: Number of Ph.D.'s will be ~ 10,000 per year in the 12th Plan period.**

Given that INSPIRE alone will be adding 1000 Ph.D.'s every year and 1250 EMR projects to new scientists (apart from the existing scientists) will be granted every year, the number of 10,000 from the present ~ 8000 per year is guaranteed.

<u>Human Capacity for Expanding R&D Base</u>

(vi) It has been suggested that the number of FTE R&D professionals should be raised from ~ 1.5-1.7 lakh to 2.5 lakh by 2017. Because of the programmes mentioned above, the additional manpower (headcount) to be added in the 12th Plan will be 12,500. Even if we assume that 100 new higher educational institutions will be added in the next Plan and with an average of 100 faculty per institution, this will only add another 10,000 in headcount. The only way to add significantly to FTEs is to bring into the R&D fold large number of college and university teachers (including engineering institutions) which are at present not active in research. This number is very large. The estimates are anywhere between 3 to 5 lakh. Many of these persons will be included in the 700 new PIs under Target 3. We can, however, attempt at bringing in additional 500 new PIs every year from the college/university sector.

***Target 6*: 500 additional new investigators from colleges/universities will receive EMR projects from DST every year till 2017.**

Even then, the total additional headcount of R&D professionals from new possible faculty and DST programmes will be ~ 23,000. ***There does not seem to be any way to have additional 1.0 lakh FTEs solely from research institutions and the academic sector. This will be possible only if R&D in the industrial sector picks up and becomes an employer of large number of engineering graduates, post-graduates and doctorates.*** This falls under the mandate of other Sub-Groups. This Sub-Group, however, lays down the following difficult target for itself.

***Target 7*: DST will establish 5 industrial R&D centres/companies on campuses of institutions during the 12th Plan.**

Some other targets mandated by the Strategy Document, RFD Document etc. in the context of human capacity building are:

***Target 8*: DST will institute a programme for quality improvement of science teachers including school teachers.**

***Target 9*: DST will establish a science management cadre to build leadership for promotion of R&D in the country.**

Chapter 8

TRAJECTORY & SELECTION OF NEW PATHS AND PROGRAMMES

The Main Principles

The main principles followed by the Sub-Group while formulating proposals for the 12th Plan were basically two:

- Recognition of different excellence/competence criteria for different sections of R&D manpower.
- Size-expansion of the R&D manpower base in the country.
- Identification of implementation mechanisms which permit scalability in terms of numbers.

The Trajectory

Guided by these three simple and self-obvious principles in the Indian context, the Sub-Group decided on the following trajectory for the 12th Plan –

Consolidate and re-invent (some of) the ongoing schemes: As mentioned in Chapter 5 earlier, all of DST schemes for supporting Basic Research have stabilized and matured over a very long period. On the positive side:

- Mechanisms to promote and support good and novel scientific ideas and projects from individual scientists, groups of scientists, one or more institutions belonging to even more than one country, institutional R&D outfits etc. already exist. DST has shown exemplary dynamism in responding to the evolving contours of basic research in different disciplines and different segments of the Indian scientific community;
- Robust peer-review mechanism has been put in place which has withstood the test on integrity over a very long period of time.
- Several initiatives taken by DST have led to nucleation and growth of entirely new disciplines of research in the country, at times culminating in establishment of even new departments/ministries.

On the negative side:

- The Basic Research and Manpower Development Schemes of DST have grown in number and size of their clientele and, consequently, DST has not been able to deliver funds to the scientists quickly;

- The budgetary restrictions and definitions have over the years become too rigid and do not respond to the requirements of the actual research methodology as practiced by scientists. While financial rectitude is to be respected by all, budgetary discipline needs to transcend mere head-wise accounting. This calls for newer approaches.

Based on these actual observations, the Sub-Group has suggested some changes in the implementation mechanism of most of the existing schemes. It has recommended re-inventing 3 of the existing schemes in the 12th Plan which will become clear from the description of the new schemes being given below.

Leverage latent R&D potential of presently inactive manpower: As is clear from the targets set in the previous Chapter for the 12th Plan, the crying need now is to engineer a sizable expansion of the R&D manpower base. Otherwise, the R&D enterprise in the country will not acquire criticality. It is already possible for competent scientists, groups of scientists and institutions to tap resources for their research. But the excellence criteria adopted by the peer-review system, with genuinely good intentions, squeezes out most potential researchers from the R&D system. The net result is that the absorptive capacity of the R&D system is reaching saturation on the one hand, and on the other, the R&D community continues to remain woefully small despite our large young population and growing enrolment ratios in the tertiary education sector. This pattern needs to be consciously broken in the 12th Plan by being more accommodating of varied levels of competence, adopting more realistic competence criteria for different segments of researchers, designing appropriate schemes and developing more socially-realistic guidelines for the peer-system. The Sub-Group has especially focused on two large, and still largely untapped, populations of potential researchers, viz. (i) College and university teachers and (ii) women. Schemes have been proposed which would not only provide research funding to these segments but would also provide effective training, mentoring and handholding to these potential researchers so that their research potential gets unleashed.

Build Research Networks: This is another aspect on which the Sub-Group has laid considerable emphasis. In India, the number of researchers in any discipline in any institution is very small. By building networks through inter-institutional projects, one would be able to supplement the intellectual power of each institution and also have a multiplier effect. In case of multi-disciplinary research and investigations requiring building and using major experimental facilities, research networks are a necessity. The competent groups and established institutions in the country know how to leverage this mode of doing R&D. Number of avenues exist in DST and other agencies to obtain funding for such networked/inter-institutional/nationally-coordinated projects. There have been quite a few success stories already in several areas of basic research. What are missing, however, are mechanisms for networking college and university teachers with established scientists and institutions. This will be a win-win proposition for both parties – it will provide training and mentoring opportunities to the college and university teachers and it will also provide research manpower to the established scientists and institutions. The Sub-Group has suggested some concrete mechanisms for doing this.

Provide continuous training: Scientific training of all classes of teaching and research manpower in the country – right from school teachers to college and university teachers and doctoral students – suffers from obsolescence and critical gaps. It is important to provide continuous training to all sections of such manpower so that the newer generation of scientists is properly trained. The Sub-Group has laid great emphasis on this aspect and suggested institutionalization of such efforts. While deliberating on this, it has kept in view the mega DST-MHRD programme BEST (Building Educators for Science Teaching) which is expected to take off in the 11th Plan itself.

Engage industry in R&D: This is an important, but much bigger, issue. This will be absolutely essential if the knowledge-capital of the country has to ultimately get translated into economic returns. The issue, therefore, falls more under the purview of some other Sub-Groups. The HR Sub-Group, however, deliberated on it from the point of view of industry being an absorber and employer of qualified R&D personnel. As pointed out in the previous Chapter, it will be difficult to expand the R&D base unless industry is able to increase its R&D activities and employ scientists and engineers for that purpose. The Sub-Group has suggested one possible institutional mechanism to promote R&D in industry and to build institution-industry network.

The Proposed New/Re-invented Programmes

Based on the above trajectory, the Sub-Group has proposed launch of some new/re-invented programmes in the 12th Plan. The details of these programmes have been given in Appendices B in the sequel. The objectives of these schemes/programmes are being described in brief below along with the proposed mode of their implementation.

Research Opportunity Scheme for College and University Teachers (ROSCUTe): The idea behind this scheme is to draw College and University teachers, especially from less-endowed State Universities, into active research through a relatively liberal and easy-to-operate research grant. [To be implemented by: DST in outsourced mode – through SERB.]

Visiting Associateship Scheme for College and University Teachers (VASCUTe): The idea behind this scheme is to enable College and University teachers, especially from less-endowed State Universities, to academically network with scientists in leading institutions in the country through a flexible and administratively convenient contact programme. This will help bring them into mainstream research, help them utilize state-of-the-art facilities and establish long-term academic contacts. [To be implemented by: DST in outsourced mode – through institutions with established research profile in the country.]

Doctoral Scheme for College and University Teachers (DOSCUTe): A large number of faculty in colleges, and some in universities, do not possess doctoral degrees. This scheme is for attracting this population to carry out their doctoral work without leaving their jobs. The aim is to reinvent the (earlier) Faculty Improvement Programme (FIP) of UGC and Quality Improvement Programme of AICTE. Such a scheme will increase the number of R&D professionals in, and research output from, the country. This will also improve the quality of teaching in such institutions. [To be implemented by: DST in outsourced mode – (i) in decentralized mode through identified institutions; (ii) in centralized mode through academies or SERB.]

DST College Improvement Programme: The aim of this scheme will be to improve upon the academic profile of selected degree and post-graduate colleges across the country. [To be implemented by: DST on its own.]

Inter-University Centres (IUCs): The aim behind creation of Inter-University Centres is to create enabling environment as well as an enabling infrastructure to help college and university teachers to enhance their research profile and productivity and to help in training different classes of teaching and research manpower. [To be implemented by: DST in collaboration with UGC/MHRD.]

DST Research Scientist Scheme: The aim of this scheme will be to offer contractual research positions with research grants in good institutions across the country. [To be implemented by: DST in outsourced mode – through SERB/another SPV.]

DST Post-Doctoral Fellowship Scheme: The aim of this scheme is to offer reasonably large number of post-doctoral positions to desirous doctorates rather quickly in good institutions. This will be done by making such positions available on a continued basis in good institutions across the country and leaving the selection to the host institution. [To be implemented by: DST in outsourced mode – in decentralized mode through identified institutions.]

Women Scientist Scheme: There are large numbers of bright women scientists who have to leave research career after Ph.D. because of family and motherhood responsibilities. The aim of this scheme is to encourage such women to re-enter into mainstream research. [To be implemented by: DST in outsourced mode – through SERB/another SPV.]

Women Post-Doctoral Fellowship Scheme: There are large numbers of bright women scientists who have to leave research career after Ph.D. because of family and motherhood responsibilities. The aim of this scheme is to help such women re-enter into mainstream research. Many such women, however, need some academic hand-holding to rediscover their research base before they can start handling independent projects. This scheme is being introduced to fill in this gap. [To be implemented by: DST in outsourced mode – in decentralized mode through identified institutions.]

Women Doctoral Fellowship Scheme: There are large numbers of bright women students who have to leave doctoral studies after Master's because of family and motherhood responsibilities. Most such women make a career in school teaching at an appropriate stage. The aim of this scheme is to encourage such women to come back to doctoral studies. The scheme will offer doctoral fellowships to such women. [To be implemented by: DST in outsourced mode – in decentralized mode through identified institutions.]

Training Scheme for Women in Scientific Services: There are large number of women with scientific training from Bachelor's onwards are available who cannot get into mainstream competitive R&D career because of a variety of social reasons. This educated and talented pool can be leveraged for a variety of scientific service jobs like patent search, lab technicians, science tutors, scientific editing, scientific data management, etc. This requires that we impart the professional skills to such women. The present scheme has been limited to patent search only. This new scheme attempts to enlarge the portfolio of training to be offered. [To be implemented by: DST in outsourced mode – in decentralized mode through identified institutions including some Inter-University Centers.]

School Science Teaching Improvement Programme: To train school science teachers in teaching modern scientific concepts. [To be implemented by: DST in collaboration with MHRD.]

Cadre of Scientific Officers: The aim of the scheme is to select appropriate scientific staff for R&D promotional activities, keep them updated with latest developments in various fields through appropriate training programmes, train them in addressing the specific and dynamic needs of management and administration of R&D programmes. [To be implemented by: DST in collaboration with other concerned agencies Science Ministries, States, UGC/MHRD, etc.]

Industrial R&D Centers in Research and Higher Educational Institutions: The aim of this scheme is promote high-end R&D culture in Indian industry so that the industry becomes an employer of significant number of researchers and basic research finds an enabling path for technology development. [To be implemented by: DST in collaboration with Ministry of Heavy Industries/DIPP/Public Sector Enterprises.]

Trajectory and New Programmes of Autonomous Institutions in the 12th Plan Period

Indian Association for the Cultivation of Science, Kolkata: This oldest research institution in the country plans to continue its advance in basic research in several frontier areas in the 12th Plan period. In the area of Molecular Science, IACS plans to focus on Synthesis of functional and chiral molecules with potential applications as drug, Single molecule spectroscopy, 2D-IR, Raman and vibrational spectroscopy, ion mass spectrometry, surface science. In Materials Science, major emphasis will be laid on Solar Energy, organic electronics and devices. In Theoretical Sciences, computer simulations of biological systems and materials will receive priority. In Biological Sciences, work on experimental biophysics and biochemistry will receive increased attention. IACS has set a target of 2500 research papers with cumulative Impact Factor of 10000, 50000 citations, 250 Ph.D.'s and an institutional h-index of 100 for the 12th Plan period.

Bose Institute, Kolkata: During the 12th Plan period, Bose Institute, Kolkata plans to undertake seven institutional programmes. They are: Plant Functional Biology of Stress Responses for Improvement and Exploring the Plant Genetic Resources; Structural Studies and Biophysical Problems; Computational Biology; Molecular Medicine; Basic and Applied Microbiology; Systems Biology; and Basic and Applied Problems in Physical and Environmental Sciences. They plan to further increase their basic research outputs further in the 12th Plan.

Centre for Soft Matter Research, Bangalore: In the 12th Plan, the approach will be to enlarge the research activities towards the interdisciplinary subject of Soft Matter encompassing physics, chemistry, biology and materials science. For example, it is planned to carry out studies on metallo-protein and lipid mixed monolayers which mimic bio-membranes; hetero-structure assembly of organic and inorganic colloidal photonic crystals for device applications; dilute semiconducting oxides, magnetic and non-magnetic doped ZnO and TiO_2, for device applications; room temperature multi-ferroicity in thin films and nanostructures; gas sensing by metal-porphyrin molecules at the single molecule level; high-density storage in thin films of non-planar metal-porphyrin derivatives; utilization of graphene substrates as highly efficient electrodes for gas sensors and biosensors; and so on.

SN Bose National Centre for Basic Sciences, Kolkata: The SN Bose Centre plans to consolidate its work on thermodynamics of small systems, black holes and non-extensive thermodynamics, nano-devices, low-temperature physics, quantum information sciences, etc. It will continue to have vigorous visitors' programme. In addition, it is planned to augment and strengthen the computational facilities at the Centre and also establish observational astronomy facilities. The Centre has set a target of 1300 research papers with average Impact Factor of 3.5, 8000 citations, 150 Ph.D.'s for the 12th Plan period.

Appendix A.1

Name of the Programme: Earth Sciences Programme (PAC-ES) under SERC

Target Group: The Scientists and Technologists who are working in the academic sector, National labs and other recognized R&D institutions and Centers of Excellence are eligible for SERC support.

Financial Mode: Grants in aid

Grants-in- aid is provided to carry out research in challenging areas of Earth Sciences, through extramural funding, facility creation and manpower development. Support for organizing national seminars as well as for attending seminars / symposia is also provided to young and deserving scientists. The scope of the programme includes study of Earth and Earth System Processes – it's coupling with the atmosphere & oceans. In this programme, individual R&D proposals attempting to carryout research in forefront areas of earth sciences are supported through peer review mechanism. Co-ordinated programmes are evolved wherever an integrated approach to understand a problem / phenomena is felt. Every year around 40 – 50 research projects are supported under the scheme. As part of manpower development several contact programmes and Summer / Winter schools are organized in areas of national / global interest. The Earth Sciences Programme is implemented through SERC Division of DST and is guided by a Galaxy of experts viz. the Programme Advisory Committee on Earth Sciences. The Programme Advisory Committee on Earth Sciences, in addition to recommending projects to be funded also shoulders responsibility to scout for talent to take up specific research problems, identifies gaps in research, information and advises DST on improving the research environment in the country through manpower training, Brainstorming sessions or facility creation. Several national facilities related to ICP-MS, ICP-AES, EPMA, Fission track dating etc have been supported to different Universities/ Institutions under IRHPA programme. Necessary efforts are also being made to create manpower around these facilities.

Implemented by : DST on its own

<u>Performance Indicator</u>

1. Publications in referred Journal,
2. Patents
3. Manpower trained
4. Facility/ Research Infrastructure created

Assessment of Program

The programme has created a good impact among all the earth scientists. After the dissolution of earth science division and closure of some sub programmes, it is the only earth science programme of DST which fulfills the need of the research community in earth sciences. Under this programme, a number national facilities and a number of good manpower have been generated which has catered to the needs of the research/ academic institutions. There is also a substantial increase in research publications in earth sciences during the last decade indicating a overall development of the programme.

Financial Year	No of Projects supported
2007-08-	27
2008-09	44
2009-10-	25
2010-11-	48

Appendix A.2

1.	**Name of the Programme**	**:**	**PAC - Health Sciences**
2	**Target Group**	**:**	Biomedical Scientists/ Doctors/ Clinicians/University / Institutional academic faculties such lectures/Readers/ Professors/ Retired Scientists/Emeritus Professor engaged in original basic/applied research in the various areas of Health/Bio-Medical sciences including emerging and front line cutting edge areas. Groups of researchers as per aforesaid target group from two or more organization. Age Group – Not specified: Regular position holder or retired from regular position. Institution: Academic/Research Institutions under Govt. /Private set up.
3.	**Financial Model**	**:**	Projects up to Rs.50.00 Lakhs excluding overhead charges for duration of 3-5 years consisting of following components. Staff salary, equipments, consumables, contingencies/other costs & travel.
4.	**Implemented by** DST on its own		Individual Scientists/researchers or group of scientists as per above target group working in a academic/research Institutions/Hospitals (Government or Private) Single or Multi-centric
5.	**Performance Indicators**		Grading on work done in the R & D projects leading to: - Generation of base line data; - New knowledge/know how/information - Development of diagnostic methods/devices/ processes; - Formulation and designs of new molecules - Development of new molecules from indigenous/herbal plant source - Study of mechanisms of actions - Translational research : bench to bed side for clinical use - No. of papers published in national/international and impact factor of the journal - Patents (process/product) filed or granted

		- No. of Ph.d registered/produced Training of manpower in the specialized area of medical sciences including surgical methods through project fellowship mode or supporting technical staff.
6	**Assessment of the Programme**	During the year 2007-08, 74 new projects sanctioned, 2008-09, 43 new projects were sanctioned and 2009-10, 56 new projects were sanctioned. Ten specialized training program/workshops organized for manpower development (2007-10)

Appendix A.3

Name of the Programme : PACs on Physical Sciences

i) Condensed Matter Physics and Materials Science

ii) Lasers, Optics, Atomic and Molecular Physics

iii) Plasma, High Energy, Nuclear Physics, Astronomy & Astrophysics and Nonlinear Dynamics

Target Group: Scientists working in various in various academic Institutes and research Labs in regular basis.

Financial Model: In this programme financial support for

Manpower such as JRF, SRF, Research Associate, Project Assistant, Scientists are provided as per the requirement in the project. In addition to these in a very special cases honorarium to the PI/Co-PI has also been provided.

In addition to Manpower funds for required Equipment, Consumables, Contingencies and travels are provided.

Some amount of grant (20% of the cost up to a limit of Rs 5,00,000/- for the Academic Institutes and Rs. 3,00,000/- for Research Labs) is provided as Over Head to the host Institute for providing infrastructural facilities.

Implemented by : DST on its own through a Member Secretary

Performance Indicators: The projects are monitors and guided by Programme Advisory Committee (PACs). While recommending future projects, performance of the earlier projects are also considered. During monitoring the committee considered the amount of work done against the proposed objectives. To judge this the PAC considered the presentation by the PI, publication made, manpower trained in the project etc. After the completion of the Project Completion Report (PCR) submitted by the PI are also got evaluated by the experts.

Assessment of the Programme:

Before selecting any project for support the following steps are taken.

i) The proposals are sent to various referees' in addition to the PAC members for their comments on the proposal

ii) The PI is then invited for a presentation on the proposal before the PAC.

iii) Considering the proposal, the referee comments on it and presentation made by the PI, the PAC recommends some of the proposals for DST support.

iv) Finally the proposal is sent to Finance with appropriate budget and approval of Secretary, DST.

v) Once the project is sanctioned, the project is monitored by the PAC.

vi) After completion of the project, the Project Completion Report (PCR) submitted by the PI are also got evaluated by the experts.

Hence each project is financially checked and technically monitored.

It is found that project get the grades below:

Excellent : 08%

Very Good : 35%

Good : 45 %

Satisfactory : 12%

Appendix A.4

Name of the Programme Fast Track Young Scientist Scheme

Target Group Young scientists below the age of 35 years to pursue their bright ideas in newly emerging and front line areas of research in science and engineering.

Eligibility: PhD in basic Sciences or Masters Degree in Engineering/Technology, Medicine/Surgery, Pharmacy,

Veterinary, Agriculture or equivalent

Financial Model **Grant in Aid**

This Program runs in different subject areas such as Physical and Mathematical Sciences, Life Sciences, Chemical Sciences, Earth and Atmospheric Sciences and Engineering Sciences. The upper limit for duration of the project is 3 years with total cost limited to Rs.17.00 lakhs (excluding Overheads). Under this scheme funds are provided for equipments, consumables, travel and contingency. The Young Scientist not drawing any fellowship/salary are eligible for a lump sum fellowship of Rs. 20,000 per month apart from grants under travel, contingency, consumables and minor equipments. The proposals under the scheme can be submitted anytime in the year. So far, 600 young scientists have been awarded Fast Track Projects in various disciplines of Science and Engineering.

Implemented by DST on its own

Performance No of papers produced

Indicators No of patents if any

Assessment of the Programmme

Group monitoring workshops are organized and the grantees are called for presentation. This is carried out at the time of Mid- Term Review**.** The Project Completion Report is evaluated by the Expert Committee on respective subjects.

This has been a very popular programme. The number of proposals under this programme has been 1.5 times in 11^{th} plan period as compared to 10^{th} plan period

Appendix A.5

Name of the Programme : **Swarnjayanti Fellowship**

Target Group : People doing basic research in frontier areas of S&T. The applicant should have a selected PhD in Science/Engineering/Medicine. Scientists selected for the award should have accomplished innovativeness in research in cutting edge areas of Science and Technology. It is awarded to few outstanding young scientists.

Financial Model : Grant in Aid Model

Fellowship of Rs.25,000/- per month apart from the salary they draw from parent institution for 5 years. The award is open to scientist between 30 to 40 years of age.

Implemented by : DST on its own.

Performance Indicators : The project should contain innovative research idea and it should have a potential of making impact on R & D in the discipline. Scientist selected for the award will be allowed to pursue unfettered research with a freedom and flexibility in terms of expenditure as approved in the research plan.

Some of the Performance Indicators of the Award are:

No of publications; Awards and fellowship to the candidate; No of PhDs produced; Any novel research emerged.

Assessment of the Programme : The selection process has 3 levels of scrutiny:

a) The Subject Expert Committee in each discipline

b) The National Core Committee for all shortlisted candidates

c) The Empowered Committee of Secretaries consisting of Secretary, DST, Secretary Planning Commission, and Secretary Expenditure.

The Empowered Committee makes the selection of fellows based on the recommendations of Subject Expert Committees.

No assessment of the Programme has been done so far as it is an award. Many fellows that were selected for Swarnajyanti Fellowships were subsequently selected as Bhatnagar Fellows or were selected as INSA or Academic Fellows. In fact, out of the 9 Bhatnagar Awardees during the year 2010, 7 were Swarnajayanti Fellows.

The Department has awarded 85 Swarnajayanti fellowships since 1997-98. No. of Fellowships awarded during

2008 - 2009 - 5

2009 -2010 - 5

Appendix A.6

Name of the Programme: Women Scientist Scheme A

Target Group

Women scientists without employment, with a minimum of Post Graduate degree, equivalent to M.Sc. in Basic or Applied Sciences or B.Tech. or MBBS or other equivalent professional qualifications, are eligible for this scheme. Maximum age limit for this category is 35 years at the time of submission of the application. The amount of fellowship for such candidates will be Rs. 20,000/- PM.

Women scientists without employment having a Ph.D. in Basic or Applied Sciences or M.Tech. or MD/MS, DM/MCH in Medical Sciences from recognized Universities can apply up to the age of 50 years. The amount of fellowship for such candidates will be Rs. 35,000/- PM.

Financial Model Grant in aid Mode

Implemented by DST on its own

Under this scheme preference is given to candidates having a break-in-career due to family reasons. The applications can be submitted anytime in the year. Project proposal should be submitted in active collaboration with an academic/R&D institution in the chosen subject area.

The scholarships have been instituted in the following subject areas: (1) Physical Science; (2) Chemical Science; (3) Mathematical Science; (4) Life sciences; (5) Earth Sciences; (6) Atmospheric Sciences; (7) Engineering Sciences.

WOS- A provides a research grant with an upper limit of Rs. 23 lakh (for Ph.D. or equivalent) and Rs. 20 lakh (for M.Sc. or equivalent) for a well-defined R&D project proposal for a period of three years. This grant will include the fellowship of the applicant and cost of small equipments, contingencies, travel, consumables etc. Institutional overhead charges will be extra.

Performance Indicators

- Research papers published in SCI Journals
- Women Scientist Scheme awardees getting regular positions in reputed institutions and industry
- Non- PhD Women Scientist completing PhD through WOS-A project.

Assessment of the Programme

In 10th Plan period about 396 WOS-A projects were awarded and in 11 th Plan period about 733 projects were submitted.

The programme was assessed by Task Force on Women Scientists in its meeting during May 2010 and praised the programme for addressing right target group and meeting its objective.

Sensitization workshops have been conducted in WOS-A scheme to encourage and mentor the women with break in career for pursuing research.

The last year indicates **35% approval rate** under the Scheme.

Analysis

The age-wise distribution of women scientist supported under the scheme show the maximum number (approx. 70% of selected candidates) are in the age group of **35-50** years, which seems to justify the age of the scheme.

Analysis of overall performance indicates that these women scientists have contributed more than **500 Research Papers** out of total research publications.

About **30%** Awardees have got employment in Universities and national labs.

Appendix A.7

Name of the Programme **INSPIRE PROGRAM**

Target Group i) **INSPIRE Award** **-** Students in the age group of 10-15 years (6^{th} to 10^{th} standards shall be identified for award). Each INSPIRE Award will provide an investment of Rs 5000/- per child. Name of the student is nominated by Principal/ Head Master/Head Mistress.

ii) **INSPIRE Internship** - Top 1 % performance in 10 class Examinations of all school boards in the science streams

iii) **INSPIRE SCHOLARSHIP**- Top 1% at both 10^{th} and 12^{th} standards at respective State and Central Board Examinations pursuing courses in Natural Sciences, Students who have secured ranks in JEE, AIEEE and those clearing CBSE Medical and opt to study natural sciences. (Age- Group- 17-22 years)

iv) **AORC (Assured Opportunity for Research Careers)**

a) **INSPIRE FELLOWSHIP**- First Rank holder in M Sc./M Tech or equivalent enrolled for PhD degree (Age- Group – 22-27 years) for a period of 5 years.

b) **INSPIRE Faculty Scheme**- Assured Opportunity for post- doctoral researchers in the age group of 27-32 years through contractual and tenure track positions for 5 years in both basic and applied science area. Under this scheme, selection will be based on the research proposal to be peer-reviewed by an international and national Expert Peer Panel

Financial Model Grant in Aid Model

Implemented by DST on its own

Performance Indicators and Assessment of the Programme

Assessment of the Programme in this case is carried out by no of INSPIRE awards/internships/scholarship/ fellowships awarded each year under different components of the program. There are set targets for different components of the Program which are summarized below:

For **INSPIRE AWARD –** Every year 2 Lakh school children avail this award. The scheme plans to reach at least two students per secondary school during the next five years.

For **INSPIRE INTERNSHIP-** The target under this category is 50,000 students attending INSPIRE camps each year.

For **INSPIRE SCHOLARSHIP**- 10,000 Scholarships every year @ Rs 0.80 lakh per year is the target

For **INSPIRE FELLOWSHIP**- 1000 Fellowships every year is the target. Till now about 600 fellowships have been awarded to the candidate and about 400 candidates are in the provisional list.

INSPIRE Faculty Scheme – Assured opportunity every year for 1000 post-doctoral researchers in the group of 27-32 years through contractual and tenure track positions for 5 years.

Some data for different components of the INSPIRE Scheme.				
INSPIRE Components	**2009-10**	**2010-11**	**Total 2009-11**	**2011-12 (Anticipated)**
INSPIRE Award	126468	250009	376477	**200000**
INSPIRE Internship	10500	42555	53055	**50000**
INSPIRE Fellowship	-	640 (+400 Provisional Offer)	1040	**1000**
INSPIRE Faculty Scheme	-	-	-	**50**
Scholarship for Higher Education (SHE) INSPIRE Scholarship	**2007-08- 811 2008-09- 930 2009-10- 1378**	**1417**	**4536**	**2000**

Appendix A.8

Name of the Programme -Cognitive Science Research Initiative (CSI)

Target Group

- Scientists, Professors, Doctors, Engineers and Teachers working in realms of Mental Health, Social Engineering, Education, and Computer Technology under Individual Research Projects.
- PhD Scholars working in the area of cognitive science for Post Doctoral Fellowship Programme.

Financial Model - Grant-in-aid

Implemented by

DST on its own

Performance Indicators

- Research Papers
- Schools/Conferences
- Patents/products
- Trained manpower

Assessment of the Programme

Programme is just 2 years old. The information related to assessment is in the process of accumulation. However, as of today, 140 research papers have been published, 6 schools and 5 conferences have been supported, and 46 research scholars are enrolled for Ph.D.

Annexure-B.1

Name of the Scheme

Research Opportunity Scheme for College and University Teachers (ROSCUTe)

Nature of the Scheme

New Scheme

Target Group

Faculty in Degree/Post-Graduate Colleges and Universities.

Objective of the Scheme

The idea behind this scheme is to draw College and University teachers, especially from less-endowed State Universities, into active research through a relatively liberal and easy-to-operate research grant.

Financial and Implementation Model

The support will be provided in the form of 3-year research projects. Any such project will get added weightage in selection if it has an established scientist as an Academic Mentor from a leading national institution in the field.

Every PI of such a project will be entitled to have at most 2 such projects in her/his career, the 2nd project to be granted after successful completion of the 1st project as detailed below. The total cost of the 1st project will be Rs. 25 lakh and of the 2nd project, Rs.30 lakh.

The 1st project will be granted after peer review, but rather liberally. The elements of budgetary support will be as follows: Manpower (no JRFs/SRFs/Research Scientists; at most 1 RA and 1 Project Assistant or 2 Projects Assistants); Equipment; Consumables; Measurement Charges; liberal National Travel to encourage such scientists to interact with their peers elsewhere in the country (Rs. 2 lakh); liberal Contingencies grant (Rs. 3 lakh).

After completion of the 3-year period of the 1st project, the PI will apply for the 2nd project.

The 2nd project will be automatic if the PI has published/got accepted 2 papers in SCI journals in the 3-year period.

In case the PI is not able to meet the publication target, the peer-review committee will subject the 2nd project to a relatively more rigorous examination and make sure that the PI could not meet the publication target because of genuine reasons before recommending the 2nd project for support.

In order that the PI's research activities do not get interrupted in between the two projects, the 1st project may be extended by 1-year at no extra cost. She/he may, however, be given complete freedom to reappropriate funds among different heads to meet the "no-cost criteria". This aspect may be an integral part of the Scheme itself and should not require further approvals in each individual case.

The 2nd project may be granted a maximum of 6-month no-cost extension with freedom to reappropriate funds under different budget heads to complete some unfinished objectives of the project.

Output Parameters

Number of papers in SCI journals; Number of papers in Conferences; Number of papers with scientists in other institutions including the Academic Mentor; Number of RAs trained; Number of other staff trained; Number of the other competitive grants obtained during or after these projects.

To be implemented by

DST in outsourced mode – through SERB.

Annexure-B.2

Name of the Scheme

Visiting Associateship Scheme for College and University Teachers (VASCUTe)

Nature of the Scheme

New Scheme

Target Group

Faculty in Degree/Post-Graduate Colleges and Universities.

Objective of the Scheme

The idea behind this scheme is to enable College and University teachers, especially from less-endowed State Universities, to academically network with scientists in leading institutions in the country through a flexible and administratively convenient contact programme. This will help bring them into mainstream research, help them utilize state-of-the-art facilities and establish long-term academic contacts.

Financial and Implementation Model

Institutions with established research profile in the country will be invited to join this scheme in a proactive fashion.

Each such institution will be provided funds for secretarial staff to manage the scheme, travel and local hospitality of the Visiting Associates, consumables, contingencies, overheads, etc.

The grantee institutions would invite applications for Visiting Associates in their domain areas of research, through advertisement or through professional contacts. After peer-review of the applications by the grantee institutions, each selected candidate will be awarded a Visiting Associateship for 3 years. The peer review will be liberal in view of the enabling nature of this scheme.

Each Visiting Associate would be entitled to spend up to 3 *months every year* to pursue research in his area of research with a scientist in the institution and benefit from the infrastructural facilities and expertise available there. The Visiting Associate would get travel support up to a maximum of round trip economy air fare plus a fellowship of Rs. 10,000/- per month during his stay in addition to his salary in his/her parent institution. His/her board and lodging expenses and cost of his research will be borne out by the concerned institution out of the grant.

Output Parameters

Number of papers in SCI journals with scientists in the host institution; Number of papers in Conferences with scientists in the host institution; Number of new research topics/techniques to which introduced in the host institution; Number of new research facilities utilized in the host institution.

To be implemented by

DST in outsourced mode – through institutions with established research profile in the country.

Annexure-B.3

Name of the Scheme

Doctoral Scheme for College and University Teachers (DOSCUTe)

Nature of the Scheme

New Scheme for DST.

Target Group

Faculty in Degree/Post-Graduate Colleges and Universities.

Objective of the Scheme

A large number of faculty in colleges, and some in universities, do not possess doctoral degrees. This scheme is for attracting this population to carry out their doctoral work without leaving their jobs. The aim is to reinvent the (earlier) Faculty Improvement Programme (FIP) of UGC and Quality Improvement Programme of AICTE. Such a scheme will increase the number of R&D professionals in, and research output from, the country. This will also improve the quality of teaching in such institutions.

Financial and Implementation Model

The earlier FIP and QIP programmes could not sustain because of the strict limit (fairly short, 3 years) on time within which the faculty had to finish his Ph.D. Colleges and universities found it difficult to allow their faculty to be away for a long time. This reincarnation of the FIP and QIP schemes seeks to remedy the situation and make this scheme more realistic.

It is now proposed to increase the time limit for completing Ph.D. to 5 years. In order that the parent institutions agree to let the faculty go for such a long time, it is proposed to bear the salary cost of the faculty completely during his doctoral tenure. The parent institutions will then be able to hire faculty on temporary basis.

The following two models are being proposed for implementing this scheme

First Model

Identify leading research institutions and universities as hosts for this scheme. Ask them for a brief proposal identifying the number of such fellowships they can accommodate, discipline-wise. Grant them the budget for advertising, selecting and supporting such faculty fellows. This may include items like salary for faculty fellows, advertisement and selection costs, consumables, contingencies and travel.

Second Model

Such fellowships are advertised centrally and the prospective faculty fellows submit a proposal with a guide from a list of identified institution and with the consent of the parent and host institution. These applications are screened subject-wise and the projects are granted to the host institution like in the young scientist and women scientist projects at the present time.

Output Parameters

Number of faculty fellows obtaining Ph.Ds.; Number of papers in SCI journals; Number of papers in Conferences; Number of new research techniques learnt; Number of new equipments used.

To be implemented by

DST in outsourced mode – (i) in decentralized mode through identified institutions; (ii) in centralized mode through academies or SERB.

Annexure-B.4

Name of the Scheme

DST College Improvement Programme

Nature of the Scheme

New Scheme

Target Group

Degree and Post-Graduate Colleges

Objective of the Scheme

The aim of this scheme will be to improve upon the academic profile of selected degree and post-graduate colleges across the country.

Financial and Implementation Model

The support will be in the form of 5-year special assistance grants. This will include support for library, electronic connectivity, teaching lab upgradation and establishment of appropriate research infrastructure.

Proposals from colleges will be invited. Each such proposal will have a "mentor institution" which will pledge academic guidance and support to the college. The mentor institution will help in setting up the right teaching lab and research infrastructure, offer guidance in improving upon research papers by college faculty so that they get accepted/get accepted in better journals, help college faculty in establishing academic contact with other institutions in the country and so on.

Output Parameters

Number of papers in SCI journals; Number of papers in Conferences; Number of textbooks; Number of students who get selected in National Level Tests

To be implemented by

DST on its own.

Annexure-B.5

Name of the Scheme

Inter-University Centres (IUCs)

Nature of the Scheme

New Scheme

Target Group

College and University Faculty

Objective of the Scheme

The aim behind creation of Inter-University Centers is to create enabling environment as well as an enabling infrastructure to help college and university teachers to enhance their research profile and productivity.

Financial and Implementation Model

The IUCs will be located as far as possible on university campuses, but will be centrally funded and governed autonomous societies.

IUCs may be created for —

- Promoting research among college and university teachers in specific disciplines like IUCAA;
- Promoting science education like Homi Bhabha Centre for Science Education;
- Promoting use of major national facilities by college and university teachers like IUAC;
- Running doctoral programme for college and university teachers under the DOSCUT;
- Running refresher courses for college and university teachers;
- Running advanced SERC-like Schools for doctoral students in both theoretical and experimental areas with hands-on training;
- Running training programmes in scientific services like patent search, lab technician job, scientific editing, etc.
- Orientation of school science teachers; etc.

Experience has shown that such IUCs cannot only be service-providers. These will be scientific institutions with small core faculty of research scientists of its own. Otherwise they will not be able to help the college and university scientists with state-of-the-art knowledge in their domain areas. In addition, however, they will have good number of Scientific Officers who will run the other training and contact programmes under the guidance of the in-house scientists, but with the course content developed by the best scientists in the country. Similarly, the lecturers will also be national leaders in their field of specialization.

Some IUCs may have to be created afresh as new institutions. It is also possible to impart the character of an IUC to some of the existing research institutions by augmenting their support facilities and by adding some Scientific Officers to their staff. This may be a cost-effective of achieving the goal of inter-university coordination.

The IUCs will have good research facilities in specific domain areas, good e-connectivity and library facilities, good guest house and training facilities for typically 50-100 teachers at one time. They will be provided budget for their core scientific and support staff, equipment and infrastructure and their maintenance, travel funds for inviting college and university and funds for running various programmes, etc.

Output Parameters

Up-time of the facilities at the Centre; Number of training programmes conducted; Number of college and university teachers trained; Number of college and university visiting associates; Number of papers in SCI journals published by the visiting college and university scientists; Number of papers in Conferences by the visiting college and university scientists

To be implemented by

DST in collaboration with UGC/MHRD.

Annexure-B.6

Name of the Scheme

DST Research Scientist Scheme

Nature of the Scheme

Continuing scheme with modifications (a revised version of the existing Young Scientists Scheme of DST).

Target Group

Scientists with Doctoral degrees.

Objective of the Scheme

The aim of this scheme will be to offer contractual research positions with research grants in good institutions across the country.

Financial and Implementation Model

The support will be in the form of 5-year research projects. The budget will include the fellowship amount, equipment, consumables, contingencies and absolutely essential support technical staff. The fellowship and the total project cost will have a graded structure with 5 slabs to offer reasonable progression to a scientist in case of more than one successive project in the scheme. The peer committees will assign a particular slab to a scientist while recommending the project.

No age limit to be put for applying under this scheme.

Such fellowships will be advertised centrally and the prospective scientists will be asked to submit research proposals along with a mentor from a host institution. The applications will be peer-reviewed subject-wise and the projects will be granted to the host institution after securing their consent like at present.

Output Parameters

Number of papers in SCI journals; Number of papers in Conferences; Number of such scientists who get regular jobs after this project support.

To be implemented by

DST in outsourced mode – through SERB/another SPV.

Annexure-B.7

Name of the Scheme

DST Post-Doctoral Fellowship Scheme

Nature of the Scheme

New Scheme

Target Group

Scientists with Ph.D. degrees.

Objective of the Scheme

The aim of this scheme is to offer reasonably large number of post-doctoral positions to desirous doctorates rather quickly in good institutions. This will be done by making such positions available on a continued basis in good institutions across the country and leaving the selection to the host institution.

Financial and Implementation Model

No age limit to be put on the entry of candidates to this scheme. The fellowship amount will, however, be fixed.

Identify leading research institutions and universities as hosts for this scheme. Ask them for a brief proposal identifying the number of such PDFs they can accommodate, discipline-wise. Grant them the budget for 5 years for advertising, selecting and supporting such PDFs. This may include items like fellowship and contingencies for the fellows, advertisement and selection costs, consumables and operational contingencies.

Output Parameters

Number of PDFs; Number of papers in SCI journals; Number of papers in Conferences.

To be implemented by

DST in outsourced mode – in decentralized mode through identified institutions.

Annexure-B.8

Name of the Scheme

Women Scientist Scheme

Nature of the Scheme

Continuing scheme with modifications (a revised version of the existing Women Scientists Scheme of DST)

Target Group

Women with Doctoral degree.

Objective of the Scheme

There are large numbers of bright women scientists who have to leave research career after Ph.D. because of family and motherhood responsibilities. The aim of this scheme is to encourage such women to re-enter into mainstream research.

Financial and Implementation Model

The support will be in the form of 3-year research projects. The budget should include the fellowship amount, equipment, consumables, contingencies and absolutely essential support technical staff. The fellowship and the total project cost will have a graded structure with 5 slabs to offer reasonable progression to a scientist in case of more than one successive project in the scheme. The peer committees will assign a particular slab to a scientist while recommending the project. No age limit is put for applying under this scheme. And, no break in career should not be treated as a disadvantage.

Such fellowships will be advertised centrally and the prospective women scientist will be asked to submit research proposals along with a mentor from a host institution. The applications will be peer-reviewed subject-wise and the projects will be granted to the host institution after securing their consent like at present.

In case of relocation of the women scientist, the procedure of transfer of scheme should be simple. Since such projects only include minor equipments, duplication of equipments in the relocated institution may be allowed in case its transfer from the first institution becomes a problem.

Special effort will be required to spread this scheme in different regions of the country.

Output Parameters

Number of papers in SCI journals; Number of papers in Conferences; Number of women scientists who get regular jobs after this project support.

To be implemented by

DST in outsourced mode – through SERB/another SPV.

Annexure-B.9

Name of the Scheme

Women Post-Doctoral Fellowship Scheme

Nature of the Scheme

New Scheme

Target Group

Women with Ph.D. degrees.

Objective of the Scheme

There are large numbers of bright women scientists who have to leave research career after Ph.D. because of family and motherhood responsibilities. The aim of this scheme is to help such women re-enter into mainstream research. Many such women, however, need some academic hand-holding to rediscover their research base before they can start handling independent projects. This scheme is being introduced to fill in this gap.

Financial and Implementation Model

No age limit to be put on the entry of women to this scheme. The fellowship amount will, however, be fixed.

Identify leading research institutions and universities as hosts for this scheme. Ask them for a brief proposal identifying the number of such Women PDFs they can accommodate, discipline-wise. Grant them the budget for 5 years for advertising, selecting and supporting such Women PDFs. This may include items like fellowship and contingencies for the fellows, advertisement and selection costs, consumables and operational contingencies.

Selecting host institutions with good regional distribution will ensure that number of such Women PDFs will grow in every region. Women, in general, have the limitation of working close to the places where their family reside.

Output Parameters

Number of Women PDFs; Number of papers in SCI journals; Number of papers in Conferences.

To be implemented by

DST in outsourced mode – in decentralized mode through identified institutions.

Annexure-B.10

Name of the Scheme

Women Doctoral Fellowship Scheme

Nature of the Scheme

Continuing scheme with modifications.

Target Group

Women with Master's degree.

Objective of the Scheme

There are large numbers of bright women students who have to leave doctoral studies after Master's because of family and motherhood responsibilities. Most such women make a career in school teaching at an appropriate stage. The aim of this scheme is to encourage such women to come back to doctoral studies. The scheme will offer doctoral fellowships to such women.

Financial and Implementation Model

No age limit be put on the entry of women to this scheme. The fellowship amount may, however, be fixed.

Identify leading research institutions and universities as hosts for this scheme. Ask them for a brief proposal identifying the number of such fellowships they can accommodate, discipline-wise. Grant them the budget for advertising, selecting and supporting such women fellows. This may include items like fellowship for women fellows for 5 years, advertisement and selection costs, consumables, contingencies and travel.

Selecting host institutions with good regional distribution will ensure that number of such women fellows will grow in every region. Women, in general, have the limitation of completing their studies close to the places where their family reside.

Output Parameters

Number of women fellows obtaining Ph.Ds.; Number of papers in SCI journals; Number of papers in Conferences.

To be implemented by

DST in outsourced mode – in decentralized mode through identified institutions.

Annexure-B.11

Name of the Scheme

Training Scheme for Women in Scientific Services

Nature of the Scheme

Continuing scheme with modifications.

Target Group

Women with Bachelor's, Master's and Doctoral degrees.

Objective of the Scheme

There are large number of women with scientific training from Bachelor's onwards are available who cannot get into mainstream competitive R&D career because of a variety of social reasons. This educated and talented pool can be leveraged for a variety of scientific service jobs like patent search, lab technicians, science tutors, scientific editing, scientific data management, etc. This requires that we impart the professional skills to such women. The present scheme has been limited to patent search only. This scheme attempts to enlarge the portfolio of training to be offered.

Financial and Implementation Model

No age limit to be put on the entry of women to this scheme. The stipend amount and duration of training may, however, be fixed.

Identify institutions which can impart such training. Ask them for a brief proposal identifying the number of candidates they can accommodate, skill-wise. Grant them the budget for advertising, selecting and supporting such women candidates. This may include items like stipend for women fellows for appropriate duration, advertisement and selection costs, consumables and contingencies.

Selecting host institutions with good regional distribution will ensure that number of such trained women will grow in every region. Women, in general, have the limitation of completing their studies close to the places where their family reside.

Output Parameters

Number of women trained; Number of different skills in which women trained.

To be implemented by

DST in outsourced mode – in decentralized mode through identified institutions including some Inter-University Centers.

Annexure-B.12

Name of the Scheme

School Science Teaching Improvement Programme

Nature of the Scheme

New Scheme

Target Group

School Science Teachers

Objective of the Scheme

To train school science teachers in teaching modern scientific concepts.

Financial and Implementation Model

This will be in the form of Orientation Programmes consisting of lectures and hands-on lab training by leading scientists of the country. These will require an enabling infrastructure on continuous basis. NCERT, Regional Colleges of Education and the IUCs could be leveraged for running such programmes.

Output Parameters

Number of orientation programmes conducted; Number of school teachers trained; Number of instruction material developed

To be implemented by

DST in collaboration with MHRD.

Annexure-B.13

Name of the Scheme

Cadre of Scientific Officers

Nature of the Scheme

New Scheme

Target Group

Scientists managing R&D promotional schemes in Ministries/Departments, State Councils, IUCs etc.

Objective of the Scheme

The aim of the scheme is to select appropriate scientific staff for R&D promotional activities, keep them updated with latest developments in various fields through appropriate training programmes, train them in addressing the specific and dynamic needs of management and administration of R&D programmes.

Financial and Implementation Model

Such Scientific Officers will be selected and cadre managed by a Central agency like a Recruitment and Assessment Board. Depending upon their domain areas, such Scientific Officers will also have limited mobility among different institutions and agencies so that their client-adaptability improved with experience.

Output Parameters

Number of Scientific Officers in the cadre; Career growth profile of such Scientific Officers

To be implemented by

DST in collaboration with other concerned agencies Science Ministries, States, UGC/MHRD, etc.

Annexure-B.14

Name of the Scheme

Industrial R&D Centers in Research and Higher Educational Institutions

Nature of the Scheme

New Scheme

Target Group

Research and Higher Educational Institutions

Objective of the Scheme

The aim of this scheme is promote high-end R&D culture in Indian industry so that the industry becomes an employer of significant number of researchers and basic research finds an enabling path for technology development.

Financial and Implementation Model

Industry, especially leading public sector enterprises, will be encouraged to set up subsidiary R&D companies/R&D labs in leading research and higher educational institutions. The Government may also invest in such an outfit set up by a public sector enterprise to provide some incentive and to absorb some risk associated with R&D investments. In case of the Enterprise deciding to close down the outfit at some point of time, the infrastructure so created may be left for the use of the host institution.

Output Parameters

Number of scientists/engineers employed in the Centre; Growth in number of scientists/engineers employed in the Centre; Number of technologies/products/IP generated; Number of technologies/products/IP generated out of research in the host institution; Number of scientists from the host institution having joint R&D programme with the Centre; Number of papers in SCI journals; Number of papers in Conferences; Number of Ph.Ds/M.Techs/Projects generated

To be implemented by

DST in collaboration with Department of Heavy Industries/DIPP/Public Sector Enterprises

Annexure 8c

Report of the Sub-Group on "Strengthening Basic Research and Expanding R&D Base –Institutional Capacity" - for 12th Plan Document

PREPARATION OF THE SUB GROUP REPORTS FOR 12th PLAN OF DST

Broad Structure

1. INTRODUCTION AND BACKGROUND
2. OVERALL OBJECTIVES
3. XI PLAN ACHIEVEMENTS INCLUDING REVIEW AND PHASING OUT/ MERGING OF ANY PROGRAMMES, IF REQUIRED
4. CHANGING NATIONAL SCENARIO AND THE ROLE OF DST
5. CONSOLIDATION OF SUCCESSFUL ONGOING SCHEMES
6. TRAJECTORY & SELECTION OF NEW PATHS AND PROGRAMMES
7. NEW APPROACHES FOR THE XII PLAN
8. SELECTION OF XII PLAN TARGETS

1. INTRODUCTION AND BACKGROUND

It is universally acknowledged that the Universities are cradles of innovation and research in universities has three-tier effect concerned with the quality of under-graduate and post-graduate education and the value of research. This mode of research and generation of high quality manpower is most cost effective and *sine quo non* for development of India. There has been a serious neglect of support for research in Universities and there is a dire need to extend support for infrastructure for research and training.

India needs to stimulate and strengthen its entire eco-system—the formal science, technology and industrial system, as well as the innovation eco-system—to develop solutions for the country's agenda of faster, sustainable and more inclusive growth. Stimulating this eco-system requires enablers in the form of policies, strategies, novel ideas, and catalysts to effectively meet the challenges in the system.

2. OVERALL OBJECTIVES

Department of Science & Technology in line with its Result Frame Document (RFD) has broadly classified the activities towards preparation and development of the 12th Plan Document into six areas as:

i) Formulation of policies relating to Science & Technology

ii) Strengthening Basic Research and Expanding R&D base – Human Capacity

iii) Strengthening Basic Research and Expanding R&D base – Institutional Capacity,

iv) Implementing Technology Development Program,

v) Societal Interventions of S&T

vi) S&T co-operation/ partnership and Alliances.

While each area being dealt by a Sub-Group has many specific areas to look into in detail, the specific focuses of the Sub-Group on "Strengthening Basic Research and Expanding R&D base – Institutional Capacity" were as follows:

Table	
1.On-going Infrastructure related Programs	**FIST, Special Regional Packages (for NER, J&K and Bihar), PURSE, CURIE, SAIF**
2. On-going Mission-mode Programs	**Nano S&T Mission, Solar Energy Research**

3. Service Providing activity	**Patent Facilitating Centre, NATMO**
4. Autonomous Institutes	**Aryabhatta Research Institute of Observational Sciences, Birbal Sahni Institute of Palaeobotany, Wadia Institute of Himalayan Geology, Raman Research Institute, Institute of Advanced Study in Science and Technology.**

The Sub-group on "Strengthening Basic Research and Expanding R&D base – Institutional Capacity" was chaired by Professor M K Chaudhuri, Vice-Chancellor, Tezpur University, Tezpur. The Composition and Terms of Reference to carry out this task in a time bound manner is at **Annexure – 1**.

The Sub-group in its two meetings deliberated the assigned task within the overall Terms of Reference towards the development of a meaning document for 12th Plan period.

3. XI PLAN ACHIEVEMENTS INCLUDING REVIEW

3.1. On-going Infrastructure related programs

The S&T sector in the universities and related academic institutions are in dire need for strengthening the existing S&T infrastructure support with adequate funding and associated flexibility. To enable Universities & academic institutions for attracting fresh talent and pursue competitive research, enhancement of basic infrastructure, enabling facilities and creating conducive environment are most important today. This would in tern improve the visibility of the departments.

The present programs of the Department of Science & Technology like i) **Fund for improvement of S&T infrastructures in universities and higher educational institutions (FIST),** ii) **Promotion of University Research and Scientific Excellence (PURSE),** iii) **Consolidation of University Research for Innovation & Excellence (CURIE) in Women Universities** and iv) **Region specific S&T Packages like North-East Region (NER), J&K and Bihar** are being in operation towards this cause. While the program like FIST is on the competitive basis of support, the PURSE, CURIE for Women Universities and Special Packages are purely pro-active measures for augmenting the infrastructural facilities at University departments. Through these programs more than 1450 Departments at about 400 Universities/ College /academic Institute have been benefited by enabling them installing many state-of-the facilities in the Department. Special supports under PURSE, CURIE and region specific Special Package have also ripped the benefit towards improving the teaching and research at the university sector in endowed and less endowed areas in the country.

FIST Program

Considering the present status of the S&T sector in the universities and related academic institutions who are in dire need for strengthening the existing S&T infrastructure support with adequate funding and associated flexibility, the above scheme **"Fund for improvement of S&T infrastructures in universities and higher educational institutions (FIST)"** was launched in 2000-2001.

Under the Program the supports have been provided for basic infrastructure & enabling facilities and conducive environment for promoting R&D in new and emerging areas including ready access to information system, networking, databases & scientific journals and also to computational facilities. This would enable the Universities & academic institutions for attracting fresh talent and pursue competitive research. This would also enhance visibility of these departments.

Till 2008, the Program was operated in two levels of support e.g. Level – I & Level – II in six broad subject areas i.e. Life Sciences, Physical Sciences, Chemical Sciences, Engineering Sciences, Earth & Atmospheric Sciences & Mathematical Sciences. A two-tier committee structure i.e. i) FIST Advisory Board (FISTAB) and ii) six Subject Expert Committees were in place for implementation of the Program. From 2009, in the event of change in policy of support under the Program, `College as a whole' instead of a department in the College is considered for support and Level – 0 has been created with the same two-tier support mechanism.

Since 2000, the Program is advertised every year seeking new proposals from the University departments and Colleges in all areas of science, engineering, medicine, agriculture & veterinary. Using the above support mechanism the proposals are considered for support under the Program. Till 2010, more than 1450 departments spread over around 400 academic institutions including about 200 Colleges have been covered at a total investment of more than Rs 1138 crores. While the Year-wise details of the investment made since 2000 under the FIST Program are given at **Table 1**, the Subject Areas-wise distribution of the investment made so far is at **Table 2**. Currently, a smaller University Department i.e. in Level – I category receives an average support of Rs 90 lakh for five years and that of a Department in Level – II category receives Rs 490 lakh for 5 years. In addition to this, 36 Colleges as `College as a whole' have also been considered for support in the year 2009 & 2010 under the FIST Program. The Program has so far able to provide support about 65-70 % of the total investment to the University sector including Colleges under these universities.

The Program has enabled departments to install some of the state-of-art facilities such as Ion Chromatograph, Automated DNA Sequencers, Ultracentrifuges, FACS, Scanning Probe Microscope, Oligonucleotide Synthesizer, HPLC-cum–FPLC, Molecular Imaging System, Liquid Nitrogen Plant, Liquid Helium Plant, High Resolution Powder X-ray Diffractometer, Single Crystal X-ray Diffractometer, 300 MHz, 400 MHz & 500 MHz FT-NMRs, Mass Spectrometer, PPMS, Thermal Analyzer Systems, Plasma Deposition Etching System, Universal Testing Machines (UTMs), Reneshaw Raman System, Electron Microprobe Analyzer, High Resolution Microscopes, Confocal Microscope, Field Emission Scanning Electron Microscope, High Resolution Transmission Electron Microscope, Protein Sequencing Platform, Atomic Force Microscope, Scanning Tunneling Microscope, Vacuum Melting Furnace, High Resolution Mass Spectrometer, High Power Computational Facility, etc. Apart from this, more than all most all departments supported under the program have created a Computer Laboratory in the department which are being extensively used by students, research scholars and faculty members for computational and other activities like Internet browsing etc.. A large number of Wet Laboratories at universities and colleges mostly in the Chemistry and Life Sciences area have also been renovated to provide a modern look. The departments of small universities and colleges have also been benefited by acquiring Text Books for the Department level Library.

Since the monitoring & review is an essential component of the Program, the progress achieved in the project are also being reviewed in one of the three categories such as i) through Progress Report, ii) through Presentation by the Department concern & iii) through on-the-spot visit of the Expert Member(s) at the Department. The review of the progress for each project is carried out twice in five years tenure i.e. one in mid-term, primarily for any mid-course correction and another at the end of the project duration. The progress of each project is also graded in four types from Excellent to Fair which is used as one of tool for considering second time support to that department under the Program. So far all the projects supported during till the year 2006 have been reviewed.

An independent study was carried out by a Group of ISI, New Delhi under the leadership of Professor K B Sinha, former Director, Indian Statistical Institute, Kolkata for projects supported under this program and completed 5 years project duration. The study basically compared and analyzed pre & post FIST support scenario in each department with statistical methods. The salient findings of the study are as:

- Substantial increase in the number of Research Publications in SCI Journals as well as non-SCI Journals, Conference Proceedings & Books,
- Increase in enrollment of students in M Tech course in Engineering & Technology in post-FIST era,

- While an appreciable increase in enrollment of PhD students in Science subjects, statistically significant increase in MSc and PhD degrees granted in Life Sciences area in post-FIST period.
- Significant increase in funding received from other sources as sponsored projects during post-FIST in all other subject,
- Significant increase in recruitment at the Lecturer level in University Departments,
- In Engineering departments, generation of funds through consultancy increased by 3-fold in post-FIST period apart from increase in publications and also increase in Industry User of Laboratory facilities in Engineering Departments.

Special Regional Packages:

During 2008 and 2009, two special package programs one for the states in the North-East Region (2008), Jammu & Kashmir (J&K) state (2009) and Bihar (2010) were initiated for augmentation of the teaching and research at the S&T departments of the Colleges and Universities. While the NER Special Package is developed for a total estimated cost of Rs 70 crores for five years and that of J&K state and Bihar are about Rs 60 crores and Rs 76 crores respectively. The broad details on elements of support of a typical package are highlighted at **Annexure – 2.** Both these special packages are being implemented through Expert Committee headed by eminent academicians like Professor TP Singh of AIIMS, New Delhi for NER package, Professor HR Mohan Ram of Delhi University, Delhi for J&K package and Professor SE Hasnain for Bihar Package.

While the NER and J&K Special Packages are being implemented for the past 2-3 years, the Special Package on Bihar has just initiated. In NER and J&K respectively 58 and 34 Science Colleges support @ Rs 50 lakh per College has able to acquire equipment required for reaching as well set up a small computer lab with internet facility for under-graduate science students in that region. Different fellowships available under this package have helped about 50 faculty members/ research students to go out of the Region/ state to learn modern techniques/skills. Special support to set up state-of-the art facilities like High Resolution Transmission Electron Microscope, Protein Single X-ray facility, High Power Computational Facility coupled with support for region specific R&D projects to individual faculty members is expected to boost up the research activities in these regions/ state.

Table 1: Year-wise investment in the FIST Program during 2000 - 2010			
Sr. No.	***Year of Program***	***No. of Departments***	***Total Amount (Rs in crores)***
1.	FIST 2000	221	**126.8**
2.	FIST 2002	238	**102.0**
3.	FIST 2003	189	**77.0**
4.	FIST 2004	120	**44.0**
5.	FIST 2005	91	**50.5**
6.	FIST 2006	102	**120.0**
7.	FIST 2007	148	**220.0**
8.	FIST 2008	156	**142.2**
9.	FIST 2009	79	**91.6**
10	FIST 2010	120	**139.4**
	Sub-Total	**1464**	**1113.5**
	Colleges	**36**	**25.0**
	Total		**1138.5**

Table – 2: Subject Areas-wise Distribution of the investment during 2000-10 under FIST Program			
Subject Area	***No. of Departments***	***Total Amount (Rs in crores)***	***% Share***
Life Sciences	496	285.7	25.7
Physical Sciences	184	144.0	12.8
Chemical Sciences	247	202.9	18.2
Engineering Sciences	331	376.0	33.8
Earth Science & Atmospheric Sciences	120	86.5	7.8
Mathematical Sciences	86	18.4	1.7
Sub-Total	***1464***	***1113.5***	***100***
Colleges	***36***	***25.0***	
Total		***1138.5***	

PURSE Program

During the year 2009, an incentive based program called `**Promotion of University Research and Scientific Excellence (PURSE)'** was designed to support in transparent and flexible format for encouraging research at the University sector**.** Based on Study Report "Status of India in Science and Technology as reflected in its Publication Output in Scopus International Database, 1996-2006" by NISTADS, New Delhi, top 35 S&T Institutions in India were listed based on `h-index' value. During the last two years 44 performing Universities (list of the Universities is at **Annexure – 3**) whose h-index ranging from 56 to 26 have been considered support ranging from Rs 30 crores to Rs 6 crores for 3 years. The total cost of this program is Rs 465 crores for 3 years

It is too early too see any impact of the support under this scheme. However, this scheme has been received very warmly by the University sector and motivated the faculty members as it recognizes their effort to receive such grant. Since the support under this program has lot of flexibilities provided to the Universities with respect to the expenditure types, selection of equipment etc, it is expected that this would definitely boost the research activities at the University sector.

CURIE Program

Similarly another special program titled **"Consolidation of University Research for Innovation & Excellence (CURIE) in Women Universities"** was developed for introducing research culture and improving the research activities in these universities. Six Universities i.e. i) Banasthali Vidyapith, Rajasthan; ii) Avinashlingam University for Women, Coimbatore; iii) Padmavathi Mahila Viswavidyalaya, Tirupati, iv) Karnataka State Women's University, Bijapur, v) Mother Teresa Women's University, Kodaikanal and vi) SNDT University, Mumbai have been identified and supported in the range of Rs 5.5 crores to 3 crores (@Rs .1.5 to 1.0 crore per year) for 3 years. The total investment is Rs 23.5 crores for 3 years.

SAIF Program

Sophisticated Analytical Instrument Facility (SAIF) program (renamed from RSIC – Regional Sophisticated Instrumentation Centre) is a service oriented scheme being implemented by the DST for more than two decades. The main objectives of this scheme is to provide service of high-end equipment facilities to the researchers in general and specially for them who do not have such facilities at their Institutes and in need of such sophisticated equipment facilities for pursuing their R&D activities. Across the country there are 12 such SAIFs available for offering such services of 103 equipment facilities to about 14,000 researchers who are mostly from academic sector (86%) as well as less endowed institutions (~ 9000). The details of SAIF locations and the available Facilities in these locations are given at **Annexure – 4.** Apart from providing services to the researchers, these SAIFs also provide solutions to many analytical problems, organizes Workshops/ short-term courses on Analytical Techniques as well as offer services on maintenance/ repair of equipment to others.

3.2 On-going Mission Mode Programs

NANO MISSION

The Mission on Nano Science and Technology (Nano Mission) was launched in May 2007 by Government of India with an allocation of Rs. 1000 crore for 5 years to promote R&D in this emerging and highly competitive area of research in a comprehensive fashion. The Department of Science and Technology is the nodal agency for implementing the Nano Mission.

The Nano Mission is an umbrella programme to promote R&D in this emerging and active area of research. Its objectives can be broadly classified as follows:

- Basic Research Promotion.
- Infrastructure Development for Nano Science & Technology Research.
- Nano Applications & Technology Development Programmes.
- Human Resource Development.
- International Collaborations.

The Nano Mission came as a follow-up of a modest programme “Nano Science & Technology Initiative (NSTI)” which was started by DST in October 2001 under its R&D programme. Highlights of activities undertaken under NSTI and the Nano Mission are given at **Annexure - 5**.

SOLAR ENERGY RESEARCH INITIATIVE

DST's Solar Energy Research Initiative (SERI) started in April 2008 aims at fostering innovative and efficient application of solar energy to societal context, integrating and improving efficiency of solar energized systems and sub-systems, and synergizing industry - institutional linkages for genuine and beneficial development of Solar Energy in country. This initiative is mainly to strengthen institutional capability and develop national core competence in developing indigenous research led competitive and cost effective solar energy options for power, thermal heat, storage, cooling, hybrid, industrial etc.

DST’s initiative on Solar Energy is positioned upstream with thrust on enabling knowledge based R&D activities for entire gamut of solar technologies including balance of systems. This is expected to be achieved through nurturing of R&D groups, formation of consortia and setting up of State-of-art facilities. DST aims at setting up test beds in off-grid situation for convergent technology solutions as well as for gathering scientific inputs for policy formulation for viability gap funding and sizing generation based subsidies. In this regard, first step has been taken up in Public-Private Partnership mode in association with M/s. Thermax Ltd, which aims to arrive at reliable estimates of the investments required for rural decentralized power using solar energy, reducing cost of solar-biomass hybrid option and work out viability gap. In this 256 kW Solar Thermal– Biomass Hybrid Plant at Village Shive in Khed Taluka of Pune district, Thermax has been collaborating with national technology and scientific institutions like IIT Bombay, IIT Madras, CGCRI Calcutta, University of Pune, ARCI Hyderabad etc to adopt cutting edge technology.

Another initiative of the Department is a PAN IIT initiative in partnership with leading solar energy provider, NTPC, to develop pre-competitive research and technology up-gradation capacity for Grid based options. A knowledge network of about 40 faculties from 6 IITs have now emerged. This initiative of DST aims to promote basic research led disruptive technology options through ideas generated by PAN IIT Group initially and to expand to other institutions subsequently. The areas for the themes identified are energy storage, battery technology, micro grid, newer materials and availability of low cost silicon etc. A Solar Photovoltaic Hub has been supported at BESU with partners from IACS, IIT-Kharagpur, Jadavpur University, etc.

3.3 Service Providing Activities

Patent Facilitating Centre (PFC)

Protection and enforcement of Intellectual Property Rights (IPR) are inevitable in the modern technology management process. The importance of knowledge about IPR has been rising steeply in India. Management of IPR requires information, skills, knowledge and experience. Patent Facilitating Centre (PFC) being a source of comprehensive information – a single window outlet and remaining innovative in the competitive era, has been harnessing the creativity of the Indian knowledge generators (scientists and technologists) in order to make India a major intellectual prowess for better presence in the global trade and commerce. PFC with its 28 Centres across the country aims at introducing patent information, providing patenting facilities to researchers, keeping watch on development in the area of IPR and creating awareness & understanding relating to patents and its challenges & opportunities. During the 11th Plan Period, it organized about 80 Workshops and 4 Advanced Training Programs on IPR issues, filled/assessed more than 400 patents, helped in providing training to about 235 young professionals under Women Scientist Scheme (WoS – C).

4. CHANGING NATIONAL SCENARIO AND THE ROLE OF DST

India has the third largest education system in the world. There are new emerging opportunities for India in the global knowledge economy for emerging as major player during the next two decades. Strategic planning for linking science, technology and innovation to the developmental economics of India during the 12th Plan period is considered extremely crucial. Investments made during the 12th plan period should enable India to mount on to accelerated and a more even growth path during the 13th plan period and thereafter. In other words, investments need to be strategic and based on calculated returns to the country over defined time horizons. It is expected that 12th plan of India will earmark a change in paradigm of planning. Knowledge and wealth creation processes in the country should be more strongly than coupled during the 12th plan period.

A conducive research sector requires cutting edge research universities, industrial R&D Centre's and a network of Government Laboratories with well-maintained infrastructure and liberal funding, working together towards defined objectives. Further, effective mechanisms of collaboration need to be created for universities and industry bodies so that research output and innovations can effectively be commercialized and transformed into marketable products and services for last mile benefits.

The approach therefore should be to (i) encourage universities and research centres to focus expertise and resources on key industrial focus areas, (ii) encourage flows of knowledge, created by universities and scientific research establishments, into industry, (iii) help universities create industry-ready talent pools, with practice-relevant skills, (iv) use university expertise to upgrade industry talent, (v) encourage universities and industries to apply faculty expertise in specific, operations-relevant problem areas, (vi) synergise the expertise in universities and research establishments – in areas such as manufacturing, ICT, and industrial management – to enhance the efficiency and productivity of existing industries vi) identify, develop, and scale programmes and projects (such as our new research parks) that draw on and synergise complementary capacities within research institutes and the private sector vii) draw on industry practitioners' experience and expertise to develop and advance research objectives at scientific establishments, teaching curriculum development and upgrades at universities, and (viii) utilize industry infrastructure for up-scaling of technologies.

5. CONSOLIDATION OF SUCCESSFUL ONGOING SCHEMES

5.1 Infrastructure related Programs

Among infrastructure related on-going programs at the DST, the ` Fund for improvement of S&T infrastructures in universities and higher educational institutions (FIST)' is one such flagship scheme which provides support on competitive model. During the last ten years of operation of this scheme, more than 1480 departments spread over around 500 academic institutions including about 240 Colleges have been covered at a total investment of more than Rs 1138 crores. Currently, a smaller University Department i.e. in Level – I category receives an average support of Rs 90 lakh for five years and that of a Department in Level – II category receives Rs 490 lakh for 5 years. The Program has so far able to provide support about 65-70 % of the total investment to the University sector including Colleges under these universities.

The Program has enabled many departments to install state-of-art facilities such as Automated DNA Sequencers, Scanning Probe Microscope, Liquid Nitrogen Plant, Liquid Helium Plant, High Resolution Powder X-ray Diffractometer, Single Crystal X-ray Diffractometer, 300 MHz, 400 MHz & 500 MHz FT-NMRs, Mass Spectrometer, PPMS, Universal Testing Machines (UTMs), Reneshaw Raman System, Electron Microprobe Analyzer, High Resolution Microscopes, Confocal Microscope, Field Emission Scanning Electron Microscope, High Resolution Transmission Electron Microscope, Protein Sequencing Platform, High Power Computational Facility, etc. The program has made impact in terms substantial increase in the number of research publications in SCI Journals as well as non-SCI Journals, Conference Proceedings & Books, increase in enrolment of students in PG and PhD courses. There is significant increase in the funding to the FIST supported departments through sponsored projects, as well as increase in the recruitment at the entry level in the University Departments.

The other programs i.e. Special Packages for Region or States like North-east Region, J&K and Bihar, PURSE and CURIE operating under pro-active model of support to many academic institutions in the country have initiated in late 2008 or later. Apart from overwhelming responses from the academic community towards their acceptance, the impact of these activities may be felt in another 2-3 years.

SAIF program has the ability to serve less endowed institutes/ academic community to enable it to reach out to larger user base. While the existing SAIFs have performed a useful function, new SAIFs may preferably set up in less endowed regions in institutions with capabilities to run/maintain facilities and equipped with rugged equipment. However, strengthening of each existing SAIFs shall also be required after reviewing their performance.

5.2 Mission-mode Programs

Nano Mission

Capacity-building in this upcoming area of research is of utmost importance for the Nano Mission so that India emerges as a global knowledge-hub in this field also. For this, research on fundamental aspects on Nano Science and training of large number of manpower are receiving prime attention. The Nano Mission is also making efforts towards development of products and processes for national development, especially in areas of national relevance like safe drinking water, materials development, drug delivery, etc. For this, it is forging linkages between educational and research institutions and industry and promoting Public-Private-Partnership. The Nano Mission is also synergizing the efforts being made by various agencies towards promoting Nano Science and Technology. International collaborations are also being entered into, wherever required. Apart from setting up a dedicated institute called `Institute of Nano Science & Technology' at Mohali, 12 Units/Core Groups having sophisticated state-of-the-art facilities, 7 Application specific Centres and a Centre of Excellence on Computational Materials Science at JNCASR, Bangalore were set up and operational now. An Ultra High Resolution Aberration-Corrected Transmission Electron Microscope at JNCASR, Bangalore and 3 Accelerator-based Research Facilities at IIT-Kanpur, Kurukshetra University, Kurukshetra and University of Allahabad, Allahabad are also in operations for carrying research in Nano science. Facilities outside India like India-Japan beam-line at the Photon Factory, KEK, Tsukuba, Japan, PETRA-III Synchrotron Radiation Facility and FLASH facility at DESY, Hamburg, Germany set up/ being set up are also expected to boost the research in this area.

Solar Energy Research Initiative

A 256 kW Solar Thermal– Biomass Hybrid Plant at Village Shive in Khed Taluka of Pune district, is being set up by Thermax in collaboration with IITs, Laboratories and Universities. Apart from this, a PAN IIT initiative in partnership with NTPC is underway to develop pre-competitive research and technology up-gradation capacity for Grid based options. A knowledge network of about 40 faculties from 6 IITs has now been initiated to promote basic research led disruptive technology options in areas like energy storage, battery technology, micro grid, newer materials and availability of low cost silicon etc. and need to be extended to other institutions as well.

5.3 Service Providing Activities

Patent Facilitating Centre (PFC)

Workshops may go with advancement in contents, IPR Bulletin to be published, WOC should continue with vigour, filing IP support would be essential and should be continued, Patent Information Centres should be strengthened, patent analysis to be taken up with more volume and scope. Advanced training programmes to be designed and organized.

6. NEW APPROACHES FOR THE XII PLAN

Currently, applications of scientific discoveries in solving socio economic problems and addressing national challenges are limited. Academy, research and industry partnerships are few. Public funding of research systems in the private sector is not common. Current practices of public funding of research is based on who receives the funds rather than who will benefit from research and development. Research and Development for public, social and strategic good in either public funded or private sector institution may be equally important. Public-Private Partnerships in Research and Development Sector for public, social and strategic good dimensions are adequately leveraged in the current policy regimes. Engagement of private sector into R&D is limited. Currently the shares of R&D spending by Central Government, state Government, university sector, and private sector are estimated at about 62, 8.5, 4.5 and 25%, respectively. Participation of states in research and development is relatively small and the deployment of technologies developed in public funded laboratories of the central government by states is also limited. It is essential to devise such policies and schemes which promote more active engagement of university and private sector into R&D and states into absorption of R&D outputs and deployment of indigenous technologies.

Basic research in India has generally followed global models during the last three decades. India had enjoyed a niche status among third world countries in science and technology sector in 1980s on account of strength in basic science and global share in publications. During the 1990s, however, on account of rapid strides made by other Asian economies in the sector, the country lost its relative position of pre-eminence. Since 2004, science and technology sector has been able to receive larger outlay and public investments. Indian share of scholarly publications is increasing. It is now estimated at about 3%. Moreover, Extra Mural Research support for investigator centric projects is varying from Rs 13 per year for 3 years project to maximum Rs 50 lakh per year in case of elite institutions. This indicates that many projects may not able to acquire high-end equipment or facility required for pursuing the cutting edge competitive research.

There is also a need to increase the investments into infrastructure strengthening in public funded academic institutions engaged in basic research. Rejuvenation of research in the university sector is of paramount importance. On account of various initiatives of the University Grants Commission and the Ministry of Science and Technology, there is an increasing participation of the university sector into creation of scientific publications during the last five years. A recent assessment shows that the share of scientific publications from the university sector has increased from the 15% levels in 2000 to about 31% in 2009. Total of 50 universities contribute to about 26% of the National share of publications as per the Scopus data base. Out of these, University of Delhi, Banaras Hindu University and Jadavpur University are among the top productive universities as per recent SCOPUS analysis (1998-2008). The larger enrolment of the university sector into research offers a wider possibility for India to increase the global share of scientific publications from the current 3% to say 5% levels by the end of 12th plan and emerge as one of the top eight nations in outputs of scientific publications.

At the end of the 12th plan period in 2017, the university sector should target at a National share at least 50% of the scientific publications in SCI journals. This would deployment of larger outlay of public funds in rejuvenation of research in the university sector. Institutions like Indian Institutes of

Technology, National Institutes of Technology and several leading universities should be supported by Plan R&D grants for supporting research on nationally relevant subjects.

While basic research would need necessarily an input-led growth path, differences in approach through output directed investment model would be required for connecting knowledge and wealth generating activities of the country. Supply side approach for promotion of advanced basic research should be further enabled with tools for demand-side planning for innovations and technology development. A few points are given below:

- Current individual investigator centric models need to be expanded for consortium funding systems.
- Possibilities of funding Indian basic research with other nations with control of Intellectual Properties through international S&T cooperation
- Mega facilities for basic research are being built and created through International consortium type of funding and plan for participation in global research consortia.
- Capability to build new instruments needed for basic research in dwindling outside the strategic research sector.
- Offer a new scheme to institutions aspiring to gain listing among the top 300 universities in the world by making higher investment with changed governance structure.
- Investment in long-term goal oriented Basic Research in national priority areas such as Water, Energy, affordable Health Care etc, as well as for impact making discovery research.

7. TRAJECTORY & SELECTION OF NEW PATHS AND PROGRAMMES

Indian science sector needs to gain global competitiveness in all its dimensions. Indian investments into Research and Development may need to match the desired goals of the country. Global indices are being developed for measurement of science and technology outputs indicators. These indicators reflect the lack of competitiveness in the global impact. Corrections are needed through both policy and resource inputs. It is essential to develop suitable measurement systems for the science, technology and innovation output indicators for India. Migration from perception based to evidence based planning models is a step forward for 12th plan planning exercise.

Considering the size of the R&D base through expansion of the sector by at least three fold during the 12th plan period, capacity building initiatives seem to be inevitable in Indian context. One also needs to strike a balance on the appropriateness of measures so that country receives a right ecosystem in its R&D growth.

- The mixture of competitive like FIST Program and pro-active model of support like Special Package, PURSE, CURIE etc., which are being used at present are is very essential in that respect. While some of the programs are very new and yet to make impact in the sector, the major flagship program i.e. FIST has already made dent in the S&T sector especially to universities. The vigour of all these programs shall need to be enhanced both in terms of investment, coverage and average support. However, one needs to address the issues like reach-ability of the Program, governance structure of the institute so that such program could reap the benefit to the sector.
- The Program: FIST which is on competitive support model extends support to a university department only having certain critical mass in the Department. However, need-based support for a limited period to augment the critical mass in case of its potential to growth further should be explored so that such department may grow further to a grater height.
- CURIE, a new pro-active initiative for inculcating research culture in women exclusive universities shall be required to strengthen and may possible be extended to women exclusive colleges due to increasing number of girls students opting for higher education including pursuing doctoral degree.
- Large investment to 5-10 identified Academic Institutions aspiring to gain listing among top 300 world universities in next 5 years,
- Government owned Universities which are less than 10 years in existence, a one-time support of Rs 5 crores for creating basic infrastructure for carrying out research,
- Allocation of planned R&D grants to select academic institutions engaged in high-end research like IITs, IISc for carrying out cutting edge and internationally competitive research. Strong parametric based selection of institution as well as quantum of grants may be used in such case.
- Capacity building department level support either already engaged in focussed areas of research or willing to start new and emerging areas like Climate Change, Solar Energy Research, mathematical modelling/ computer simulation studies on geosphere, near-Earth space, interplanetary space and the Sun etc.. This support would be considered on a competitive model through bidding process.
- While the existing SAIFs may be considered to strengthen by augmenting the facilities after undertaking the review of each one separately, there is a need to set up at least half a dozen new SAIFs to less endowed region institutes capable of running/ maintaining with rugged equipment for facilitating research to the academicians of those less endowed region institutes.

- The activities under the Nano Mission must continue with same vigour. However, focus technology areas may be pursued towards realizing its potential.
- Participation in international mega facilities like India-Japan beamline, PETRA-III Synchrotron Radiation Facility, FLASH facility etc. by the Indian researchers may be enhanced.
- The awareness and facilitation process need to be enhanced in the growing need of knowledge economy era. The infrastructure of PFC at DST as well as its Regional Centres needs to be augmented. However, PFC should also enlarge its scope of activities on `commercialization and marketing process'.

8. SELECTION OF XII PLAN TARGETS

Indian science and technology sector has shown good indications of growth in scientific publications, citations of Indian papers, number of intellectual properties generated etc. On account of investments made into basic research in the country during the 10th and 11th plan periods, India has registered an annual growth rate of scientific publications at 12% as against the global average of ~4% during the last three years. Global research report brought out by Thomson Reuters in October 2009 has indicated the increasing growth trends in publications. Approach plan for the 12th period may need to take into account of the input and output correlations in the basic science sector.

With this enhanced institutional capacity building measures proposed in 12th Plan period, the deliverables need to be in the measurable form. At the end of 12th Plan period, the following deliveries are expected:

- Publications in the university sector shall be increased from 31% to 50% with respect to total publications in India.
- 10 States will have significant improvement in research capacities
- 5 Institutions will be within top 300 world institution list,
- 50 % enhanced research output 10 Institutions and 15 Universities,
- 25 % enhanced research output in 100 Colleges.

Annexure - 1

Composition & Terms of References

Strengthening Basic research and Expanding R&D base - Institutional Capacity

Prof. Mihir Kanti Chaudhuri (Chairman)

Dr. Archana Bhattacharya (IIG, Mumbai)

Prof. Seyed. E. Hasnain (IIT Delhi)

Prof. Sanjay Puri (JNU)

Prof. V. K. Singh (IISER, BHOPAL)

Prof. Ashutosh Sharma (IITK)

Prof. Manoj Mishra (VC, Lucknow University)

Prof Ranjan K Mallik (IIT Delhi)

Dr. George John (DBT)

Dr. Nisha Mendiratta (DST)

Dr. A. Mukhopadhyay (Convener)

Terms of Reference

- To recognize potential areas of gaps in institutional capacity in priority research areas.
- To examine various means of strengthening institutional capacities in a pragmatic time frame and suggest some possible approaches.
- To review some ongoing measures and suggest means of further strengthening useful measures.
- To suggest road map for rejuvenation of research in university sector.
- To suggest possible means of promoting private sector participation into R&D in industrial sector.
- To suggest some innovative ways of building institutional capacity for research and development in a time bound manner.
- To review quantitative deliverables proposed by the Department in the area and suggest alternative targets, if any.
- To suggest indicative of budgetary needs for the objective.
- Any other priorities of choice of the Committee.

Annexure - 2

Typical Special Package – Various Support elements

Average cost of Package: ~ Rs 70-75 crores for 5 years.

A. Augmentation of S&T education infrastructure

Under the initiative, colleges identified and selected based on considerations of potentials for excellence in science education. Rs.50 lakh per college for 5 years is envisaged.

B. Enrichment of research efforts through exchange fellowships

1. *Visiting Professorships for short term attachment to the universities in that region/ state*
2. *Visiting fellowships to research students from that Region/ State for work in other regions:*
3. Faculty Assistance programs for young researchers
4.

C. Special FIST assistance to universities in the region Support would be extended to University (as Unit) up to Rs 1.5 crores for teaching related support (not for research activity).

D. Strengthening of physical infrastructure in universities One time support not exceeding Rs 50 lakhs per university for improving the uninterrupted and stabilized power supply.

E. Major Facility Support Two units would be supported at a total cost of Rs. 10 crore in the region for acquiring major Facilities like SEM/ NMR/ Single Crystal Facility etc.

F. Summer School / Winter School for UG & PG Students A number summer/winter schools are planned in the area relevant to the region.

G. Focus R&D Support Research having relevance to that region/ state like bio-diversity, disaster management, flood control etc. is proposed to be supported in consortium mode.

Annexure - 3

Promotion of University Research and Scientific Excellence (PURSE) Program during last 2 years

No`	University	h-index
	2009	
1	University of Delhi	56
2	University of Hyderabad	54
3	Punjab University	50
4	University of Pune	44
5	Jadavpur University	43
6	Banaras Hindu University	42
7	University of Madras	37
8	University of Mumbai	37
9	Jawaharlal Nehru University	33
10	Anna University, Chennai	31
11	Karnatak University	30
12	Aligarh Muslim University	30
13	University of Rajasthan	27
14	Andhra University	26
	2010	
1.	University of Calcutta, Kolkata	42
2.	Annamalai University, Annamalainagar	41
3.	Bharathidasan University, Trichi	37
4.	Bharathiar University, Coimbatore	37
5.	University of Burdwan, Burdwan	36
6.	Guru Nanak Dev University, Amrisar	36
7.	Sri Venkateswara University, Tirupati	35
8.	Mahatma Gandhi University, Kottayam	35
9.	University of Jammu, Jammu	34
10.	Cochin University of Science &	34

	Technology, Cochin	
11.	M S University of Baroda, Vadodara	33
12.	Shivaji University, Kolhapur	33
13.	Utkal University, Bhubaneswar	33
14.	Madurai Kamaraj University, Madurai	32
15.	University of Kerala, Trivandrum	32
16.	Osmania University, Hyderabad	32
17.	Dr Harisingh Gour University, Sagar	32
18.	Mangalore University, Mangalore	31
19.	University Kalyani, Kalyani	31
20.	University of Mysore, Mysore	30
21.	University of Lucknow, Lucknow	30
22.	Pondicherry University, Pudducherry	30
23.	CCS Haryana Agricultural University, Hisar	30
24.	Bangalore University, Bangalore	30
25.	Punjab Agricultural University, Ludhiana	29
26.	Tamil Nadu Agricultural University, Coimbatore	27
27.	University of Agricultural Sciences, Bangalore.	28
28.	Alagappa University, Karaikudi	27
29.	Sardar Patel University, Anand	26
30	North Eastern Hill University, Shillong	26

Annexure – 4

INSTRUMENTS AVAILABLE AT THE INDIVIDUAL SAIFs AND THEIR AREAS OF SPECIAL FOCUS

Table

SAIFs	Instruments available	Areas of special focus
1. SAIF, IIT, Chennai	FEG SEM, XRD (Single crystal), XRF, VSM, 500 MHz FT-NMR, EPR, GC-MS, Mossbauer, ICP-AES, UV-VIS-NIR, FT-IR, Fluorescence Spectrometers, Thermal Analysis System (TGA/DTA/DSC).	Spectroscopy; X-ray Crystallography
2. SAIF, IIT, Mumbai	FEG SEM, TEM, Image Analysis System, Secondary Ion Mass Spectrometer, FT-IR Imaging System, LA-ICP-MS, ICP-AES, XRF, Thermal Analysis System (DTA/TGA/DSC), FT-NMR, ESR, HR GC-MS, LC-MS/MS, CHNSO Analyzer, FT-IR Spectrometer.	Electron microscopy; Spectroscopy
3. SAIF, CDRI Lucknow	400 MHz FT-NMR, Mass Spectrometers (FAB, EI, CI, ESI, API, LC-MS, GC-MS, MS/MS, Accutof DART, Q-TOF HRMS), CHNSO Analyzer, GLC, FT-IR, Polarimeter.	Mass spectrometry; NMR Spectroscopy
4. SAIF, Punjab University, Chandigarh	SEM, TEM, XRD (powder), 400 MHz FT-NMR LC-MS/MS, CHN Analyzer, HPLC with Amino Acid Analyzer, UV-VIS-NIR, FT-IR, Liquid Nitrogen Plant.	Electron Microscopy; Spectroscopy
5. SAIF, NEHU, Shillong	SEM, TEM, Microscope with Image Analyser, FT-NMR, LC-MS, CHNSO Analyzer, AAS, Graphite Furnace, Liquid Nitrogen Plant.	Electron Microscopy; Spectroscopy
6. SAIF, Nagpur University, Nagpur	TEM, XRD (powder), Thermal Analysers (DTA/TGA/ DSC), AAS.	Thermal analysis
7. SAIF, IISc., Bangalore	FT-NMR Spectrometers (300 MHz, 400 MHz & 500 MHz)	NMR Spectroscopy
8. SAIF, AIIMS, New Delhi	SEM, TEM, Complete set up for biological sample preparation.	Electron microscopy for biological applications

9. SAIF, Gauhati University, Guwahati	XRD (Powder), XRD (Single crystal), XRF	X-ray based analysis
10. SAIF, IIT, Roorkee	Electron Probe Micro Analyser	EPMA
11. SICART, Vallabh Vidyanagar, Gujarat	SEM, TEM, XRD (powder), Laser Flash Thermal Conductivity Meter, ICP-AES, 400 MHz FT-NMR, LC-MS/MS, GC-MS, GC, GPC, HPLC, CHNSO Analyzer, Laser Particle Size Analyser, UV-VIS-NIR, FT-IR, Thermal Analysers (DTA/TGA/DSC), MHT, UTM, Liquid Nitrogen Plant	-
12. SAIF, STIC, Kochi	SEM with EDS, XRD (Single crystal), XRD (powder), ICP-AES, UV-VIS-NIR, FT-IR, Thermal Analysis System (DTA/TGA/DSC), 400 MHz FT-NMR, GC-MS, CHNS Analyzer.	-

Annexure - 5

HIGHLIGHTS OF ACTIVITIES

Capacity-building in this upcoming area of research is of utmost importance for the Nano Mission so that India emerges as a global knowledge-hub in this field also. For this, research on fundamental aspects on Nano Science and training of large number of manpower are receiving prime attention. The Nano Mission is also making efforts towards development of products and processes for national development, especially in areas of national relevance like safe drinking water, materials development, drug delivery, etc. For this, it is forging linkages between educational and research institutions and industry and promoting Public-Private-Partnership. The Nano Mission is also synergizing the efforts being made by various agencies towards promoting Nano Science and Technology. International collaborations are also being entered into, wherever required. Major highlights of activities from the NSTI and the Nano Mission are summarized below:

Infrastructural Facilities

- A dedicated Institute of Nano Science & Technology at Mohali.
- An Ultra High Resolution Aberration-Corrected Transmission Electron Microscope costing Rs. 32.62 Crores at the International Centre for Materials Science, JNCASR, Bangalore as a National Facility.
- Established 3 Accelerator-based Research Facilities at IIT-Kanpur, Kurukshetra University, Kurukshetra and University of Allahabad, Allahabad.
- Set up 12 Units/Core Groups on Nano Science having sophisticated state-of-the-art facilities across the country.
- Apart from specific application focussed Seven Centres for Nano Technology, a Centre of Excellence on Computational Materials Science at the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bangalore.
- Established an India-Japan beamline at the Photon Factory, KEK, Tsukuba, Japan. Access to all the beamlines at the PETRA-III Synchrotron Radiation Facility and FLASH facility at DESY, Hamburg, Germany is expected to be funded shortly.

Other activities

- In order to utilize the existing expertise in research and educational institutions towards developing products and processes of direct interest to industries, Nano Mission has promoted Joint Institution-Industry Linked Projects. In many of these activities, the industrial partners have also invested financially into the projects. These activities will help us to simultaneously leverage the scientific knowledge-base existing in our research and educational institutions and the commercial vision of our industry to generate competitive technologies leading to products and devices. Six such projects have received financial support so far for work related to nanofillers for tyre application, nano-textiles, nano materials, drug delivery, etc.

- Post Graduate Programmes (M.Sc / M.Tech.) in 16 Institutions/Universities across the country.
- Institution of attractive Post-Doctoral fellowships through Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bangalore.
- Funding of around 235 individual scientist-centric research projects on fundamental scientific aspects of nanoscale systems.
- Support to International/National Conferences, Seminars, Workshops etc. extended.
- The process of laying down a Regulatory Framework for Nanotechnology in India has been initiated in consultation with concerned Ministries.

Annexure 8d

REPORT OF THE SUB GROUP

ON

TECHNOLOGY DEVELOPMENT PROGRAMME OF DST

FOREWORD

Technology Development Programme is one of the 6 thrusts identified by the DST in the XI Five year plan. This programme has had an impressive track record in the past 5 years and the task of this subcommittee was to build on the excellent work already done. From the brief for the subcommittee it was clear that there was one outcome that was very important and that was that we had to come up with recommendations for translating existing/ new technologies to the marketplace.

It is difficult to be prescriptive about the way one translates technology to practice. This depends on a number of factors not least the climate in which one operates. In a country where history suggests that technology adoption by the industry is limited, the climate is at best skeptical. At the same time there is no denying that we are in an era of innovation and responsible innovation at that: innovation that is environmentally sustainable, scalable, that generates employment across skill levels and is profitable.

If the last twenty years have proved anything it is the indefatigable spirit of enterprise in the country. It is this that one must depend upon and leverage if we are to usher in an era of responsible innovation in the country. The DST has started an initiative of supporting technology led start ups. This is an underutilized initiative and offers scope for bringing technologies to market. Start ups have several advantages. Their smallness of size encourages experimentation with business models – critical for success. Their nimbleness means that they are able to put behind failures and try a different track eventually striking a winning approach. Many influential companies like Google were start ups not so long ago.

Clearly we need a bold and even controversial approach if we are to make a difference. One such approach is for DST to start technology development activity by first scoping the business case. As a part of the incubation activity started by DST there is a need to make a provision for allocation of resources for startup companies to get established. The recommendations contained in this report have been made with such an approach in mind.

It is appropriate to record my appreciation of the efforts made by the DST to bring this subcommittee together and facilitate the discussions. I would also like to sincerely thank all the participants for their unstinting cooperation and willingness to contribute. Any deliberation within a subcommittee is bounded by the experience and expertise of the participants. The subcommittee focused on issues that are universally acknowledged as critical for our country. The recommendations address some India centric opportunities and suggest ways of exploiting them through application of technology.

(Dr. C.V. Natraj)

Dated:

Chairman

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1. INTRODUCTION AND BACKGROUND

2. OVERALL OBJECTIVES

3. XI PLAN ACHIEVEMENTS INCLUDING REVIEW AND PHASING OUT/ MERGING OF ANY PROGRAMMES, IF REQUIRED

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ACKNOWLEDGEMENT

ANNEXURES

- Composition of the Committee
- Minutes of the First meeting on 25.06.2011
- Minutes of the Second meeting 06.08.2011
- Working Group documents

1. INTRODUCTION AND BACKGROUND

Department of science & Technology is engaged in promotion of R&D leading to funding development, deployment and utilization of technologies and mounting mission mode initiatives in the areas of drug and pharmaceuticals, solar energy research, security technology, water technology, potash based fertilizers etc. The Department is engaged in mapping the technology assets available with public funded R&D institutions and sources in the country and promoting appropriate level of demonstration and assessment in credible scales for promoting deployment and replication. The Department is also actively engaged in the assessment of indigenous technologies for their techno social viabilities by referencing them to the social contexts of deployment. Technology leads are gained through research in large number of public funded institutions in the country. The Department has been undertaking a responsibility to promote the demonstration of various technology leads after due diligence under real field conditions and promote the utilization and adoption of technology leads emanating from public funded research under Technology Development Schemes. The Department had promoted a large number of technology demonstrations in different parts of the country to local bodies and other users. Such demonstrations of technologies to ultimate users did not lead to required level of technology penetration in the absence of adequate linkages among the technology sources and the industrial sector in non-strategic areas.

2. OVERALL OBJECTIVES

i) Promote India-centric “frugal, distributed, affordable innovation” that produces more “frugal cost” products, services and processes to serve the people at low levels of incomes without compromising the safety, efficiency, and utility of the products

ii) Develop Cutting edge technologies and innovations for globally competitive and inclusive growth to power technology led economic progress of the country

3. XI PLAN ACHIEVEMENTS INCLUDING REVIEW AND PHASING OUT/ MERGING OF ANY PROGRAMMES, IF REQUIRED

One of the focused areas for intervention by the Department has been Drug and Pharmaceutical Research. In recent times, the Department has also added technologies for water, security, solar energy, potash fertilizer, climate change sensitive actions and cognition science. DST has been an active promoter of indigenous capacity to design and develop a range of scientific instruments required for analysis and health care.

One of the strategic directional changes brought about by the Department in the Technology Development Programmes (TDP) has been in the focus on implementing sustainable convergent technology solutions rather than limiting interventions to technology demonstrations. Establishment of test-beds for solar energy based on hybrid technologies as well as potash fertilizers from sea water have been identified for support by the Department. These interventions offer opportunities for providing scientific inputs to policy development in the areas of fertilizers and viability gap and generation-based subsidy of solar energy in the country. The Department has been directed by the Supreme Court to implement water technology mission. Under the Mission “Winning, Augmentation and Renovation (WAR) for water innovative deployment of technology solutions for 26 types of water challenges is being attempted. A technology compendium listing technology assets available with various scientific departments of the Government has been prepared and technology portal launched for the benefit of states to assess the local needs and build technology partnerships with states. Some of the recent initiatives of the Department in technology development sector has focused on strengthening linkages among academy-research and industry. As a result of various initiatives of the Department, new mechanisms and models for technology diffusion and adoption in the user sector are emerging. Promotion of Public-Private Partnerships for R&D sector and clean energy is accorded high priority in selection of projects and interventions by the Department. Drug and Pharmaceutical Research Programme (DPRP) as a scheme has promoted a number of PPP initiatives in drug research. More than 100 collaborative projects under PPP have been supported by the Department. Technology Development Board mechanism has been leveraged to promote an innovation support system and invest into “Fund of Funds” to create an angel financing system needed for promoting an innovation eco-system.

The Department of Science and Technology had played catalytic role in initiating the STAC mechanism in 24 socio- economic ministries. Under Technology Systems Programme (TSP) proposals having "proof of concept" are supported and the programme has carved a clearly identified niche role in technology development chain. One of the pre-requisites of the programme is that there should exist sufficient R&D knowledge base from which technology development efforts could be initiated. The notable achievements are technology systems for water purification, R&D in production, processing and utilization of bio-fuels and value addition to by-products, upgradation of Glass and Ceramics industry, application of surface engineering techniques for adding value to traditional products, development and application of micro wave technologies for indigenous applications and development of ceramics, bio-molecular and optical sensors. DST has taken solar energy research initiative which aims to harness solar energy through innovative R&D breakthroughs and ingenuity in system integration that culminate in various options ranging from an incremental improvement to completely leapfrogging the existing state of art technology. This will feed into the major National mission on solar. The Department has mounted an initiative to develop research capacities in the country in the areas of homeland security, cognition science, climate change science and technology, Himalayan Glaciology through coordinated programmes.

Models are being built by the Department to increase the academy-research and industry linkages in the area of technology development and deployment.

4. CHANGING NATIONAL SCENARIO AND THE ROLE OF DST

The evolution of S&T investment has followed similar paths in a number of countries. Typically they have begun with an investment in infrastructure development, though the starting points have been different. Thus it began after the first world war in the UK and in S Korea in the '60's. South Korea began from a position not dissimilar to our own in the '60's. The first phase lasting about 20 years was an Institution building phase. This was followed by 'Support to Manufacturing' phase when R&D actively tried to understand the needs of the Manufacturing Industry and provided technological support. The most recent phase is the ongoing phase of 'Innovation' where the S&T is charged with the responsibility of 'leading the world' in specified areas with the intention of being the first to market in these areas. During these fifty years it is interesting that the S&T investments which were predominantly Government funded (80%) are now predominantly from the private sector (80%). The absolute sums are also impressive at $22 Bln and it is about 2.6% of the GDP. In the corresponding period, the population has doubled from about 40 million and the per capita income has gone up more than an order of magnitude.

The situation in India has parallels in that we also began from a relatively poor base and there have been impressive achievements in successive 5 year plan periods in terms of infrastructure development and trained human capital. **That we have not had subsequent phases of active participation between academia and industry owes as much to public policy as academia being happy in their comfort zone and the Industry finding the necessary barriers to competitive entry.** We are now poised in the 21st century to usher in an 'Innovation' phase where we want technology to lead a sustainable development that minimizes our environmental footprint, distribution of wealth, creation of equal opportunity, sustainable food supply and affordable health care. We cannot afford the luxury of waiting for the industry to embrace technology and lead the innovation phase. Whilst we develop ways of working with industry to maximize the impact of technology, we need to identify ways of bringing science to market. Here we are helped by the innate enterprise of our scientists and technologists who with some support and mentoring are capable of developing viable businesses starting from the laboratory. The biggest barrier for technology transfer is often the risk averseness of established industries who feel that there is an unacceptable level of uncertainty in new technology. This is where start ups have the biggest attraction. Since the investments are minimal, the scale of losses in the event of failure is minimized. However if the technology gets past the initial hurdles, it becomes easier to convince established industries who may be more comfortable with the level of uncertainty involved.

The overall learning from a study of the situation elsewhere is best captured by a quote from the EU Expert Panel-"the European economic model is built upon old paradigms and a R&D system which is strong in generating knowledge but unable to transmit effectively its results to the economy. The way forward for Europe depends on a creative system disruption based on long-term coherent investments in Key Technologies. The Research and Development (R&D) system as a vital part of the interfaces must be re-configured in order to take a continuing proactive attitude to 'Bring society to science' and 'Take science to the economy'.

- The current level of coupling between the academy, research and industry in India is weak. Technologies developed by public funded institutions are not adequately absorbed and applied by the industrial and state sectors. The current level of technology intensive manufacturing in the country is estimated to be relatively low.
- The National vision for Indian Science sector has been developed recently by the Scientific Advisory Council to the Prime Minister. Global leadership in Science has been enunciated theme of India's R&D strategy. Such a strategy calls for increasing the global competitiveness of the Indian S&T sector on the one hand and build a dynamic system to respond to changes in the external global R&D environment.
- Technology development will be affected by growth trends in GDP, and other economic paradigms.
- With the growing recognition of India's cost advantage for returns on dollar invested into R&D, the engagement of foreign companies in R&D climate of India is increasing on account of economic considerations. The number of foreign companies establishing R&D centers in India has increased from 100 in 2003 to 750 in 2009. This could alter the R&D environment in the country with Indian IQs developing Intellectual Properties for other economies of the world.
- PMs Council on Trade and Industry has focused on the development of Public-Private Partnerships in R&D and Clean Energy. This is a direct indication of the emerging trends in linking technology with trade in the country.
- Inclusive growth agenda for the country demands emphasis on affordable innovations as the main agenda of the National Science and Technology sector. The choice of affordable innovation agenda for the national S&T sector will be strongly influenced by the socio-cultural dimensions and the context of the country.
- Currently the level of coupling between the S&T sector the socio-cultural context is limited. With the strategy to increase the role of technologies in the developmental agenda of the country, the impact of changes in socio-cultural context on S&T sector is likely to increase.
- The Government has liberalized its policies in regard to commerce and trade, entered into several international agreements and allocated adequate financial resources for Science and Technology sector.
- In India Information Technology industry accounts for 5.19% of the country's GDP export earning as of 2009 while providing employment to a significant number of its tertiary sector workforce. More than 2.3

billion people are employed in the industry either directly or indirectly making it one of the biggest job creators in India and a mainstay of national economy. In 2010 annual revenue from outsourcing operations in India amounted to US$54.33 billion compared to China with US$35.76 billion. Indian outsourcing industry is expected to increase to US$225 billion by 2020. India's growing stature in the information age enabled it to form close ties with USA and European countries. However, the recent global financial crisis has deeply impacted the Indian IT companies as well as global companies. As a result hiring has dropped sharply and employees are looking at different sectors like the financial services, telecommunications and manufacturing industries which have been growing phenomenally over a few years. Growth in Indian IT has been driven by export. Knowledge and technology have become key factors of economic growth and international competitiveness in India and China. This puts premium to education, skills and technologies as well as innovation capacities. The problem of environment is a global issue affecting the economic progress of all countries developed, developing and undeveloped. Environment legislation, energy consumption, waste disposal, carbon reduction etc are burning issues require solution from scientific angles. The government is conscious of these issues and several legislations have been passed to save the planet. Local, National and international laws have an important role in the development of science and technology in the country. DST has entered into several international agreements with several countries of the world in consultation with ministry of external affairs DST has finalized innovation law 2008 which is in the process of consultation with other ministries to encourage local and foreign entrepreneurs.

5. CONSOLIDATION OF SUCCESSFUL ONGOING SCHEMES

i) **National Spatial Data Infrastructure (NSDI)** The NSDI initiative aims to develop and maintain standard digital collection of data, common solutions for discovery, access and use of spatial data in response to needs of diverse user groups, and to increase awareness and understanding of the vision, concept and benefits of NSDI. During the XI Plan, emphasis was given to develop geo-spatial data standards and interoperability, geo-portals/ clearinghouses for data sharing and access, application studies for demonstrating NSDI vision, concepts, and benefits, human resource development and end user linkage. Formulation of Policy on 'Data Sharing and Accessibility' and strengthening of National capacity through technology development and implementation strategies and systems is the identified quantitative deliverable of the programme for XII Plan.

ii) **Innovation Clusters** Innovation Clusters have also been established under Public-Private Partnership with the objective to foster technology leadership through knowledge based strategies. So far, three clusters have been picked for suitable intervention viz., (i) ICT cluster at National Capital Region, (ii) Hyderbad Pharma Cluster, and (iii) Ahmedabad-Vadodara-Rajkot pharma Cluster.

iii) **Security Technology Initiative** A nationally coordinated initiative on S&T inputs to Security Technology has been commissioned with Indian Institute of Science as the implementing agency. Five core areas for further study and research activities have been identified. They are Technologies for Material Detection, Video Surveillance and Video Analytics, Large-scale Data Mining, Information Security and Sensors for Homeland Security. Two white papers, on video analytics and the sensors for homeland security have been published defining the broad areas where research initiatives will be taken up.

iv) **Water Technology Initiative** The objective of the scheme, initiated in August 2007 is to promote R&D activities aimed at providing safe drinking water at affordable cost and in adequate quantity using appropriate Science and Technology interventions evolved through indigenous efforts. Since quality is the main consideration of safe drinking water, processes which imply nano-material and filtration technologies have been focused. The initiative also includes the pilot testing of credible number of products and referencing of selected technologies to the social context of the application region.

v) **Winning, Augmentation and Renovation (WAR) for Water Programme** In pursuance of directives of Hon’ble Supreme Court, Technology Mission on Winning, Augmentation and Renovation (WAR) for Water has been launched in August 2009 to undertake research-led solutions, through a coordinated approach, to come out with technological options for various water challenges in different parts of the country Geohydrological maps comprising of the location of river basins, ground water potential, geo-hydrology and drainage pattern for 89 selected clusters were prepared. In an effort towards augmentation of water resources, seawater based farming system, allowing cultivation of halophytes and culture of fish has been launched in east coast near Vedaranyam in Tamilnadu. The target is to provide sustainable technology solutions to at least 15 types of water related challenges in at least 25 clusters of human population of 10-20 thousands

vi) **Solar Energy Research Initiative (SERI)** Initiated in January 2009, Solar Energy Research Initiative (SERI) is aimed at improving efficiency of devices, systems and sub-systems; to promote innovative R&D based demonstration projects for 24x7 off grid power supply. In addition to demonstration of hybrid solar power systems integrated on various R&D pathways and multiple technology alternatives for distributed energy use to validate their viability to meet rural energy needs and associated societal development, development of innovative materials, devices, coatings, etc., for solar based system are pursued. DST has formulated plans towards establishment of 200 kW Solar Thermal Technology Demonstration Project for Rural Energy and Electrification Power Plant based on Solar Technology and Biomass Combustion at Shive, Pune District, Maharashtra. Activities have been initiated to establish Solar Photovoltaic hub at Bengal Engineering and Science University, Howrah. The programme targets to promote indigenous research capacity to drive the costs of delivered solar energy by 25% from the current levels through technology innovations and create at least 100 PhDs and MTechs in solar energy research area within the next five years.

vii) **Climate Change Programme** DST has been entrusted with the responsibility of spearheading two out of eight national missions on climate change under the aegis of the National Action Plan on Climate Change (NAPCC). These are:

(a) **National Mission on Strategic Knowledge for Climate Change (NMSKCC)** The NMSKCC has been launched with the broad objectives of mapping of the knowledge and data resources relevant to climate change and positioning of a data sharing policy framework for building strategic knowledge among the various arms of the Government. 30 top R&D and academic Institutions/Universities in the country having measurable outputs on climate change research during past 10 years have been invited to submit proposals for setting up of Centres of Excellence, Strengthening of Existing Centres of Excellence, launch of Major R&D Programmes and major Human Capacity Building programmes. In addition, all State Governments and Union Territories were requested to set up coordination mechanism and enroll R&D Institutions engaged in climate change aspects into the mission.

(b) National Mission for Sustaining Himalayan Ecosystem (NMSHE)

Understanding of the complex processes affecting the Himalayan eco-system and evolve suitable management and policy measures for sustaining and safeguarding the Himalayan eco-system are the broad objectives of NMSHE. There has been good response from a number of state governments. A meeting of Stakeholders which include governments of all the Himalayan states, concerned central ministries/ departments, NGOs, Civil Society organizations, Institutions working on Himalayan ecosystem is being planned. The Expert Committee for preparation of Detailed Project Report (DPR) for setting up of a National Centre for Himalayan Glaciology has submitted its report. The follow up action is being initiated. Establishment of at least 10 strategic knowledge centers in scientific assessment of climate change concerns is envisaged.

viii) Enlargement of Drug and Pharma Research Programme The Scheme "Drugs & Pharmaceutical Research" was intiated by DST for promoting R&D in drugs and pharmaceutical sector so as to achieve synergy between the innovative Indian Pharmaceutical Industry and academic institutions. The approach is a project based support with product and target oriented efforts. It supports drug development for all types of medicinal systems, be it traditional Indian medicinal system or the modem one by financially supporting industries as well as publicly funded institutions by providing projects for development of new drugs for communicable as well as non-communicable diseases and certain life style diseases. Extensive efforts for funding projects resulted in providing grant-in-aid to 39 projects (23 PPP collaborative projects + 14 projects for creation of national facilities + 2 grants-in-aid projects to industry for neglected diseases) and 30 loan projects to pharma R&D industries. 14 national facilities were created in different national labs, public funded educational institution/universities on Bio-safety level-4, standardization and quality control on medicinal plants, cGMP pilot plant for extraction, formulation and packaging of traditional herbal medicinal formulation, clinical research facility for stem cell, nano-microparticle based biomaterials advanced drug delivery systems, upgradation of clinical trial infrastructure of Unani System, drug targets through functional cell dynamics, herbo-metallic preparations, bio-equivalence, Rasayana products, clinical facility with GLP & GCP standards for ISM etc. Also two grants-in-aid projects funded for conducting clinical trials in neglected diseases such as Malaria and Kala Azar. Several products have been commercialized. So far, 22 product patents and 13 process patents have been obtained.

ix) **<u>Technology Systems Development Programme (TSDP)</u>** TSDP supports activities aimed at developing and integrating technologies to evolve technology systems both in the advanced/emerging areas and in traditional sectors/areas. Areas of focus have been selected based on the social good priorities. Network initiatives have been mounted in place of individual demonstration of technology elements. Around 150 projects have been supported through this scheme. It is envisaged to deliver a test bed for potash technology from sea water with a capacity of 3 TPD and provide inputs to evidence based policy inputs to Ministry of fertilizer.

x) **<u>Instrumentation Development Programme</u>** This programme supports development of industrial instruments, medical and health care instrumentation and sensors for various applications. Pro-active efforts for made to develop R&D capacity through conducting cluster of project meeting. A sensor hub has been established at Kolkata for batch production of sensor and related instruments leading to commercialization of laboratory prototypes**.**

xi) **<u>National Programme on Carbon sequestration Research</u>** Under this programme projects for sequestration studies using solar/chemical methods, improving carbon and nitrogen sequestration and predicting soil carbon change under different bio-climatic systems and carbon dioxide sequestration potential of agro-forestry system under irrigated and rainfed conditions were supported.

xii) **<u>National Accreditation Board for Testing & Calibration</u>** NABL has gained self-sustainability with respect to revenue expenditure and the number of certificates issued is growing annually at rate of around 14%. The major sectors in which NABL has granted accreditation are Textiles, Automobiles, Power, Telecom, Petroleum, Food, Health and Environment. As on date, more than 1300 laboratories have NABL accreditation, out of which 20% are Government laboratories.

xiii) **<u>Good Laboratory Practices</u>** DST has been entrusted with the responsibility for certifying Test Facilities with a Good Laboratory Practices compliance certificate for preclinical testing of Pharmaceuticals, Industrial Chemicals, Agrochemicals, Cosmetics and Food and Feed additives. GLP certification is required by manufactures while registering these substances for use in humans and in animals. India has completed all requirements as stipulated by OECD for GLP compliance monitoring. The OECD recognition and Mutual Acceptance of Data (MAD) has been received.Data from Indian laboratories would now be acceptable in all 34 OECD member countries removing a new tarrif trade barriers for the country.

xiv) **<u>Survey of India</u>** Department of Science and Technology has been promoting Survey of India which provides R&D services in the areas of Geospatial technologies, testing and standardization for quality systems for manufacturing. Geospatial technologies and map products of SOI are known for their brand value. These organizations have rendered critical and important services to the country.

xv) **<u>Advanced Research Centre for Powder Metallurgy & New Materials</u>** The main research areas are Nanomaterials, Engineered Coatings, Ceramic Processing, Laser Processing of Materials, Sol-Gel Coatings, Non Oxide Ceramics, Carbon Materials and Fuel Cell Technology. Technologies for nano-silver suspension for anti-bacterial textile applications have been transferred. The institute has state-of-art cold metal transfer welding facility, CNC machining centre, chemical vapor deposition reactor for CNT, high pressure reactor for aero gel synthesis etc.

xvi) **<u>Agharkar Research Institute</u>** The institute conducts research in the areas of animal sciences, microbial sciences and plant sciences and has the status of an academic institution in life sciences. Some of the salient achievements include plant based attractant for honey bees, development of platform technology for DNA preservation, development of a bread wheat variety released for cultivation in Maharashtra and Karnataka and prototype kit for rapid identification and anti-biotic susceptibility testing of microbial pathogens. The institute has successfully developed an integrated microbial cum-adsorption arsenic removal system which has been installed at Rajnandgaon in Chhattisgarh.

xvii) **<u>Shree Chitra Tirunal Institute for Medical Science & Technology</u>** The institute has been declared as an institute of national importance. The mandate of the institute is to develop appropriate technologies to meet the health care needs of the country and initiate training and research programmes integrated bio-medical technology and health sciences. The institute has transferred technologies for two bone graph products and has initiated a number of collaborative projects with public and private R&D institutions

6. TRAJECTORY & SELECTION OF NEW PATHS AND PROGRAMMES

The department has now fortified its strategy and changed its focus on convergent solutions rather than technology demonstrations alone. The Department has taken new initiatives for technology development in the areas of water, security, solar energy, drugs and pharmaceuticals, nano science and technology to give an oriented focus. The current strategy of the department is to identify and bridge areas of gaps in the conversion of knowledge into know-how, know-how into show how, show-how into do-how and do-how into use-how. Technology mission on "Winning, Augmentation and Renovation of water" focusing on Innovative deployment of technologies under real field conditions complete with revenue models for sustainability is an area of technology intervention in conversion of Do-how into Use-how. With the help of the Ministry of Fertilizers and Fertilizer Industry Association and a corporate house, the Department has now commissioned a project to establish a test bed for the manufacture of potash based fertilizer at 3 TPD level based on technology developed by one of the public funded which is an example of conversion of know-how to show-how. The Department has also mounted a national initiative in development of technologies for driving the costs of solar energy through technology innovations which is an example of conversion of know-how into show how.

Based on the strategies outlined above, possible Technology Development Support actions that can be continued in XII Plan are enumerated below:

- Demonstration and promotion of the use of Spatial Data Management Technologies for micro level planning under diverse terrain conditions.
- Establishment of critical number and carefully sized test beds for proving the techno-commercial viabilities of technologies selected from technology compendium and portals to enroll the academy-research-industry partnerships and develop policy support mechanisms for addressing the subsidy burden in areas like fertilizers and energy needs.
- To establish credible number of innovative technology deployment clusters in areas like water technology and prove sustainability through appropriately developed revenue models.
- To create and establish knowledge networks and institutional capacities in the areas like climate change and clean energy.
- To promote R&D in areas like Drug and Pharmaceuticals and biomaterial devices and technologies for affordable health care.
- To devise policy and programme inputs for promoting PPPs in R&D in clean energy.

7. NEW APPROACHES FOR THE XII PLAN

7.1 Implementing Technology Development

In the end, all technology development will need to have a recipient industry with the appropriate 'go to market' strategy for realization of its value. This will also serve to establish important parameters such as scalability and affordability of the technology. Perhaps the simplest mode of translating technology is to transfer the know how to an established industry. Currently there are processes established within DST that are addressing this issue. **The suggested approach goes beyond this and identifies ways by which the nascent intellectual property that is developed in our academic institutes can be translated into practice.**

The salient features of proposed approach are:

Approach	Paradigm	Models	Stakeholders	Focus Areas
Participative: Technology Platforms	**Convergent solutions**	**Private Public Partnership models** **a) For industry ready private sector R&D and** **b) for R&D for public and social good**	**Industry, Academia, Society, Government**	• **Distributed Solar Energy Generation and Storage for Homes** • **Technology Platforms for Membranes, rapid contaminant detection and systems for individual, small and large communities and water on the go** • **Energy Efficient low emission wireless technology** • **Integrated computational material engineering**

7.2 Means and mechanisms for building technology partnerships among key stakeholders: Identify ways of working between Academia and Industry to maximise the chances of successful technology transfer

At its simplest, the Industry is seeking to access knowledge/ expertise that will further its goals and the academia is seeking to identify problems of relevance and for funds. The nature of the interaction varies considerably starting with the industry seeking to **access** a specific skill or method or a sophisticated equipment that is available with the Academic institution such as an analytical service. At the next level there can be a relationship to **develop** such a method or a new process which involves a greater interaction between the two organisations. An interaction that attempts to **solve a problem** that the industry is facing is a more intimate one with both parties contributing to the problem definition and solution and sharing the IP so generated. Some industries have **scouted** for technologies in academia and subsequently developed these in their laboratories and eventually marketed them. More recently, Pharmaceutical companies have been aggressively seeking partnerships with academia and Contract Research Organisations for lead molecule identification, High Throughput Screening, access to chemical libraries, in-silico screening and modelling and Clinical trials. The motivations have been several of which rising costs of Research is an important one. **Open Innovation** is a term coined by Henry Chesborouh at Berkeley and has been widely adopted by virtually all industries. Though the original definition was to realise economic value from technologies on the shelf in industrial R&D labs by incubating them with external funds, currently most industries use open innovation to mean accessing technologies developed outside the organisation.

7.2.1 Models for Industry-Academia interaction:

At its simplest the academia could have a **menu** driven approach for the services offered. The pricing would include fixed costs, depreciation/ replacement value, labour, costs of developing the methodology and a mark up.

For joint or **collaborative project**s, the actual costs in terms of the people costs, infrastructure, consumables etc in addition to overheads and mark up could be used. In this instance since there is likelihood of generation of IP there should be an agreement for the academic institution to share in the monetary benefit to the industry. This could be an upfront payment or a percentage of the incremental sales generated through application of the technology for a specified period or a combination of both. It is important to point out that this is a skilled activity and academia should seek specialist advice.

A third model is where the industry may seek to **rent space** in the academic institution and install their personnel to work on a joint programme. There are some merits to this model. Proximity enables better coordination. Transferring dossiers does not transfer technology as effectively as transfer through personnel. Very often Technology transfer is about 'know how' which is difficult to commit to paper.

A fourth model is the **'incubator'** model. The academic institution sets up processes to establish a start up company with the intention of developing a business based on technologies developed in the Institute. Normally the process begins with calling for potential technology entrepreneurs to submit proposals along the lines of seeking funding for projects. A better process is to **scout** for the technologies taking the help of established entrepreneurs. The initial investments include licensing the technology, providing infrastructural support in terms of space, utilities, software licenses, access to laboratories and staff. The institute may extend loans in return for equity. To ensure that the venture is a success, the institute could appoint a committee of experts (including entrepreneurs from outside) and mentors for the start up company. The benefits of this model are that the process of incubation creates an entity with clearly assessable value which can then be 'sold'. More importantly it creates a culture of enterprise within the organisation which will serve to connect the institution to the outside world. Lastly and perhaps most importantly, it helps define the questions that are relevant in the context of the society.

7.2.2 Some Generalizations:

- There is a skill gap that is being bridged in these interactions.
- In some instances there is an attempt to look for opportunities with an open mind.
- When the problem is well defined the interaction tends to provide uniform satisfaction.
- There is asymmetry in the expectations on both sides. Thus the industry is often critical of the academia in terms of their ability to stick to agreed milestones and times. The academia is often unhappy with the industry for the lack of scientific rigor, changing priorities and the lack of longer term vision for technology.
- Often there is insufficient interaction between the parties leading to a mismanagement of expectations. Further, change in personnel particularly in the industry leads to change in priorities.
- Ownership of Intellectual Property can become a vexing problem and it is best to spend quality time up front resolving the issues and coming to signed agreements.
- Assessment of the value of the technology to the industry, over time, is an important but non exact science. Hence agreeing a compensation package for the technology transferred requires skill and experience.

7.2.3 Role of DST

In the context of the foregoing DST has a seminal role to play in ushering in an era of 'Innovation' in the country by being the catalyst in ushering in a new era of Industry Academia cooperation. **DST should take the lead in improving the Industry Academia partnership, develop a web based information system that enables entrepreneurs to access good quality support for IP, legal and Accountancy and institute a fund for 'incubation' of technologies in premier institutions. This could have two components – a soft loan and a loan against which the startup issues equity. A live technology portal for India incorporating above needs to be developed**

7.3. Innovative methods of selecting technology priorities complete with techniques for deriving benchmarks and Suggested mechanisms for promoting development of convergent technology solutions for some key challenges of India : Technology Platforms (TP)

TP identification needs participation from R&D of Industry, Academia and National Labs where relevant. It is often led by the Industrial R&D. The identification of what needs to be done in a TP is followed by how it should be done and an analysis of who are the people currently working in the area. This enables identification of gaps in our knowledge and hence priority sectors for funding. When this process is done well it has a good chance of developing technologies which are solutions to problems rather than a technology searching for a problem. This also enables a better take up of the technology by industry and thus fulfills an important aspect of the mission for S&T in India.

7.3.1 Characteristics of Technology Platforms

i) TP's are themes requiring multidisciplinary science and engineering inputs to address challenging questions.

ii) TPs Focus on solution rather than science (driven by 'what' rather than 'how'). This has to be arrived at by having all stakeholders contribute to defining the solutions needed to address the Technology Missions.

iii) TPs may be relevant to a plurality of Technology Missions, products and processes.

iv) TP's can span more than one institution.

v) TP's need skilful leadership and offer unique career opportunities. TP's provide opportunities for developing leaders with an ability to deal with complex problems and situations.

vi) TP's enable identifying unique and often breakthrough solutions

7.3.2 Process of identifying Technology Platform:

i) The first task is to define the 'what' of any problem. *These represent the consumer relevant 'what's'*. To meet these requirements it was necessary to identify the issues to be addressed under a variety of manufacturing, storage and use conditions. Such studies enabled identifying fundamental questions (*technical 'what's'*) which when answered could give rise to unique solutions. For problems in specific areas like health care, transportation, steel, food supply and water it is necessary to articulate the customer and the technical 'what's' by the industry or a department in a ministry where appropriate.

ii) The next task is identifying 'how' for the technical 'what's'. This is an iterative process and requires individuals from several relevant disciplines get together and articulate the questions. Often it will need some initial experiments to be done to even identify the key questions and their importance.

iii) Once the 'how' has been articulated it is important to identify the best talent ('who') that can be accessed to work on the questions identified.

iv) Technology platforms are a collection of projects with a common set of objectives.

v) Technology Platforms need skilful leadership. Typically it is led by the end recipient of the technology.

8. <u>SELECTION OF XII PLAN TARGETS</u>

8.1 <u>Scoping of key sectors of priorities for technology development</u>

The scoping of key sectors of priorities has been done keeping in view the overall objective to promote India-centric "frugal, distributed, affordable innovation" that produces more "frugal cost" products, services and processes to serve the people at low levels of incomes without compromising the safety, efficiency, and utility of the products as well as develop Cutting edge technologies and innovations for globally competitive and inclusive growth to power technology led economic progress of the country.

Considering the expected contributions to national need, present and potential opportunities, core competence , significant base-work done in the past, expertise available and potential industry-institute synergy, following key sectors were prioritized for providing convergent technological solutions:

i) Solar energy

ii) Water technology

iii) Telecommunication

iv) Materials

v) Drugs & Pharmaceuticals

8.2 Technology Mission Mode Programmes of National Importance

The following four **Technology Platforms** are proposed to be initiated in XII plan capitalising on perceived India-Centric opportunity with clear user-centric focus, well defined requirements and active private-public –partnerships. These Platforms are likely to have an impact in several of the existing technology missions and would also contribute to establish input-outcome linkages in technology interventions.

i) Distributed Solar Energy Generation and Storage (Annexure-I)
ii) Membranes as technology platform and novel rapid contaminant detection sensors for potability of water (Annexure-II)
iii) Integrated computational material engineering (Annexure-III)
iv) Energy Efficient low emission wireless technology (Annexure-IV)

8.3 Quantitative deliverables

It is expected to develop at least 4 vibrant Private Public Partnerships for R&D in areas relating to public and Social good like water, energy, telecommunication and computational materials technology developing appropriate technologies.

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Annexure-I

Distributed Solar Power Generation and Storage

1. Context

Energy technology development is a broad spectrum activity in which many national entities are already involved. Given the key role of energy for development, our limited energy resources, and the challenges involved in terms of minimizing the adverse impact of energy on the environment, energy policy makers and experts agree that adoption of new and emerging energy technologies will be of vital importance in our quest for progress toward a sustainable energy future. What will distinguish the next generation of energy technologies from current technologies is their accent on efficiency and near zero emissions.

Rapid developments are taking place in renewable energy technologies all over the world. Further research and development efforts are needed to evolve cost-effective systems suitable for conditions and circumstances in our country, if wider scale applications are to take place. In order to plan development of convergent technological solutions for identified technological priorities complete with benchmarks, Solar Power Generation and storage can thus be taken as India centric opportunity, which has the potential for transforming existing scenario through development of technology platforms for taking up R&D programmes with key participation of the industry. The initiative proposed to be pursued now is a kind of targeted effort in some selected areas for achieving concrete results in Solar Energy utilization for applications both for power as well as other than power generation with a view to provide convergent technology solutions under real-life conditions.

2. Changing national scenario and the role of DST

There is general acceptance about the urgency for faster progress in the application of clean energy and energy efficiency technologies. It is said that the world must propose a low-emission technological revolution, which is key for energy security, climate change and universal access to energy as the central driving forces of medium and long-term economic growth. This is proposed in a scenario for 2050 with a projection of energy demand which will be twice that of today, mainly due to the rise in consumption in developing countries associated with fulfilling the unmet energy needs and improvements in the standards of living.

There is, in turn, general recognition that the efforts made in this direction up to now have not been enough. There are still numerous and very diverse obstacles to the adoption of this type of technology, worsened by the current economic crisis which has placed other problems in the spotlight. The G20, concerned with energy issues, has launched a new Working Group on clean energy and energy efficiency (C3E) calls on Governments *"to take steps to create, as appropriate, the enabling environments that are conducive to the development and deployment of energy efficiency and clean energy technologies, including policies and practices in our countries and beyond, including technical transfer and capacity building."* The clean technologies include nuclear energy, large and medium hydro electric projects, and transformational technologies like hydrogen, and fusion etc. Innovative technologies like bio-fuel, bio-diesel, cellulosic alcohol, carbon fixation should command equal priority as given to other renewables like wind, solar etc.

Implication is that the initiative should focus on development and transfer of other new technologies having large potential of helping in global emissions reduction and make them affordable rather than remain limited to exploiting existing costly technologies which may only benefit some companies but not address the real issues of affordability of energy to all. While enhancing connectivity and delivering up the electricity supply and utilization capacity, there is need to ensure that this is carried out in a sustainable manner – economically, environmentally, and socially. As a result, the country is strongly pursuing policies to promote energy efficiency on both energy supply and demand sides, and to enable each new infrastructural or end-use installation to be more efficient than the last. It may be mentioned that the energy intensity of the Indian economy has declined from about 0.21 kgoe/$ GDP-PPP in 2000 to 0.14 kgoe/$ GDP-PPP in 2008 – a fall of about 30% in 8 years. This is unprecedented for any large country. A slew of policies are in place to enable energy efficiency in the appliances & equipment, buildings, industrial, municipal, power generation, and agricultural sectors.

There have been strong programmes to promote renewable energy in the national energy mix, despite the fact that renewable energy costs more than energy from fossil fuel, and there is limited ability of Indian consumers to pay for energy. The Electricity Act, 2003 requires each distribution company to procure a minimum percentage of electricity from renewables. As a result, about 16% of the electrical energy in the country is generated from renewable energy resources, with the renewable energy generators receiving premium prices.

The country has also launched the National Solar Mission with the goal of installing 20,000 MW of solar power generation plants by 2020. The Government has announced the National Solar Mission with the objective of to achieve volume production of solar technology at a scale which leads to cost reduction and rapid diffusion and deployment across the country. Mission aims at achieving grid tariff parity by 2022 by creating enabling policy framework, volumes for deployment, domestic manufacture, support infrastructure and R&D. Mission to be implemented in three phases and by 2020, the installed capacity in India is expected to be 20,000 MW. The mission seeks to encourage Innovative investor friendly single window mechanism, Solar specific Renewable Purchase Obligation (RPO), Concessional Finance / subsidy for decentralized, off grid systems, Attractive feed in tariff for utility scale and rooftop solar power plants and Tariff based bidding for large solar thermal plants.

The adaptation of existing clean energy technologies to meet our needs (in terms of performance and price), and the development of new technologies for our needs, is a continuing challenge. A number of national initiatives are in place to promote the development and introduction of affordable appropriate technologies. DST being the R&D ministry would act as a nursery for innovative technologies and attempt to develop technology platforms which could be subsequently leveraged for large scale replication under National Mission by the line ministry.

3. Scoping of Priority areas for developing convergent technology solutions

In the national context, the long term goal for the energy sector ought to be to progressively achieve a transition to a more efficient energy system with increasing contribution from renewable energy technologies, and from, what are called, the next generation of energy technologies, in order that energy does not become a constraint for sustainable development. In the near term, attention needs to be focused on promising renewable energy technologies of relevance to our country for decentralized applications and cost-effective solutions are to be developed for this purpose.

During previous plan periods, government has provided significant R&D support to a wide range of institutions in the country which has resulted in a certain level of technological capability in institutions and industry in the country. Solar power has started to make inroads into our power sector as is evidenced by the large number of projects and extension activities at the central and state levels. Yet the levels of performance and cost continue to be the main barriers for wider scale use. Hence further efforts are needed to intensify R&D activities to address these constraints and to achieve breakthroughs needed to bring about wider scale utilization in the country by targeting appropriate technical and cost goals. Such a goal-oriented approach, developed in partnership with industry and other stakeholders, will have a vital role to play in addressing the challenges of the National Action Plans on Climate Change, and related Missions that are currently being pursued in the country.

DST's efforts during the 12th plan period should aim at

- Targeting certain scalable solar power technologies in the context of the National Solar Mission by intensifying R&D, and to assist in building multi-institutional technology platforms with industry participation for achieving technological breakthroughs in this field

- Intensifying R&D efforts in energy storage technologies -advanced batteries, fuel cells for stationary and mobile applications, thermal storage systems
- Generating R&D and industry partnership in development of the next generation of alternate fuels for vehicles

A focused goal oriented approach is envisaged for developing better collectors for solar thermal, high efficiency materials for solar PV and state of art storage systems for decentralized distributed energy generation. It is proposed to develop these systems meeting price –utility envelope suitable for not only Indian markets but other third world countries as well. Support for goal-oriented R&D involving partnership between R&D institutions and industry coupled with Technology demonstration and diffusion is envisaged. Towards this end, certain Technology Platforms are proposed.

5. SELECTION OF XII PLAN TARGETS Technology Platforms

During the 11 Plan, DST has already embarked on a solar energy initiative aimed at achieving practical solar energy devices and systems that are scalable. The plan for the next five years would be to focus and intensify technology development efforts in certain priority areas of national importance such as, **Cost-effective distributed solar phototovoltaic and thermal power technologies for homes, schools, community facilities and micro-enterprises in the context of the National Solar Mission.**

i) Cost-effective distributed solar phototovoltaic technologies for homes, schools, community facilities and micro-enterprises in the context of the National Solar Mission

Distributed solar power in homes and institutions could be considered as an alternative to grid connected solar PV farms provided subsidies are provided in a successful fashion without diversion and leakage. The technologies that would be required relate to DC fan, lightings and light circuits which are not insurmountable challenges. This concept can technologically be developed from prototype to pilot scale. However, up-scaling at national level will require ratification of standards, planning of manufacturing capacity and development of process of installation, maintenance and technology up gradation. Compared to grid-connected solar farms, the inefficiencies of d.c.-a.c. conversion, and subsequent T&D losses, are avoided in this concept. Large tracts of land need not be acquired to deploy panels. If properly implemented, there is scope for creating a vibrant industry around it, as well as a nationwide renewable energy footprint. Suitable Energy storage technologies- thermal, chemical and electrical options, tailored for the specific applications and having attributes such as Efficiency, Durability, Low cost. High energy density, Recyclability needs to be explored. The detailed concept note is enclosed at Appendix-I.

ii) Cost effective Solar Thermal Power technologies and systems for rural and urban applications in tune with the objectives of the National Solar Mission

As mentioned earlier, Department has supported 200 kW solar biomass hybrid thermal technology demonstration plant. Besides contributing to the development of indigenous technologies which would bring cost effectiveness, the performance data generated from this plant would enable scientific assessment of viability gap for setting up such plants in yet to be electrified villages as well as villages facing electricity shortage. The success of this project is expected to be followed up through development of pioneering solutions to generate energy through high thermal efficient, scalable and cost effective suitable for the needs of rural areas.

In continuation with the initiative taken by the Department in the XI Plan for Solar Desalination, it is proposed to use Solar and Bio-mass energy to produce power as well as desalinated water. In order to make the process cost effective, technological challenges related to bio-mass solar integration including superheating of solar steam by bio-mass and desalination utilizing waste steam from power plant are proposed to be addressed. Suitable Energy storage technologies- thermal, chemical and electrical options, tailored for the specific applications needs to be explored.

Appendix-I

Distributed Solar Power in Homes and Educational Institutions

Preamble

Solar water heaters have been successfully deployed in a distributed fashion in homes and hostels in educational institutions. Subsidy has also been successfully provided by the government in order to ease the capital expenditure burden. This subsidy scheme has been implemented without significant diversion or misuse. This subsidy has reduced the investment in electricity generation, which would otherwise have gone to run electrical heating appliances. The cost of generating an equivalent amount of electricity would have been higher, not to mention the additional carbon emissions as a result.

Today, electricity is supplied to domestic consumers across the country at a subsidized rate. The subsidy is very high (often, around 80-90%) for the first thirty or fifty units per month, the rationale being that basic lighting, and maybe fans too, must be within the reach of all. Thereafter, the subsidy drops gently towards zero as consumption increases to a few hundred units each month, typically in homes with air-conditioners, geysers, etc.

The capital expenditure per Watt of thermal power is around 33-40% of that of D.C. power from solar PV (without the A.C. grid connection, land etc.). Besides, there is fuel and operational cost, and T&D losses, as well. Thus, 40-50% of the subsidy needed if solar-PV electricity is provided locally at homes for, say, the first 50 units per month, is already being given in the form of almost free thermal power. In view of the global commitments to reduce carbon emissions, the government is committed to subsidizing solar power generation up to a certain target level by 2020.

The question arises: *can the solar generation target is met substantially by distributed solar PV installations in homes* (and educational institutions), rather than grid-connected polar PV farms? Can part of the subsidy for solar PV equipment be diverted from the subsidy already being given for thermal power. Can this subsidy be provided in a successful fashion without diversion or leakage, as has been achieved in the case of solar water heating? (Since grid power will also be available at the home, this is a non-trivial issue. In the case of solar water heaters, the unit cannot be sold to another user, since anyone can get the same subsidy directly when a solar water heater is procured. In this case, a non-subsidized electricity consumer, say a commercial establishment, would be a ready second buyer for the subsidized solar PV system.). If the answers are in the affirmative, what are the technologies that need to be developed to make it possible.

D.C Fan and Light Circuit

With the advent of brushless d.c. (BLDC) motors, fans with the same air throw and form factor require only 40% of the power of a similar a.c. fan. The cost of the fan also does not increase significantly. Similarly, LED lighting can be run on a d.c circuit. However, LED lighting products are not yet mature, there is considerable variation in performance, and durability is not yet established. As an alternative, one can deploy CFLs that are designed to operate on d.c. power.

Normally, consumers can be expected to be unwilling to invest in CFLs, or replace a.c. fans with more efficient d.c. fans. However, if they are going to be provided subsidized solar PV panels, it is cost-effective to provide the CFLs and d.c. fans and thereby reduce the requirement of solar power. Typically, the cost of additional solar PV panels to power a.c. bulbs and a.c. fans will be three times more than the cost of providing CFLs and d.c. fans.

In somewhat more affluent homes, a d.c. refrigerator will also be an important product to develop. Here again, the power required will reduce by 50-60% if d.c. compressors and fan motors are employed. With regard to other household appliances such as washing machines, the duty cycle (running time per day) is small, and it may be not be worth developing d.c. models.

It will be necessary to standardize on the d.c. supply voltage for the light and fan circuit. The voltage used in telecommunications equipment, namely, -48V, is a candidate. The choice will have to be made such that standard 5A and 15A wiring can also be used for the d.c. circuit. Once the supply voltage is standardized, one can encourage electronic appliance manufacturers to provide a d.c. supply socket in addition to the a.c. socket. It will not add any significant cost to the SMPS in the appliance. Till such appliances become common, an inverter will be needed to run low-power a.c. appliances such as TV sets. DC fans, CFLs and refrigerators need to be brought to market. The lights and fans can be bundled with the solar PV installation, and a separate market channel is not needed.

It is expected that the a.c. circuit for mixers, grinders, washing machines, iron, etc will continue to be powered from the grid. The total power consumption by these appliances is expected to be low.

Solar PV requirement

It is proposed that the solar PV equipment for the household will be subsidized by the government. One will need panels ranging from 100W to 500W in steps of, say, 100W to cater to all types of homes – from the humble hut to the well-appointed apartment. The d.c. circuit can be powered directly from the PV panels, or more likely, after d.c.-d.c. conversion. A battery may also be charged for powering the d.c. circuit at night. Grid power is the back-up source for the days when solar power generation is poor.

The solar power generated is also metered, and the consumer is charged the same subsidized rate for it as is charged today for the first 50 odd units per month. The rating of the PV panel deployed is such that it is capable of supplying the amount of subsidized power normally consumed by the user per month. Thus, additional power drawn from the grid will be paid for at the non-subsidized rate.

An exception to this can be made when the solar unit has not generated sufficient power on a particular day. An equivalent amount of power from the grid can be provided at a subsidized rate. The shortage of solar power could happen due to malfunctioning, or just cloudy weather. In any case, the consumer is protected. An intelligent power management unit can keep track of the amount of solar power generated. With the fast evolving Internet of Things, it should be possible for the unit to send a maintenance message to a service centre in case of suspected malfunctioning.

It should be possible to do away with the subsidized supply of grid power to those consumers for whom solar PV systems are deployed. Once the subsidy is removed from grid power, disposal of the PV equipment to a second buyer is deterred. Any consumer who does this will have to pay the unsubsidized rate for all the power consumed.

<u>Other applications</u>

Although the subsidy for educational institutions is less than that for homes, such institutions are prime candidates for deployment of similar solutions. Such institutions run only in the day time (by and large). The need to store solar power is thus obviated. Typical requirements are in the range of 250-300W per class room. The majority of educational institutions, particularly schools, are run by the government. It is easier to finance the solar PV equipment for such schools, since there is no subsidy involved here to another party.

<u>Solar PV potential for homes</u>

Even if we assume that 70% of homes (mostly rural) will be served in the manner described above, the number of such homes is 170 million. If each home requires on the average a 200W panel, the installed capacity will be 34000 MW. This exceeds the 2020 target set for solar PV generation by the government. Since 20% or more of the population will be in schools for 200 days in a year, solar PV installations in schools can vastly improve the school environment. They will also add significantly to the installed capacity.

Finally, it is worth noting that with solar power in the home, the bane of power cuts will be a thing of the past. At long last, a rural consumer, howsoever poor (s)he may be, will have 24x7 power in the home. It is likely that the technology will become popular in small towns and cities as well.

Technological challenges

The technological steps to develop this concept from prototype to pilot scale are not daunting. However, to scale it up thereafter to national level will require ratification of standards, planning of manufacturing capacity, development of processes for installation, maintenance, and technology upgradation.

Most of the constituent technologies are readily available. One key goal would be to keep the system simple, with d.c-d.c conversion avoided to the extent possible in order to maximize efficiency. The d.c. supply voltage will have to be chosen to leverage the standard AC 5A wiring widely available. If this voltage is not too high (say, 48V), PV panels can be stacked to obtain the required voltage directly. CFL electronics have to be modified to work off the d.c. supply voltage. CFLs are available for 12V d.c., but may not be available for the supply voltage decided upon. Similarly, BLDC fans that are identical functionally to a.c. ceiling fans will have to be developed for the d.c. supply voltage desired. Some companies have already developed d.c. ceiling fans but have not commercially released the product yet. Their plan is to release it as an efficient a.c. fan with internal a.c. – d.c. conversion. It is not known what d.c. supply voltage they are using, since it is an internal design parameter. Finally, d.c. compressors for refrigerators are available, often for 12 / 24 V. Here, it may be better to use a d.c. – d.c. converter to match the supply voltage to the available compressors, since the refrigerator cost will only be marginally impacted.

When the products are developed, standards will have to be evolved for sockets, etc that distinguish these from a.c. products. Since the fan and light circuit in most homes is a separate one, converting it to a d,c, circuit is fairly easy. However, if there are a.c. sockets in the circuit, they have to be isolated on a separate circuit connected to the grid. An intelligent power management electronics circuit has to be designed that switches from PV to grid when solar power is insufficient. One can implement the metering and subsidy policies to ensure that (i) grid power is drawn only when solar and battery power are insufficient, (ii) grid power is drawn as far as possible in off-peak hours, and (iii) grid power drawn during because of failure of PV system or due to cloudy skies is given the appropriate subsidy.

Technology development for solar homes will ride on the developments in the area of PV panels and batteries. It is desirable that panels have a lifetime of more than 25 years, possibly even 40 years if possible to match the lifetime of the house itself. Batteries will need replacement every three years or so. CFLs will need replacements too. A robust process for after-sales service and maintenance is vital. Since both batteries and CFLs are high capital cost items relative to incomes, it will be a good idea to design a scheme in which the payments for these are collected on a monthly basis (maybe it will be the subsidized payment made for the solar power) so that the replacements for batteries and CFLs can also be subsidized. In other words, success will depend not just on development of a robust system, high-volume multi-vendor production and a good after-sales network, but also a proper funding and sustenance scheme.

Summary

Compared to grid-connected solar farms, the inefficiencies of d.c.-a.c. conversion, and subsequent T&D losses, are avoided in the proposed approach. The solution is matched to the subsidy regime already in place in India, and thus makes economic sense in the specific Indian context. Large tracts of land need not be acquired to deploy panels. The subsidized power generated will go to the most needy, who have been at the losing end with regard to grid power. While there are no basic technological challenges, a lot needs to be done towards standardization, product development, supply chain development, after-sales service, maintenance, and technology upgradation (e.g., to LEDs, when they become mature). If properly implemented, there is scope for creating a vibrant industry around it, as well as a nationwide renewable energy footprint.

Annexure-II

Sustainable Solutions for addressing Water Scarcity through Science & Technology – Development of Appropriate Technology Platforms

Context

India is currently facing diverse challenges in the water sector. In view of increasing population and growing trend towards urbanization, demand for water is likely to outstrip the supply. Water is a key resource and needs to be viewed holistically to assess its potential to meet competitive demands of various sectors namely domestic, industries and agriculture. There are several programs being implemented in India for finding socio-economically viable solutions. Technology Mission: Winning Augmentation and Renovation (WAR) for water has been launched by DST under the directives of Supreme Court. During the course of implementation of the program, several water-related challenges facing the country have been identified in consultation with the stakeholders. Quantum deficit of water for agriculture needs and quality deficit for drinking water are two of the most important challenges that face the country currently. Sustainability of the holistic solution for adequate quantity and quality of water requires consideration of technical feasibility, social acceptability, environmental friendliness as well as financial viability. WAR for water program is thus in search of professional organization which can provide affordable solutions to water challenges in India.

Also, the gravity and diversity of existing as well as emerging water quality problems including its spread and extent in the country and its effect on costs of healthcare makes it necessary to give focused attention to R&D activities in the area of drinking water. DST is also implementing Water Technology Initiative, a research based program aimed at development and proving of low cost convergent technology solutions for domestic applications to ensure safe drinking water quality under real life conditions.

There is thus a need to encourage indigenous research initiatives for addressing issues related to water availability, water purification and water reuse and recycling. Scientific evaluation of technologies for safe drinking water for decentralized applications, creation of database of technologies for referencing them in specific social context, capacity building of academic/ R&D Institutions and state S&T councils in conducting R&D activities for addressing water challenges, development, field assessment & pilot testing of technology options for drinking water purification are some of the goal oriented activities that are required to be taken up urgently.

Governance Mechanism

Innovative mechanisms of stakeholder partnership including but not limited to industry-academia partnerships need to be evolved to identify and work on R&D themes to not only develop and deploy convergent solutions for problems of water scarcity but also capitalize on opportunities for India, in other developing countries facing similar water challenges. In order to develop sustainable convergent solutions, a consortium approach involving R&D institutions/academics, industries, local bodies and community is essential.

The Group recognizes that development of a few generic technology platforms (TP) targeted towards providing cost effective convergent solutions to the challenges facing us in India in ensuring the quantity and quality of water to all citizens of the country, must be taken up in the XII Five Year Plan. Technology Platforms thus developed will offer opportunities to all stake holders to leverage the technology prowess of the country developed over several decades for applications in different social contexts.

Scoping of Priority areas for developing convergent technology solutions

i) Solutions for 'water on the go' so that consumers can use portable devices that can upgrade poor quality water to potable water

ii) Real time analysis of Water Quality particularly for microbial contamination (including detection of residual chlorine) – development of appropriate diagnostic technology platforms – for example easy to use sensors for the analysis of microbes, arsenic, fluoride and heavy metal contamination in water

iii) Development of Technology Platform for charged and uncharged membranes covering broad array of application from drinking water, sea water desalination, dialysis etc.

iv) Collaboration with certain public sectors /municipalities to initiate water audit/ water recovery & reuse systems. Innovative Water recycling activities to make unusable water usable for municipalities and industries. (sewage treatment for household, colony and clusters)

v) Development of innovative devices for water purification interfaced with location specific alternate energy options and innovative strategies for treatment of contaminants, non-membrane non ion exchange solutions for water purification

vi) Development of technology platforms for solving major problems related to arsenic, chromium and fluoride contamination in ground water (several areas in India are facing acute shortage of drinking water because of these contaminants in the surface and ground waters)

vii) Setting up of Water Technology Park to create general awareness of water technologies and comparative merits of operation and maintenance of different units available commercially as well as under pilot development.

viii) Desalination with rejects (disposal of residues)

ix) Capacity Building : Training Program on Scientific Water Management Practices in States and other stakeholders; Capacity Building of

Academic/ R&D Institutions - Human Resources, Infrastructure, dedicated program to encourage young water professionals etc

x) Setting up publically owned and privately managed national centre dedicated to Water Related Research, five regional centres of excellence and large number of college centres for pursuing applied water research

xi) Water testing institutions at State level in government-academia partnership for ensuring continuous water quality monitoring and remediation for providing drinking water

xii) Application of ICT tools for the development of appropriate software and hardware for monitoring water quality and the efficacy of water treatment methodology.

xiii) Co-development of solutions to meet price-utility envelope of developing countries as well as mutually identified priorities for joint research in water sector

India –Centric Opportunities in Water

While Technology solutions available off the shelf for water related challenges are valuable, further value addition to such solutions for applications in the social contexts of emerging economies like India is possible through cost optimization and solution design approaches. Designing solution for water availability should take into account the utility-price envelopes and potentials for driving costs of delivered water through scaling and manifold expansion of volume. Indian market and innovation landscape offers such potentials. There is untapped synergy among systems both nationally and internationally.

Both Indian market and innovation systems offer opportunities for cost optimization of designed solutions in the widely varying social contexts of India. There remains an untapped opportunity for India to develop affordable innovations for applications in both emerging and developing economies with income disparities.

The India-specific opportunity therefore relates to development of a few Technology Platforms in a consortium mode that is, through private - public partnerships (PPP). PPP models will necessarily consist of innovative business models through which several institutions possessing the knowhow and the knowledge will be able to collaborate with small and medium enterprises as well as major companies for designing solutions to the challenges in the water sector within the utility-price envelope of our own country as well as for countries facing similar challenges.The group has identified a couple of technology platforms as described in the following sections.

Technology Platform I

Recommendation to set up test beds to take forward indigenous membrane technologies and build up capability in "Membrane as technology platform"

Various institutions and companies in India have been carrying out R & D work on membrane-based separations for water purification and desalination, as also for industrial, bio-medical, environmental and energy-related applications. Membranes are at the heart of all such processes and, yet, almost all membranes are presently imported. It is imperative that membranes be viewed as a critically important technology platform in which the country must have a strong presence. Although several CSIR laboratories, DAE, DRDO and other institutes have worked over decades on membrane development, there is a need to take the developments to the next level through setting up of test beds; especially in those cases where "proof of concept" has been rigorously established. Such test beds would not only help to cater to larger requirements for R&D, societal and strategic needs, these would also help show case the technologies at a scale and in a manner which would facilitate their licensing to prospective entrepreneurs. In line with this thinking, a 2000 sq. m. per day test bed is being considered by CSIR for thin film composite Reverse Osmosis membrane (*SISOMSO*™) forward integrated to module production. Recently, hollow fibre membrane knowhow has also been licensed by CSIR-CSMCRI but the need for a test bed is still felt to cater to large societal demands and other emerging applications. The membrane technologies which are of considerable importance as technology platforms are listed below:

1. **Micro- and ultrafiltration membranes**. Both ceramic and polymeric membranes have gained wide acceptance for diverse applications. The ceramic membranes are of tubular design and typically have microporous structures suitable for removal of particulate matter and bacteria. A major advantage is their thermal and chemical stability which allows for easy sterilization and removal of foulants. Polymeric membranes, on the other hand, can be manipulated to have still finer pores covering demanding ultrafiltration applications that require specific molecular weight cut offs in the range of 10-100 kDa. These membranes are also the precursor to thin film composite membranes and membranes for many other specialty applications. Hollow fibre UF membranes are also polymeric membranes, albeit of a different configuration. Not only do these have an important application in water purification and water pre-treatment, these are also at the heart of kidney dialysis units.

2. **Thin film composite membranes.** While these have a similar conceptual design, the actual membranes can be fine tuned so as to cater to diverse applications. These include: (i) nanofiltration, (ii) desalination, (iii) dewatering, (iv) gas separation, (v) solvent recovery, (vi) degumming of vegetable oils, and (vii) pervaporation. As mentioned above, a test bed is already being contemplated for the specific application of desalination – all the way from brackish to seawater – but it can be seen that the canvass is very large.

3. **<u>Charged membranes.</u>** These are typically polymeric membranes bearing anionic or cationic groups that allow for selective migration of ions under an applied electric field. Important applications include: (i) electrolytic synthesis including caustic soda and chlorine production from brine, (ii) electrodialysis for desalination of brackish water and for numerous industrial desalting applications, (iii) recycle of spent salts in effluents into their constituent acids and bases (through Bipolar ED), (iv) continuous deionization with in situ regeneration of resins, (v) applications in batteries/fuel cells, etc.

In view of the broad range of applications as mentioned above, and given that there are competent laboratories in the country which have the necessary capability, a composite facility is recommended for setting up of test beds for production of the above three categories of membranes and further forward integrated with module/stack fabrication having state-of-art designs. The unit could possibly be operated in a consortium mode.

<u>Technology Platform II:</u>

Nanotechnology based sensors including biosensors for real time field analysis of water contaminants such as microbes, fluoride, arsenic, chromium, heavy metal ions, etc.

One of the most important challenges which have been identified by several forums in India is the development of affordable, portable, highly selective and robust sensors for detecting water contaminants (which include microbial, organic and inorganic contaminants) at ultra low concentrations in drinking water so that the quality of water being supplied to the users can be ascertained and guaranteed. Several research groups in the country have articulated the need to initiate a comprehensive program on the development of sensors for detection of contaminants in water. Properly engineered “lab on a chip” kind of concept must be explored in this context. Multi-disciplinary expertise is needed to come up with a cost-effective solution relevant to India.

Annexure-III

INTEGRATION AND COLLABORATION PLATFORMS FOR MATERIALS DISCOVERY, DEVELPOMENT AND PRODUCT DESIGN

Vision

Sustained economic growth over the past two decades has thrown up a plethora of opportunities and challenges to the Indian industry. Advanced materials development forms an important and integral part of technological preeminence of the nation. Success of a number of industrial sectors is closely linked to the development of new materials, manufacturing processes and incorporation of new design paradigms with these materials. Some examples needing urgent attention are given below:

- Indian Automobile industry is one of the fastest growing industries in the world. The automobile, in the coming decade, has to become significantly safer, lighter, cheaper and more energy efficient. Next generation advanced high strength steels (AHSS) or alternate aluminum or magnesium alloys form one of the major needs for new materials and these are not produced in India. It is seen that this development would require a long lead-time to catch up and go beyond. Can we accelerate the development of new generation AHSS to reduce the developmental time by half?
- Alternate sources of energy to replace/add to the ubiquitous internal combustion engine of an automobile will be another major driver for greener roads and sustainability. Though Lithium-ion battery is seen as the high-energy density storage device of the future, there is a need to explore other options in view of limited natural availability of Lithium in India. Can we explore alternatives with materials available in India abundantly and design high-density energy storage batteries?
- India has ambitious programs in developing its own commercial aircrafts. The latest commercial aircraft from Boeing consists of more than 50% fibre reinforced composites, replacing the traditionally used aluminum alloys. Can we come up with materials, which are less expensive alternatives with better properties to meet our requirements?
- With 53% of installed capacity, coal based thermal power generation is current and likely future mainstay of our power generation. Ultra super critical technology seems to be a preferred option of the future, but is limited by the availability of high-temperature materials. Can we come up with alternative materials to the currently used nickel based super alloys to meet these requirements?
- Impact of fossil fuel based energy on the environment and issues related to their sustainability is forcing the world to seriously explore alternate sources of energy. Solar energy is one of the major alternatives, which will have higher relevance to India in view of its geographic location. However, large-scale deployment is limited by the efficiency of the solar energy systems and their cost. Can we come up alternative materials for solar energy systems at affordable costs?

- Modern health care is undergoing tremendous transformation and a significant part in terms of implants and medical devices is driving a large need for new materials. Changing lifestyles and affordability has significantly increased the use of implants and varieties of medical devices in India. There is also a need to make cheap and portable medical devices for rural and semi-urban needs. Can we come up with materials that address these needs for cost effective implants and devices that serve our needs?

All the above-mentioned engineering challenges have one common but formidable requirement at the heart – *materials development*. State of the art methodologies for materials development for engineering applications require considerable time and significant investments. A summary of current needs related to materials development in India include

- Development of new cost effective materials to replace existing materials
- Frugal engineering through new materials
- Develop materials that will lead to greener environment over its life cycle
- Reduce the material development cycle time and cost
- Leverage large base of materials research and product design in India
- Leverage information technology (IT) leadership position to develop enablement platforms for materials development

There is an articulated need to combine material discovery, manufacturing processes and product design to address the above needs. It is also seen that this process should learn from other disciplines such as product design and take greater advantage of computational tools to reduce expensive experimentation, and time and cost of development. Integrated Computational Materials Engineering (ICME) is an answer to this grand challenge [1,2,3] which brings in a paradigm shift in new material development process and integration of materials design and product design. Early applications of ICME have shown significant returns on investment [1] for the industries that have experimented with it.

We should develop a national platform for development of ICME framework, tools and technologies and demonstrate it through addressing a few key problems facing the Indian industry.

Vision

Develop new and advanced materials through modern, greener and innovative technologies for the benefit of our people and place the nation in a leadership position in this key underpinning area of technology

Research and Development needs of ICME

Common and advanced materials development today, the world over, is a largely intuition and trial-and-error driven process with heavy dependence on experiments. Knowledge and data from the past is scattered in various sources and is not systematically represented and stored for efficient use. Besides this, any new development of a material has to be closely linked to the target performance requirements for its entire design life, which is largely determined at the product design stage. Additional constraints are being imposed, in recent times, on designers and suppliers for light weight construction and/or reduced environmental impact and recyclability. Due to insufficiency of tools for systematic (and standardized) approaches, selection of materials and manufacturing processes is often limited to the comfort level of the people involved. This calls for a holistic approach to the understanding of the interplay of materials and their manufacturing processes along with the other aspects of design. Therefore, there is a need for a systematic approach involving increased use of available data and knowledge, coupled with mathematical models to aid development of new materials, selection of materials and manufacturing processes.

As stated earlier, Integrated Computational Materials Engineering (ICME) is an emerging field through which these interplays can be captured for new material and product designs in the future, *i.e.* achieving better material synthesis/ manufacturing route combinations with good returns on investment (ROI) [1]. Besides looking for what is known, ICME, when backed with sound physics may enable “discovery” of “emergent-properties” of the materials and systems that may be either beneficial or detrimental under unintended circumstances. A number of challenges exist in ICME at fundamental, computational, developmental and execution levels.

Fundamental Research: At the fundamental level, there is a great need to bridge the gap between various length and time scales that exist in the different domains of materials research, which impact the final performance [4]. This large gap needs to be bridged selectively through a combination of intense research in materials science, and modeling and simulation, ably supported by guided experimentation. Multi-scale models, starting from ab-initio atomistic calculations to continuum scale models need to be developed across the country focusing on the materials of relevance to India.

Computational Tools: Soft-computing techniques specific to materials domain is a largely ignored area in the country with a few exceptions, e.g. application of techniques such as Artificial Neural Networks (ANNs). A combination of these should finally address the needs of linking composition, processing, structure, properties and performance [5]. Development of multidisciplinary optimization (MDO) models and decision support tools for use by the community is another major need of the hour. Besides these, one should also adapt systems engineering approaches for material and product development to make the process more systematic [6]. Additional research is also needed to speed up simulations and reduce lead-time.

Developmental Needs: The development requirements include (a) easily available reusable tool base for scientists and engineers to implement fundamental models in a computational framework for materials development, (b) tools for data and text mining of experimental and simulation data and also published literature, (c) platforms to link various tools through adaptable IT platforms that enable easy build up of complex interplay of phenomena with appropriate simulation data management, and (d) tools to guide experimentation. The community can use existing open-source or commercial platforms as appropriate first and then should focus on developing what is additionally required.

Challenges of Execution: At the level of execution, the country needs to build standards and infrastructure for various forms of collaboration. This encompasses setting standards for material and process representation (in coordination with international bodies), developing national database platforms for sharing data with sufficient detail for exploration across the community, collaboration portals for exchange of information, etc. with appropriate mechanisms for certification and access control. As experimentation is key to success of ICME and materials development in general, we need to set up national infrastructure for material development, characterization and testing needs. Besides the above, we also need to develop materials science and engineering curriculum that exposes and prepares the future scientists engineers and technologists with sufficient background in ICME-related aspects.

Focus application areas: The following is a list of possible focus application areas across three critical industrial segments. Other areas may be added as the need arises.

Automotive materials – (a) Light weight high strength steels with alloying additions easily available in India and to meet performance needs of India (low cost, high dent resistant outer panels), (b) Smart materials for enabling sensing and control, (c) Alternate materials for high-density energy storage.

Aerospace materials: (a) Fibre-reinforced composites and multi-material systems to build next generation aerospace structures with embedded sensors for health monitoring, (b) Super alloys and cheaper alternatives for high temperature applications.

Power plant materials: Materials for high temperature needs of super-critical thermal power plants to replace the need for nickel base super-alloys.

Construction materials: A paradigm shift in current practices of reinforced concrete (RCC) and utilize cheap and easy to fabricate construction materials with high thermal efficiency and capability to withstand natural calamities.

Rare earth materials: Production and use of rare earth elements to address their increasing use in electronics and appliances.

Solar energy: Development of alternate materials and coatings for use in photovoltaic cells a well as other forms of solar energy utilization.

Health care: Development of materials for portable and affordable medical devices and affordable implants.

Focus Research Areas

Some of the possible themes for research include:

- Development of fundamental understanding and models across length and time scales for materials and linking of these scales
- New and novel experimental techniques to address multiple scales of the material
- Knowledge extraction from materials & processing data through materials informatics (data mining and text mining appropriate to ICME).
- Process modeling for advanced processing technologies and materials and also to fill the existing gaps of process modeling that are needed to make ICME a practical reality.
- Virtual testing for performance prediction using material information across scales
- Computer aided design and engineering analysis integration with modeling of materials and processes
- Multidisciplinary design optimization to address multiple processes, physics and materials.
- Systems approaches, integrated simulation & enabling IT platforms
- Frugal engineering for and through materials technologies

The above need to be articulated in detail and/ or fine-tuned based on the focus application areas.

National Network

ICME requires considerable efforts on research and development front across diverse fields as articulated above. Such needs cannot be met in isolation by individual teams or institutions and need to be taken up as national missions with participation from a number of organizations. A few technology demonstration projects should be executed in this mode. Specific customizations can be done by the interested industrial organizations for proprietary use.

A small headway is already made in the country in the area of ICME. National Metallurgical Laboratories, Jamshedpur (NML) has an articulated research program in the area of ICME. IGCAR, Kalpakkam has been working in the area of multiscale modeling of materials and ICME. Various academic research programs at premier institutes such as Indian Institute of Science, Bangalore have a large and direct bearing on ICME. DMRL, Hyderabad has also shown significant interest in this area. In the private sector, Tata Consultancy Services (TCS) has a large internal research program on ICME addressing both computational tools and IT enablement of ICME. Recently TCS has conducted a workshop on ICME in February 2011 where a number of participants from Indian industry, national laboratories and academia have participated and expressed interest in ICME. A major outcome of this workshop was to bring together the community that has significant interest in ICME. With this background, it will be apt to develop a national mission and network for ICME.

Some of the potential institutions, which may be a part of the national initiative, include:

- Academic Institutions (IITs, IISc, Central Universities and those State Universities and Deemed Universities that have a Research Culture) – Fundamental research, multi-scale modeling, computational research, applied research, experimentation
- CSIR (NML, NAL, NCL and other interested national laboratories) – For both fundamental and applied research, allowing the use of their national experimental and computational facilities and for setting up of additional facilities
- DAE (BARC, IGCAR, CAT) – End user, material development, sensor development, applied research, development of material models
- DST Laboratories (ARCI, Shree Chitra Tirunal Institute, JNCASR, IACS) – For both fundamental and applied research, utilization of computational and experimental facilities for ICME programs.
- Materials and Manufacturing Industries: (Metals – Tata Steel, Aditya Birla Group; Automotive – Tata Motors, Ashok Leyland; Aerospace – HAL, ISRO; Defense - Midhani) - End user and material development
- IT companies (TCS) - Computational tools, IT enablement platforms, etc

- DST & other national bodies: Program management, coordination of evolving standards along with international bodies, etc.

Infrastructure Development

The following are the key national infrastructure needs:

- National databases available centrally and accessible to users on need basis
- National computational facilities
- National experimental facilities
- Collaboration portals
- Tool foundry and platform for sharing computational tools
- National educational resources related to ICME

Operating Model and Governance

A national body consisting of government and partner organizations should be set up as an independent nodal organization to manage the ICME mission. The activities of this organization include:

- Setting up the detailed agenda for national mission on ICME,
- Identification of critical mission programs,
- Providing funding for infrastructure, research and tool development,
- Setting up teams for all mission programs,
- Identification and monitoring of common aspects of all mission programs,
- Managing common infrastructure and intellectual property,
- Monitoring mission programs, and
- Industrialization of the outputs of mission programs through appropriate technology transfer / proliferation mechanisms.

Each of the mission programs should be led by an appropriate nodal agency by forming a consortium of all relevant players.

Specific aspects of research and tool development as well as infrastructure that can impact multiple mission programs should be run as independent projects in the early stages such that these can be leveraged in mission programs.

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Annexure-IV

India-specific Opportunities during the XII Plan Period In Wireless Telecommunications

By

Bhaskar Ramamurthi (IITM), Abhay Karandikar (IITB) and Ajit Chaturvedi (IITK)

Introduction

More than any other large country, India is dependent on wireless telecommunications for the so-called last-mile connectivity. Today, the fraction of the population which depends ***exclusively*** on wireless last-mile connectivity for telephony, in the form of cell-phones, is in excess of 95%.

As India seeks to usher in universal broadband connectivity, wireless connectivity will once again be the only choice for the last mile. Given the nature of broadband applications today, one needs a speed of a few Mbps to get good Quality of Experience (QoE). Increasingly, one needs not only good download speeds, but also in the reverse direction due to social networking applications. As a result, no technology can claim to be future proof. One would have averred, till recently, that ADSL technology with download speeds of several Mbps and upload speeds of a couple of hundred kbps was all that one needed. Yet, today, ADSL is founding wanting due to insufficient upload speeds. Therefore, it is safe to assume that, going forward, one needs a few (at least 1-2) Mbps in both directions. Further, since one never knows what compelling applications will emerge overnight, one would like the technology deployed to have scalability at least by one order of magnitude, when needed, by augmenting capacity.

With 4G technology, it is feasible to provide these kinds of speeds to users, using the same kind of mobile devices that are in use of today for telephony and Internet access. The spectral bandwidth needed, though large, can be made available. However, speeds supported typically double, or at most triple, across generations of wireless technology (say, e.g., 3G to 4G). Higher levels of scalability call for some radically new approaches.

There is another limiting aspect to wireless last-mile access. Since RF power decays as the fourth power of distance in built-up environments, a fairly large amount of power must be radiated in order to provide coverage to every nook and corner. The more the speed per user, and the further the user is from the base station, the more power one needs per MHz of bandwidth. For example, each base station site will emit around 12W of power per MHz of bandwidth. Since we can expect a couple of 100 MHz of spectrum or more to be licensed, the emission levels will be quite high. With such levels, the coverage radius of a base station, over which one can expect reasonably good speed and QoE, can be easily 500m or more.

The user device emission level is limited for safety reasons to a maximum of 250 mW. There is continuing research on the health effects of microwave radiation, and one does not know if this level will be revised downwards in the coming years. Even at the existing level, the uplink speed of wireless broadband connectivity is getting limited to unacceptable levels when the base station is several hundred meters away.

Finally, base station sites that emit upwards of a kW, dissipate several kW of power in the electronics and the cooling equipment. Assuring such quantities of power 24x7 requires generators, fossil fuels and batteries. Today, 70% of the operational expenditure of a mobile service provider is on energy.

The next generation of wireless telecommunications technology

Given the above, what is needed globally today is (i) low emission (ii) low energy (iii) high capacity (and speed) wireless communications technology. This new technology is particularly important for India given its second largest subscriber base, its critical dependence on last-mile wireless connectivity, poor energy availability and its resulting adverse impact on the environment. Given the crucial importance for India, it is natural choice as a focus area for Indian scientists and engineers. Since there is trade-off between emission level and coverage radius (beyond which the speed is too low to be acceptable), this means we will need a technology where the cell radius (coverage radius of one base station) is scalable to much smaller levels.

The need for smaller cells has already been articulated, even without the specific target of reducing emission levels. However, these small “pico” cells are in addition to the larger “macro” cells, and are in fact contained within the latter. This is in order to enhance capacity in hot spots such as malls, airports and so on. The standards bodies developing 4G technology are currently engaged in research to enhance their systems to such heterogeneous networks with a mix of pico and macro cells. Indian contributions to this research are also being made through participation in the standards bodies.

Every base station must have a high-speed optical or wireless backhaul link connecting it to the core network. As one adds pico base stations, such backhaul links my not always be feasible. Hence, the 4G systems also include wireless relays, which establish a high-speed wireless “in-band” link with a base station, and act as a surrogate base station to user devices nearby. While such relays have been already proposed, much research remains to be done, since the designs till date are primarily for extending coverage and not increasing capacity (as a substitute for a pico base station).

While a heterogeneous network for hot spots and relays for coverage extension are being developed internationally, the India-specific opportunity is to turn the emphasis towards the triple goals of low emission, low energy, and yet high capacity. Further, India will need a very dense heterogeneous network with a large number of pico base stations and relays deployed opportunistically where subscriber demand is high and where backhaul can be provided cost-effectively. This will call for new self-organizing, deploy-and-forget network architectures.

Specific focus of wireless telecommunications technology development in India

While India may have specific requirements, it is neither practical nor wise to develop a custom technology for India. Global standards are critical in wireless technology in order to achieve scale, to leverage galloping state-of-art electronics technologies, and to enable global roaming. Thus, the technological avenues explored in India must not be isolated from or orthogonal to those being explored elsewhere. Fortuitously, it turns out they need not be so. Thus, while Indian scientists and engineers should focus on making significant contributions to global standards in all aspects of importance such as efficient spectrum utilization, lower cost, and so on, there could be a special focus on shaping the next- generation standards towards low energy, low emission, high capacity systems. Some specific areas of research and technology development, which are aligned with current areas of global interest, are outlined below.

Pico base stations and Relays

Pico base stations and relays typically emit 100 mW per MHz of bandwidth. Further, pico base stations or relays of multiple operators will rarely be co-sited. Hence the emission from a pico or relay site will be two to three orders of magnitude lower than that from a macro site. However, the coverage radius of a pico or relay base station is of the order of 40-50 m, an order of magnitude lower than that of the macro base station. This will imply that the number of such sites will be two orders of magnitude more, which could be a problem from a deployment perspective. The pico and relay base stations will dissipate only a few Watts, and can easily be solar-powered. In fact, they can be designed to be of the “deploy-and-forget” type. Nevertheless, an increase in their number by two orders of magnitude could be impractical.

In-Building Solutions

One of the reasons why cell radii are so sensitive to transmit power levels is that the signal has to penetrate walls to provide coverage inside buildings. An emerging paradigm that will mitigate this problem significantly is the so-called “in-building solution (IBS)”. Here, leaky feeder antennas or multiple transceivers deployed within the building provide coverage inside. The RF signal is fed via cable from equipment connected to the distributed antenna system (DAS), located typically in the basement or on the roof (if the feed is via a relay).

While IBS based on leaky feeders are already widely used in large buildings, those based on multiple transceivers have been slow to take off. This is because a different set of transceivers are needed for each operator, which can be impractical when there are a large number of them, as in India.

There is tremendous scope for developing an IBS which resembles the combination of structured cabling and switches that are used today for provisioning a LAN in large buildings. Here, one would have an operator-agnostic IBS based on transceivers deployed tens of meters apart, connected to the equipment of various operators at the building's gateway. Software-defined-radio technology can be leveraged effectively to develop such a system. It is also feasible to leverage existing standards, modifying them a little if needed, to enable inter-operability.

A major advantage of using an IBS for wireless broadband connectivity is that a large fraction of users will typically be inside buildings when connected. Since they will be connecting to base stations that are meters away, the user devices will need to emit only a few mW of power most of the time. There are no limits to the uplink speed due to limits on the emission level. Scalability is achieved in a manner that is future proof, no matter what speeds are sought by the user, and even if emission limits are scaled down by one or two orders of magnitude for health safety reasons.

Heterogeneous Network of macro, pico and relay base stations and IBS

Once IBS are developed that are as easily deployable as LANs today, outdoor coverage can be now limited to streets. Now, pico base stations can beam signals along a single dimension, extending coverage to a couple of hundred meters. The number of pico / relay sites will now grow relative to the number of macro sites only by roughly one order of magnitude.

No network consisting of such a patchwork-quilt of small cells can guarantee ubiquitous coverage. So macro sites will still be needed to provide umbrella coverage. However, the traffic carried by the macro site will keep decreasing as pico sites and IBS proliferate. Thus, while the emission levels from the macro sites will still be of the order of 10-12W per MHz, the total bandwidth employed by macro base stations can be shrunk drastically, reducing the total power emitted. This will also ease the power supply requirements at the macro sites.

Backhaul and Self-Organizing Architecture

One cannot expect optical fiber backhaul to become available to 100% of an increasing number of pico sites. While relays can be used where fiber is not available, the number of relays cannot be scaled limitlessly, since their backhaul links are to other base stations with limited capacity. Thus, one will need wireless backhaul in a separate spectral band to supplement the optical backhaul. This is common even today. Apart from wireless backhaul, one can profitably develop 70 GHz backhaul too. This is an emerging technology. The band is unlicensed, and has many characteristics similar to optical transmission. Thus, it is suitable for short-haul down-the-street type of backhaul rings.

When a heterogeneous network with a large number of nodes is deployed and grown in a scalable manner, it is imperative to have self organized distributed architecture, where all the paths are discovered and managed through a network of packet switches, much like IP networks. This enables a much simpler path "management", akin to Ethernet switching and IP routing. This simplicity will lead to significant cost reductions in future generation equipment - both capex and opex. The Radio Access Network (RAN) will an IP network of base stations and relays. While an "All-IP RAN" is part of the 3GPP protocol suite, next generation Layer 3 protocols will focus on self-configuration and auto-discovery in the RAN elements. Relays and base stations co-operate to maintain a connected topology at layer 3. Path connectivity to the Internet and between peer mobile stations will be maintained by co-operation protocols operating in the RAN. Mobility, network discovery, and QoS will be managed by protocols at the IP layer. The first access link - from mobile station to relay or base station will also be managed by IP layer protocols.

Summary

There is thus tremendous scope for development of wireless telecommunications technology and global standards for broadband services in a form that is driven by requirements of low emission, low energy consumption, and scalable capacity, which are of great interest globally and crucial for India. Specifically, significant contributions can be made to the technologies of heterogeneous networks, capacity-enhancing relays, in-building solutions, wireless backhaul and self-organizing architectures. Products engineered to meet Indian requirements can give a first-mover advantage to Indian manufacturers, enabling them to leap-frog into the club of globally competitive world of wireless infrastructure providers, whose membership is now down to half a dozen companies. At the same time, significant IPR can be contributed to global standards, which will lead to India becoming a major global player in wireless technology development.

Annexure-V

Minutes of the first meeting of the Sub-group for formulation of XII Plan on Technology Development Programme of DST held on 25.06.2011 (Saturday) at Indian National Science Academy (INSA), New Delhi.

Participants:

1. Dr. C.V.Natraj , Technical Advisor, IISc., Bangalore — Chairman
2. Dr. A.R.Upadhya, Director, NAL, Bangalore — Member
3. Dr. G. Sundararajan, Director, ARCI, Hyderabad — Member
4. Dr. T.S.Rao, Advisor, DBT — Member
5. Dr. Bhaskar Ramamurthi, Prof. IIT, Chennai — Member
6. Mr. Mallikarjun Javali, Sr. Consultant, CII, New Delhi — Member
7. Dr. Dipanjan Banerjee, Sr. Asst. Director, FICCI, New Delhi — Member
8. Mr. Agnideep Mukherjee, ASSOCHAM, New Delhi — Member
9. Dr. Ajit K. Jindal, VP & Head Tech (Comm. Vehicles), TATA Motors Ltd., Pune — Member
10. Dr Pradip, Chief Scientist & Head, PEIL, TRDDC, TCS, Pune — Member
11. Dr. Ajay Mathur, DG, Bureau of Energy Efficiency, New Delhi — Member
12. Dr. J. Gururaja, Former Advisor, MNRE, Bangalore — Member
13. Dr. P.K.Ghosh, Director, CSMCRI, Bhavnagar — Member
14. Dr. Shashikant Kadam, GM, Piramal Healthcare Ltd., Hyderabad — Member
15. Dr. G.J.Samathanam, Head – TDT, DST — Convenor
16. Shri Sanjay Bajpai, Scientist-F, TMC, DST — Co-convenor

DST

1. Dr. Neeraj Sharma, Head - Plan
2. Dr. V. Raghupathy, Head – IS-STAC
3. Dr. Siva Kumar, Head, NRDMS
4. Dr. Vimal Kumar, Head – Fly Ash
5. Dr. (Mrs.) S.N. Khan, Scientist-F, TDT
6. Dr. Anita Agarwal, Scientist-C, TDT
7. Dr. J. K. Pathak, Scientist-E, IS-STAC

8. Dr. K.D.Chakraborti, Consultant, Plan
9. Dr. R. Ranade, Scientist, ARI, Pune
10. Dr. K.M.Paknikar, Scientist, ARI, Pune

Dr. Samathanam welcomed the participants and apprised the Group of the various initiatives of the Department to promote research and development in the country. He mentioned that the composition of the present sub-group was unique in terms of significant representation of the industry. He specifically mentioned various partnerships evolved out of DST's efforts and stressed upon DST's resolve for greater public-private-partnership (PPP) for Technology Development.

Prof. Natraj in his opening remarks welcomed the participants and thanked them for sparing their precious time for promoting the cause of Technology Development. He stressed upon the need for cohesive efforts for providing technology leadership to the country in select niche areas of strength.

Shri Neeraj Sharma made a presentation on the approach for the development of DST's plan for the 12^{th} Plan period. He apprised the Group of the various functions of the Department and elaborated upon initiatives for implementing Technology Development Programmes during the 11^{th} Plan and their outcomes. In the 12^{th} Plan Department would like to focus on promoting convergent technology solution based programme by identifying and developing appropriate partnerships. He stated that DST would welcome critical appraisal of its programmes and radical suggestions deviating from past approaches to realize the objectives of the Department. The sub-group appreciated the lucid presentation made by Shri Neeraj Sharma and felt that it has set the right perspective to discuss the issue.

The Chairman made a presentation outlining some of his ideas regarding scoping the Technology Development Programmes of DST and the possible models for interaction. He stated that country needs to move towards innovation based knowledge economy with significant voluntary increase in R&D by the industry. He elucidated the concept of Technology platforms to develop the convergent technology solutions and forge appropriate technology partnerships. He also stressed upon the needs for developing customer relevant definition of the problem which could be converted to scientific principles and quantified in next stages. There is need to develop collaborations between industry academia and various approaches such as renting space, joint development, technology incubators etc. could be followed. Academia could be supported by the Government for negotiations with respect to intellectual property and sharing of returns. He stressed upon the need for development of a business model capable of exploiting unique benefits of the technology. He stated that industries look forward to a business model and generally would like to minimize risks involved through appropriate instruments - Technology platforms, incubators and venture capital funds are some of such instruments. The Chairman also stressed the need for partnering with industry of appropriate size and option of easier exit route. Concluding his presentation, the Chairman proposed following points for discussion:

- Identification of select areas for developing convergent technological solutions
- R&D programmes with key partnerships of industry
- Technological priorities complete with benchmarks

This was followed by discussions amongst the members. During the discussions following suggestions were made:

- Need for technology intelligence and strategic analysis of that information to charter technology development path.
- Identify critical areas in the energy sector having possibility for transforming existing scenario such as solar energy, bio-fuels.
- Increase absorptive capacity of the industry for R&D manpower and voluntary increase in R&D share of the industry.
- Creation of select centres of excellence by public funding managed privately.
- Development of collaborative partnership with stakeholders and participation of nodal ministries.
- Possibility of R&D funding to industry specifically start ups and small and medium enterprises.
- Facilitating R&D institutions to develop complete package for technology transfer.
- Technology development effort to be based on strong IPR foundation.
- Focus on products having required market pull such as energy efficiency in air conditioning, fans, lighting and industrial waste heat utilization.
- Incentivize industry for achieving price and performance targets and providing suitable technical assistance, infrastructure and pilot trials.
- Focus on evolutionary nascent technologies where leap-frogging current state-of-art is possible.
- Business model for upgrading material technologies including integrated competition
- Area selection to follow required due diligence and build on existing success.

- Focus on select areas such as silicon production, membranes, batteries, steel etc.
- Industry institution partnership for health related issues.
- Focus on one or two areas where India can attain technology leadership.

Based on the suggestions made by the members following recommendations emerged for follow up action:

1. Technology Platforms (TP) are a good way of bringing about Industry academia partnerships.
2. TP's serve to identify big R&D themes to address convergent solutions for problems of national relevance.
3. Problems of national relevance have been identified by the DST through a process of consultation with key stakeholders.
4. This sub-group concentrated on identifying a few key technology platforms to address some of these problems.
5. The guiding principle is to identify India centric unique opportunities and scope them.

It is important to recognize that in anything that is identified there is a great deal of expertise and good quality work already done. Whilst the group was conscious of this using the guiding principle above, four areas were identified for further work:

1. **Energy:** The India centric opportunity is distributed solar power generation and storage.

2. Water: The India centric opportunity is to come up with solutions for 'water on the go' so that consumers can use portable devices that can upgrade poor quality water to potable water.

3. Telecommunications: The India centric opportunity is energy efficient low emission wireless technology.

4. Materials: The India centric opportunity is integrated computational materials engineering.

The chairman in consultation with members of the sub-group proposed the following smaller group to work further on the above areas to articulate the approach and content of the work to be done through the DST's Technology Development Programme in XII Five Year Plan in the form of a brief working paper for discussion in the next meeting:

1.	Energy	:	Dr. Ajit K. Jindal*, Prof. J. Gururaja, Dr. Bhaskar Ramamurthi, Dr. Ajay Mathur.
2.	Water	:	Dr. Pradip*, Dr. P.K.Ghosh, Dr. K.M. Paknikar, Shri Sanjay Bajpai
3.	Telecommunications	:	Dr. Bhaskar Ramamurthi**
4.	Materials	:	Dr. Anantha Krishnan*, Dr. Bhaskar Ramamurthi, Dr. A.R.Upadhya, Dr. G. Sundararajan, Dr. Pradip

* Coordinate the finalization of respective group report.

** May co-opt appropriate expert and finalize the report

Note: Communication details of all the above members are provided in the annexure for coordination.

The Chairman requested the above identified experts to complete preparation of working paper within a fortnight. The next meeting of the Working Group was proposed in third week of July, 2011.

Proposing Vote of thanks, Shri Sanjay Bajpai thanked the sub-group member for their valuable suggestions which would pave the way to promote participative transformational research and technology development supported by innovative mechanisms and platforms. The approach also marks a phase shift where opportunity would be pro-actively identified and capitalized. He assured the members of pro-active follow up of the recommendations and looked forward to their continued support.

The meeting concluded with vote of thanks to the Chair and esteemed members.

Sd/-

(Dr. C.V. Natraj)

Chairman of the Sub-group
on Technology Development Programme

09.07.2011

Annexure-VI

Minutes of the second meeting of the Sub-group for formulation of XII Plan on Technology Development Programme of DST held on 06.08.2011 (Saturday) at Agharkar Research Institute (ARI), Pune.

Participants:

Dr. C.V.Natraj , Technical Advisor, IISc., Bangalore	Chairman
Dr. M.K. Sridhar, Scientist representing Director, NAL, Bangalore	Member
Dr. T.S.Rao, Advisor, DBT	Member
Dr. Bhaskar Ramamurthi, Prof. IIT, Chennai	Member
Mr. Mallikarjun Javali, Sr. Consultant, CII, New Delhi	Member
Dr. Shantanu Dutta, Tata Motors Ltd., Pune representing Dr. Ajit K. Jindal, VP & Head Tech (Comm. Vehicles), TATA Motors Ltd., Pune	Member
Dr. Philip Jose, ERC Adv. Engineering, Tata Motors Ltd., Pune	Member
Mr. Agnideep Mukherjee, ASSOCHAM, New Delhi	Member
Dr Pradip, Chief Scientist & Head, PEIL, TRDDC, TCS, Pune representing Dr. K. Ananth Krishnan, Vice President & CTO, TCS	Member
Dr. J. Gururaja, Former Advisor, MNRE, Bangalore	Member
Dr. P.K.Ghosh, Director, CSMCRI, Bhavnagar	Member
Dr. Shashikant Kadam, GM, Piramal Healthcare Ltd., Hyderabad	Member
15. Dr. G.J.Samathanam, Head – TDT, DST	Convenor
16. Shri Sanjay Bajpai, Scientist-F, TMC, DST	Co-convenor
17. Dr. D.R. Ranade, Officiating Director, ARI, Pune	Invitee
18. Dr. K.M. Paknikar, Scientist & Head – MSD, ARI, Pune	Invitee
19. Shri C. Rajadurai, Scientist-C, DST	

Dr. Ranade welcomed the Committee to Agharkar Research Institute.

Dr. Samathanam in his introductory presentation highlighted the decision of first meeting of sub-group held on 25th June, 2011 at INSA, New Delhi. He emphasized the need for further discussion on the four areas viz. energy, water, telecommunications and materials identified in the first meeting. The sub-group reports on these areas received were presented. He thanked the Sub-Groups for devoting considerable time and preparing draft reports for discussions. In addition, he also shared the suggestions received on Drugs & Pharmaceuticals sector by the Expert Committee of DPRP. The format of the report suggested by the working group convener Shri Neeraj Sharma, DST and the sub-groups were presented.

Dr. Natraj in his remarks thanked Agharkar Research Institute for hosting the meeting and appreciated the efforts of DST Secretariat for holding the second meeting at a short notice. He requested the members to share their views on the identified areas and what is that finally at the end of five years, the Department should look for. In planning the technology development activities, he emphasized the importance of country centric and customer centric focus, addressing the issues like what, how, who are of utmost importance, as practical deliverable things are very important in market place. Broader consultation with the industry was a necessary prerequisite before embarking on action. Considerable planning effort need to be made to define 'What'. This would ensure that end-use drives the technology development effort. The Chairman complimented the secretariat for preparing the draft sub-group report, which captures the recommendations of the first meeting. He then solicited views of the members on the draft report.

The members expressed their broad agreement with the scope of the activities as elaborated in the draft report. While it was felt that mass transportation and scalable and sustainable housing were also important areas in view of national requirement, the Group did not find it viable for DST to step into this sector, considering the need to retain focus on core strengths and limited experience of DST in these sectors. Commenting on the draft report of the Sub-Group, the Sub-Group felt that initiatives suggested may be suitably merged with the existing programmes. The following specific suggestions were made:

i) TDP should focus only on those activities in which there is proven strength based on earlier R&D and potential commercilisable opportunity exists.
ii) The technical and cost goals of the development effort for each activity need to be specifically quantified, which should be internationally competitive.
iii) TDP should retain focus on select technologies and aim at practical deliverables.
iv) The delivery mechanism of technologies should involve end-user and co-development of technologies with the end-user should be encouraged.
v) Technologies which can be potential 'Game Changers' may be identified and vigorously pursued.
vi) The existing programmes are serving useful purpose and need to be continued. However, they may be appropriately reoriented to broad objectives of TDP.
vii) The report should be suitably edited to ensure smooth flow of text.

This was followed by detailed discussions on the Working Papers in the four areas:

I. <u>Distributed Solar Power Generation and Storage</u>:

The Members expressed broad agreement with the activities outlined in the draft paper. However, following suggestions were made to focus the scope of the activities:

i) The members strongly felt that TDP should address the ruggedization of solar energy technologies to take care of cyclicity of usability and storage.

ii) The novel concepts such as 'Flexible Substrates as roof suitable solar panels', 'Solar cooling of ice in night to be used as airconditioner in day' need to be explored further to make them a reality.

iii) It was felt that the concept note of Prof Bhaskar Ramamurthi on decentralized solar energy has to be included in toto so as to give complete perspective to the recommendations of the Sub-Group.

iv) The focus of the development should be on energy needs of the house. The development effort should be commensurate with defined service parameters, price challenges and cost goals. The batteries development should also focus on houses. Limitations of existing batteries in terms of power density, cycles, depth of discharge, feasibility of alternative options such as lithium Ion batteries, conducting polymers, solar hydrogen etc, would define the need for development. DST may seek inputs of Dr AR Shukla (Former Director), Dr Vijay Mohanan, Director, CECRI to shape this initiative.

v) It was important to study existing system size, current costs, business model and power generated in Karnataka for providing electricity through solar route. Entrepreneurial association for incubating the system and developing the business plan would be useful. Costings have to be based on net energy produced and not wattage ratings, which could be misleading.

II. <u>National level Initiative in Computational Materials - Integrated Computational Materials Engineering Platform (ICMEP):</u>

Mr. K. Ananth Krishnan, Vice President & Chief Technology Officer, Tata Consultancy Services through teleconferencing elaborated on the current materials development needs in India on the following:

(i) Development of new cost effective materials to replace existing materials

(ii) Frugal engineering through new materials

(iii) Develop materials that will lead to greener environment over its life cycle

It was stressed that since the design of materials of multifunctional capability requires computational inputs, an Integrated Computational Materials Engineering Platform (ICMEP) would enable the country to:

(i) Reduce the material development cycle time and cost

(ii) Leverage large base of materials research and product design in India

(iii) Leverage Information Technology (IT) leadership position to develop enabling platforms for materials development

He described the vision of ICMEP as *"To develop new and advanced materials through modern, greener and innovative technologies for the benefit of our people and place the nation in a leadership position in this key underpinning area of technology".* Dr Sridhar, NAL also felt that the Integrated Computational Materials Engineering (ICME) was an answer to the challenges in this sector and felt that association of Centre for Mathematical Modeling & Simulation (CMMS), NAL Campus, Bangalore will be useful for the development of the platform. The Committee further discussed the need for ICME platform as a paradigm shift in new material development process and integration of materials design and product design. While appreciating such a platform, the Committee emphasized the participation of several national laboratories of DST, CSIR, DRDO, Space etc. Such platform will enable material scientist to explore new avenues through tapping complementary expertise and experience in the informatics, biology each contributing to different computational parts to create a body of knowledge leading to incremental progress as well as leap frogging successes. The larger collaborative efforts of wide segment of industry, and institutions with varied expertise focusing initially on select problems and gradually expanding would make ICMEP a success.

III. <u>Technology Platforms for Water</u>

Dr PK Ghosh Director, CSMCRI piloted the discussion on Water Technology Initiatives presented the draft report of the Sub-Group and stated that the Sub-Group has specifically recommended set up test beds to take forward indigenous membrane technologies and build up capability in *“Membrane as technology platform” and* Nanotechnology based sensors including biosensors for real time field analysis of water contaminants such as microbes, fluoride, arsenic, chromium, heavy metal ions, etc. The Group felt that **c**onsidering the need to encourage membrane development for entire spectrum of application with higher recovery and lower wastage followed by large scale validation and acceptance, development of such a Platform will be useful. The need for rapid detection technologies to determine potability of water emanated from a felt need and was considered important for development. The Group felt that development and deployment of cost effective robust water purification technologies to meet the needs of individual households, villages, small communities and large communities equipped with rapid detection for potability of water should be focused. ‘Water on the Go’ is specific India

Centric Opportunity and suitable system could be devised based on already available experience.

IV. Wireless transmission with less emissions

Dr. Bhaskar Ramamurthi shared the working paper jointly prepared with the inputs from Prof. Abhay Karandikar, IIT, Mumbai and Dr. Ajit Chaturvedi, IIT Kanpur on India Specific opportunities in wireless telecommunications. The paper states that the aim of this platform was to develop low power low emission network architecture. According to the paper, as India seeks to usher in universal broadband connectivity, wireless connectivity will once again be the only choice for the last mile. At present, it is achieved through cell phone to the tune of 95%. Considering the health effects of microwave radiation at the present level of 250 mW, the uplink speed of wireless broadband connectivity is getting to limited to un-acceptable levels when the base station is several hundred meters is away. They will be emitting upwards a kW, dissipate several kW of power in the electronics and the cooling equipment. Assuring such quantities of power 24x7 requires generators, fossil fuels and batteries. Today, 70% of the operational expenditure of a mobile service provider is on energy. There is tremendous scope for the development of wireless telecommunications technology and global standards for broadband services in a form that is driven by requirements of low emission, low energy consumption and scalable capacity, which are of great interest globally and crucial for India.

V. Drugs & Pharmaceuticals

There was a discussion on the Drugs & Pharmaceuticals Sector, the recommendations of the Expert Committee on this programme was endorsed **(Appendix-II).** In addition, the area of sustained release of drug, in particular diabetes & hypertensive was suggested apart from efforts to bring reality in GMP, GLP, GCP, green applications, rapid diagnostic kits, strip based kits, telemedicine, large national resource centers, independent validation centers, animal facilities, large animal facilities are some of the areas suggested by the group. The idea of publicly owned privately managed testing facilities was suggested for consideration.

Dr. Natraj in his concluding remarks thanked all the members for their excellent inputs. DST Secretariat will incorporate these suggestions and finalize a draft report with the enclosures and annexures and forward the same to the Chairman for his approval before submitting it to the Plan Division of DST.

Shri Sanjay Bajpai proposed vote of thanks to the Chair and esteemed members.

Appendix-VII

Suggestions of Expert Committee of Drugs & Pharmaceuticals Research Programme (DPRP) for 12th Five Year Plan strategies in the meeting held on 10-11th June, 2011 at Tezpur University, Tezpur (Assam).

- New initiatives for transfer of technology on translational path
- Animal health related projects need to be enlarged.
- Popularization of DPRP by organizing regional workshops and brainstorming meetings with academic and industry/industrial associations.
- Monitoring & evaluation needs strengthening.
- Success stories of the programme could be made in the form of CD.
- GLP/GMP should be insisted in the institutions and industry.
- Clean Pharma Technology through green chemistry could be adopted.
- Human resource development in analytical wet labs / equipment handling is to be organized through short training programmes/summer/winter schools.
- Brainstorming sessions with pharma industries for partnerships and further improvement.
- Human resource development centre in 5-6 centers in the country including boarding & lodging facility with state of the art infrastructure both in drug development in biotech product development / pre-clinical animal studies / PKPD / Bioequivalence / Bioavailability / safety pharmacology / clinical research etc. to be attended.
- Special coverage for biostatistics / protocols development and powerful software and capacity building.
- The development of vaccines with a link to Ayurveda and Siddha drugs, adjuvants and vaccines, vaccines and green chemistry could be emphasized.
- Diabetes and related complications, cardiology, cardiovascular disease, are likely to become important in the future and special thrust could be given to this sector.
- Diagnostics are likely to become more important. Research on various monoclonal antibodies and its application for diagnostics could be encouraged. Similarly, medical appliances also deserve more focus under this programme.
- Standardization, scientific validation of Ayurvedic/Siddha formulation be continued.

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Annexure-VIII

COMPOSITION OF SUB-GROUP ON TECHNOLOGY DEVELOPMENT PROGRAMME FOR 12TH FIVE YEAR PLAN – DST

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Annexure 8e

Report of the Working Sub-Group

on

"Societal Interventions of S&T for 12th Five Year Plan"

1. INTRODUCTION AND BACKGROUND

Societal Programme of the Department of Science & Technology have played a pivotal role in the S&T based development strategy of various sections of the society, which provides challenges and opportunities to motivated scientists, engineers and field level workers to take-up time bound and action oriented developmental projects with inputs of Science & Technology for the benefit of disadvantaged sections of the society. The programme is being implemented through S&T institutions, universities and S&T based voluntary organizations under various schemes and mission mode programmes. There are many initiatives which have had considerable impact however because of the magnitude and number of the issues societal expectations remains somewhat unmet. The reason may have arisen from the scattered and fragmented nature of activities because of which visibility of initiatives has remained low another reason is that the replication potential of technology packages has not been actualized also partly, as a result of economic growth and somewhat better living conditions, the aspirations of society have naturally arisen further. The continued need for technology as a tool for enhanced livelihood and a improved quality of life for disadvantaged sections has never been felt more than in recent years.

The goal during the 12th Five Year Plan would thus be to make significant dent on the problem of poverty, environmental vulnerability and social equity. This can be achieved through large concerted technology driven programmes with strongly monitored deliverables involving inclusive innovations, institutions and initiatives. To address grassroots level problems a need is emerging for affordable technologies having a specific budget provision in 12th Plan for action research and for making countrywide impact. A working sub-group was constituted by Chairman working group/ Secretary DST for formulating initiatives in the 12th Plan towards "Societal intervention of S & T". The Sub-group chaired by Prof Ashok Jhunjunwala had two meetings in DST, Delhi to work on the task assigned. Working sub-group after in depth consultations and series of discussion with different stakeholders came to a conclusion that for a country as large as India and with multitude of issues, diverse demographic populations it was indeed a matter of concern that very few S & T based groups are working on issues in rural areas for socially disadvantaged groups in the country. For inclusive growth the need of the hour is to develop workable models for sustainable rural enterprises and thereby strengthen S & T based rural development.

2. OVERALL OBJECTIVES

The overall objectives of the societal programme of the Department of Science & Technology is to develop and facilitate research and application/interventions of S&T based solutions to identified problems and societal needs in different parts of the country. Some specific programmes/schemes covered have targeted objectives as follows for the benefit of different sections of society:

A. Technology Development related Schemes: Science & Society Programme

- To motivate scientists for applying their knowledge and expertise to problems of communities in rural areas.
- To promote research, development and adaptation of technology for improving quality of life of people belonging to weaker sections, especially in rural areas.
- To strengthen existing institutions, field groups, science based voluntary organizations, etc. involved in research and application of innovative S&T solutions; and
- To encourage young scientists and technologists to work and apply their expertise to problems in the rural areas.

Long Term Core Support - Technological Advancement for Rural Areas (TARA):

To provide long term core support to Science **based Voluntary Organizations/field institutions to** promote and nurture them as “S&T Incubators” / “Active Field Laboratories” in rural and other disadvantaged areas to work and provide technological solutions and effective delivery of technologies for livelihood generation & societal benefits.

Technology interventions for Addressing Societal Needs (TIASN):

- To catalyze research, development, design, adaptation and application of innovative S&T solutions for rural applications by supporting time bound development efforts with well defined milestones.
- To motive scientists and technologists for applying their expertise to find novel solutions for problems in the rural as well as urban areas having societal relevance.

B. Beneficiary oriented Schemes:

S & T for Women:

- To promote research, development and adaptation of technology, improve the working conditions and opportunities for gainful employment of women especially in rural areas.

- To increase the contribution of women to science and technology and development.
- To motivate scientists and technologists for applying their expertise to solve the problems of women in rural areas.
- To establish the two-way referral system for identifying felt needs at the grass root level and linking it to proactive R&D.
- To implement schemes for providing opportunities to women scientists to reenter S&T careers.

Scheduled Castes Sub Plan:

- Develop and demonstrate technology packages for improving the quality of life of the economically weaker sections of scheduled castes in urban/rural areas.
- Encourage scientists & technologists to apply there knowledge and expertise to the needs of economically weaker scheduled caste communities, especially in rural areas.
- Promote replication and scaling up of successful approaches leading towards empowerment and technical **capacity building of scheduled tribal populations.**
- Undertake capacity building in focused areas for SC's to enhance potential in the service sector and for self employment.

<u>Tribal Sub-Plan - Technological Interventions for Tribal Empowerment (TITE):</u>

- **Promote research, development & adaptation of S & T for improving quality of life of tribal groups.**
- **Initiate location specific S & T based program in major socio-economic sectors**.
- **Support & Enhance traditional artisanal skills with S&T inputs.**
- Build on local innovation & local knowledge systems in designing local resource management strategies.
- **Explore & promote alternative livelihood potential (wherever the present occupation is dwindling) on innovative community-based approaches and technological options to enhance field-level impact.**
- **Improve existing equipment and machinery &introduction of new techniques/systems and complete technology package.**
- Promoting replication and scaling up of successful approaches leading towards empowerment and technical **capacity building of tribal populations.**

- To undertake capacity building in focused areas for SC's to enhance potential in the service sector and for self employment.

3. XI PLAN ACHIEVEMENTS INCLUDING REVIEW AND PHASING OUT/ MERGING OF ANY PROGRAMMES, IF REQUIRED:

Scheme wise achievements are as under, while phasing out or merging of the programmes & schemes is not envisaged as all the ongoing schemes are having specific importance to meet the ultimate goal of socio-economics development of the country especially disadvantages sections of the society.

Science & Society Programme

Under this scheme, activities undertaken include adaptive research, design & development of machineries and implements, adaptation of available technology as complete package for field level application in farm as well as non-farm sector, demonstration skill development and help in setting up viable production units/micro-enterprise. Specific achievements are as under;

- Long Term Core Support extended to 20 S&T based field groups for innovative and adaptive research to address rural livelihood needs.
- Supported individual projects in non-farm as well as farm sector focusing on application of S&T inputs and also develop technology models for rural application to benefit rural artisans, small and marginal farmers and other weaker sections of the society.
- Continuation of co-ordinated programmes on Village-level enterprise model for gainful utilization of Non-Edible Oils (NEO) bearing plants involving 10 VOs; Telemedicine application; programme for mountain regions; and a mission mode programme for finalization of existing technologies to develop effective business models suitable for rural settings.
- A Mobile Elderly Unit to meet elderly health needs for promotion of health care and wellness activities by screening and providing medical facilities at their door step. A web portal was also developed and launched covering information on issues related to S&T interventions for elderly populations.
- Model mechanism for registration of farmers' varieties for rice and millets from Uttarakhand, and development of modular cost effective drier suitable for vegetable frying in hilly region.
- Development of safe chaff cutter to minimize associated injuries.
- Technology package for water management- Artificial glacier in Leh-Ladakh Region.

- Development of Models Packages like Operation of fruit processing unit using upgraded water mill for mountain areas, Energy-Efficient Rural Jaggery-making Systems, briquetting technology package using invasive biomass for energy needs and fuel efficient Tava stove with reduced fuel wood consumption.
- Development of location specific low carbon technology models and institutional mechanism of distributed energy to address small energy needs (e.g. for lighting) and linking it with micro-enterprise generation in non-grid villages.
- Establishment of common facility centre for Seabuckthorn processing and making value added product involving community in Leh region.

S&T for Women

This scheme since its inception has supported projects in areas such as Health, & Sanitation, post harvest technologies, land based activities, energy conservation, Natural resource conservation, Livestock management, Marine & fresh water based activities, design of tools and implements suitable for women, Forest based activities for women in the tribal areas, and income generation activities. Apart from supporting time bound individual projects some coordinated programmes have also been launched to replicate some of the successful projects in locations all over India. Specific achievements are:

Women Technology Parks set up in Karnataka and Gujarat which act as windows for providing information, creating awareness, giving training for appropriate technologies leading to skill up gradation and also possibly to establish important forward and backward linkages for income generation through micro enterprises for women.

A coordinated programme on “Large scale employment generation in coastal India through sustainable utilization of marine bio-resources” was launched at six centres in coastal India not only as an alternate source of livelihood but also as an environmentally friendly technology for biomass supply to the seaweed industry.

A total of 102 new projects were taken up by young women scientists to work on societal problems under women scientist fellowship scheme in the fields of agriculture & allied sector, health care, pharmacology, aquaculture, medicinal plants etc.

Coordinated programme on Fodder and Feed involving rural women.

Implementation of a coordinated programme on Green leafy vegetables in partnership with Home science colleges, NIN, Agharkar Research Institute, Voluntary Organizations at 16 different agro-climatic regions of the country to tackle the wide spread problem of anemia prevalent in adolescent girls and young women.

Technology package developed specifically for women viz production of low cost sanitary napkin has been developed and is being widely disseminated in different parts of the country by setting up of production units/common facility centre.

Co-ordinated Programme on Biomass based Tray Dryers for value addition to fruits and vegetables for economic empowerment of women" in six selected areas of Sub-Himalayan regions.

Besides above, Department of Science and Technology has proactively taken some gender enabling measures to enhance gender parity in Indian science these are:

- Fellowship Scheme for Women Scientists
- CURIE (Consolidation of University Research for Innovation & Excellence in Women Universities) for infrastructure support for women only universities.
- Gender budgeting
- Women Scientist Cell "Protshayaki"
- Annual National Awards for Women Scientists/biotechnologists
- National Training programme for women scientists
- Standing Committee for Women in Science
- Women Technology Parks
- Leelawati's Daughters (Book on lives of eminent women scientists)
- Website : www.indianwomenscientists.in

Scheduled Castes Sub Plan

Over the years, the scheme SCSP has achieved significant breakthroughs in developing and demonstrating technology packages in several sectors with the association of S&T based field groups and S&T institutions. The focus in the 11th plan was to consolidate the achievements of earlier successful projects and launch coordinated programmes in other areas to achieve a spread effect, skill development in newer areas with opportunities of self employment and technology development and adaptation to reduce drudgery in occupations traditionally being practiced by scheduled caste populations such as municipal work, carcass collection, tanning, footwear making, basket making, carpet weaving, construction work, pig and other small animal rearing.

A coordinated programme, on Resource Management and Development for the Empowerment of Scheduled Castes in Coastal and South India, has been implemented in a cluster of fourteen villages each in 9 locations at Andhra Pradesh, Kerala and Tamil Nadu. In all locations, special emphasis have been given on health and sanitation, food processing, animal husbandry, low cost construction with locally available material and safe drinking water as well as strategic needs such as contract farming system, local resources as new source of livelihood, skill up-gradation for better output and empowerment.

Similarly, A Coordinated Programme for Development of Scheduled Caste community in arid zone and Central India through Resource management, Technology transfer and empowerment has been launched in the four States of. Gujarat, Maharashtra, Madhya Pradesh and Rajasthan.

For 12th plan period, following sectors have also been identified for intervention through research design and adaptation:-

Development adaptation and popularization of improved machineries in traditional occupations.

- ❖ Introduction of alternative vocation and entrepreneurial skill development for artisans.
- ❖ Products from agro-processing / horticultural produce.
- ❖ Production of Non-traditional fiber composite.
- ❖ Production on recycled material –waste utilization
- ❖ Introduction of Non-traditional high value crops for small farmers
- ❖ Value addition in ceramic / pottery wares.
- ❖ Solid waste management / vermicomposting.

Tribal Sub-Plan - Technological Interventions for Tribal Empowerment (TITE)

During the Plan period from 2007-12, 82 inter-disciplinary projects of multi-sectoral nature having innovative S&T components have been taken up in the areas of farm & non-farm sectors, horticulture and processing techniques, sustainable agricultural practices, health and sanitation, MFP, medicinal plants, animal husbandry etc. These projects have been implemented in different tribal pockets of the country focusing on appropriate and cost effective technology modulation and transfer, based on location specific needs/conditions. Some projects which have made visible impact on the well being of the tribal population are:-

- Dairy cattle improvement through scientific breeding plan and artificial insemination at Block level in Uttarakhand.
- Cost effective design & development of a manually driven washer pump to lift water from open water sources in Ranchi Jharkahancd.
- Setting up of incubation support centre of technology skill up-gradation and design development on woolen garment at Ziro, lower Subansiri district, Arunachal Pradesh.
- Local area coordination project on system of Rice Intensification in Jharkhand tribal villages.
- Introduction of improved technology for production of bone meals and its application for bettering the socio-economic status of Mizo cultivators.
- Implementation of coordinated programme on demonstration and training in sustainable agricultural technologies and related entrepreneurship development in NE India. This network programme with technical and co-ordination support of G.B. Pant Institute of Himalayan Environment and Development, Itanagar Unit in partnership with seven VOs has benefited and empowered total 1540 lead farmers in 49 villages covering six states.Total 69 SHGs have been formed involving 11 tribal communities from North-East who have adopted these technologies in their operational areas.
- Implementation of coordinated programme on sustainable livelihood of tribals around protected area/national parks - a Joint initiative of the SEED, DST and WWF-India to support the efforts of local and grassroots VOs for technological interventions that enhance sustainable local livelihoods for local and indigenous communities living around PAs. More than 2000 tribal households have been involved directly around 12 project locations through S & T based activities for MFP Value Addition, Nursery Raising, Medicinal Plant Cultivation, Millet, Pulse, Cereal and Oilseed Processing etc. Overall, this programme has engaged with over 66 existing village level institutions and created around 40 new groups/institutions at local level.
- Continuation of Coordinated programme for the development of Angora Wool Sector to enhance income and employment generation opportunities in tribal areas of five district of Uttarakhand involving 12 VOs.
- Establishment of small scale virgin coconut oil extraction unit with improved machine and cost effective process in Nicobar island owned by local tribal community. This will help to fetch premium prices from the pharma and perfume industry for its use as a raw material and as a base for soaps and cosmetics.

- Promoting community based enterprise of tribal communities through technology transfer for sal leaf plate making in selected villages of Mayurbhanj district in Orissa.

National Innovation Foundation (NIF), Ahmedabad - NIF, an autonomous institute of the Department aims to develop the grassroots innovation system in the country.

National Mission on Bamboo Applications

Objectives: Development and induction of technologies, products and application in the bamboo sector, income generation and employment opportunities, sustainable livelihoods for the rural poor, tribal, backward and hilly regions, promoting bamboo as a wood substitute.

National Mission on Geospatial Applications

National Spatial Data Infrastructure (NSDI) approved by the cabinet and passed through a resolution is a national platform created under a partnership between the Department of Space and Department of Science and Technology in 2006 has emerged a data sharing platform for geospatial data among various arms of the Government of India.

NSDI has been established in separate office premises with CEOP and has become fully functional. NSDI is actively promoting the concept of establishing state level Spatial Data Infrastructures.

4. CHANGING NATIONAL SCENARIO AND THE ROLE OF DST:

In view of increasing need for livelihood needs at the grassroots level, there is a dire need to address equity and developmental issues for societal interventions through S & T emphasizing on improved quality of life and better livelihood opportunities. **Working sub-group stressed that to address such emerging issues, there is a need is to conceive and deliver innovative structures for 12th plan that demonstrate long term commitment to making an impact.**

Major inputs/suggestions of the sub-group are as under:

- Link programme impact of 11th plan to S & T policy and future planning.
- Motivate young mind in rural areas particularly in North Eastern region: Inculcate advantages of S&T through scholarships;

- Increase capacity building for enterprise creation in the area of Medicinal plants & Agro-horticulture with value addition specially in the NE
- Need for scalability with entire value chain, new structure for commercial and social application/impact.
- Establishing end to end support: special purpose vehicle for technology delivery.
- Right element of subsidy.
- Focus on bringing a fixed number of prototypes under commercial products like solar battery charger as per market demand
- Development of Network programmes for wider impact with several components for end to end solutions besides technology. It should evolve like a Amul, Lizzat Papad model providing real benefit to poor people as major stakeholders.
- Actionable but **focused programmes** in 12th Plan for multiple innovation and grassroots solution.

It was also agreed that for societal intervention, 12th plan should have focus on developing location specific thematic programme for core areas like Decentralized power generation; processing and packaging technology for livelihood generation, value addition of agri/horti and forest produce and manufacturing and also ensuring reliable infrastructure in rural India from long term sustainability. Programme should also have in-built component for soft skill training to involve rural youths and drop outs in community level services and establishing local manufacturing/service enterprises linking rural to urban market. Sub-group was of the view that **Rural Livelihoods** is an emerging need which should be addressed properly for better health care, housing, energy needs and in the ICT sector.

To make real impact, the sub-group felt that Rural GDP has to be enhanced to provide impetus for inclusive growth and also address the migration of rural communities to urban areas in search of livelihoods. In this endeavor, emphasis should be to make **focused effort to take technology as a complete package in enterprise mode with commercial viability in rural settings to empower rural India**. The Sub-group also recommended the need for initiating co-ordinated research programmes linking soil, plant, animal and human health: effective nutrient chain; herbal based curative & prophylactic health care for masses; Biodiversity based knowledge systems & *in-situ* value addition; creation of grassroots innovation fund for investment in small technologies for social and commercial market and **initiation of a new programme called Chunauti (Challenges for unfolding and augmenting technological innovation for society**) for addressing problems at the grassroots with S&T solutions.. Sub-group felt that there is also a strong need to find out viable and affordable solutions for improved cooking stoves, low cost water filter, and affordable use of renewable energy technologies to address basic needs of rural areas.

According to the 2001 Census that nearly two-thirds of the SCs and over 80% of the STs are engaged in primary sector activities like agricultural and forest based activities. The livelihood strategy would thus have to take into account the current occupation, level of skills, socio-economic conditions, low level of HDI, physical infrastructure and natural resource-base in the areas having predominantly SC & ST populations. The role of the Department of Science & Technology would be critical and would have to be driven towards demonstration of workable model (s) of science based solutions to address emerging issues of equity, food, nutritional as well as livelihood security of SC/ST population in the country. Efforts of the Department would be improving the social contract of science by delivering social value based technology solutions and services to socially disadvantaged population after developing reliable technology packages. Supporting small-scale enterprises by ensuring a sustainable supply of input materials, providing managerial and technological assistance, and improving access to credit would have to be taken up in select areas as a model.

5. CONSOLIDATION OF SUCCESSFUL ONGOING SCHEMES: Strengthening & Expanding successful 11th plan initiatives

The working group retreated those successful 11th plan initiatives like Council for Science & Technology for Rural India should be strengthened. At least 50 CSRTI centers to be nucleated in the country during the12th plan. The Long Term Core Support programme for Technological Advancement for Rural Areas (TARA) would be extended to cover nearly 50 institutions. Horizontal spread of select field proven/validated technologies through network programmes in 8 technology areas with end product as micro-enterprise will be taken up. Demonstration of technologies for livelihood generation, drudgery and health & nutrition along with social diffusion at multiple sites in difficult/remote areas would be done. Technology support for the disability sector will be included in the ongoing programme on Technology Interventions for Elderly (TIE) ,with a focus on development of innovative, cost-effective, preventive & curative technology packages like development of enabling devices, designs of homes, technology package for healthcare of elderly.

The Department of Science and Technology has pioneered several gender initiatives these initiatives have provided replicable models in the area of livelihoods, drudgery reduction and health and sanitation. Efforts should be continued and strengthened with an aim to disseminate successful technology packages. The successful programme on Rural Women Technology Parks to be expanded aiming at setting up Rural Women Technology Parks at least 25 locations. Network programmes on need based themes such as processing of horticulture/agriculture produce in different Agro-climatic regions; women's health issues to include health, nutrition and hygiene, Intervention package on non-communicable diseases – urban lifestyle disease to be replicated in different parts of the country. Vector Control with Community Participation and design of rural habitat addressing indoor air pollution.

Science & Society Programme: Under this scheme major focus has been on technology development at the grassroots level for socially disadvantaged section of the society. Some successful initiatives at pilot scale are:

- Extension of Mobile Elderly Units in other parts of the country to meet elderly health needs by screening and providing medical facilities at their door step.
- Village-level enterprise model for gainful utilization of Non-Edible Oils (NEO) bearing plants including specialty utilization of seabuckthorn involving selected groups of science-based NGOs with possible linkages from S&T institutions in various parts of the country generating employment.
- Development of Technology models for innovative water management (e.g. artificial glacier, dew harvesting, solar aquatics).
- Development of Technology driven Models Packages like Operation of fruit processing unit using upgraded water mill for mountain areas, Energy-Efficient Rural Jaggery-making Systems, briquetting technology package using invasive biomass for energy needs and fuel efficient Tava stove with reduced fuel wood consumption.
- Development of location specific low carbon technology models and institutional mechanism of distributed energy to address small energy needs (e.g. for lighting) and linking it with micro-enterprise generation in non-grid villages.

S&T for Women: Apart from sponsoring time bound projects, some of the successful technology models developed in individual projects are being replicated in different parts of the country as coordinated programmes:

- **Coordinated Programme on Large Scale Employment Generation in Coastal India through Sustainable Utilization of Marine Bio-resources** as one of the major sources not only as an alternate source of livelihood but also as an environmentally friendly technology for biomass supply to the seaweed industry.

- **Coordinated programme on nutrition based women's health**
    - Anemia during pregnancy continues to be a major public health problem in India through nutritional inputs and awareness among young rural women in India to promote consumption of iron rich foods like Green Leafy Vegetables (GLV).

- **Coordinated Programme on Development and Production of Low Cost Sanitary Napkins with knitwear waste** that are affordable by the poor. The technology developed for the manufacturing of sanitary napkins is simple and women can be trained to operate this technology to manufacture sanitary napkins.
- **Coordinated Program on Biomass Dryers** for economic up-liftment and empowerment of livelihoods of women through food processing involving biomass based tray dryers in North and Northeast India.
- **Women Technology Parks as** a single platform for improving the socio-economic quality of life. These Women Technology Parks would act as windows for providing information, creating awareness, giving training for appropriate technologies leading to skill up gradation and also possibly to help establish the all important forward and backward linkages for income generation through micro enterprises for women. Twenty Women Technology parks have been facilitated in different States to showcase technology options, backward and forward linkages to rural women for income generation activities based on local resources.
- **Fellowship scheme for Women Scientists** to provide opportunities to women to re-enter into mainstream academic, research, design and development work. Under this scheme, three categories of the scholarships are being provided – (a) to pursue research in frontier areas of Science and Engineering, (b) to pursue research on societal problems requiring S&T intervention, and (c) for undergoing S&T based internship leading to self-employment.
- **National Award for Women's Development through Application of Science & Technology** with an aim to recognize the contribution of an individual / institution who have worked out at the grass root level for women's development through application of science and technology..
- **Setting up of Standing Committee for Women Scientists** to address issues pertaining to women scientists to implement the recommendation of the Task force for Women in Science under the Chairmanship of the Hon'ble Minister of Science and Technology.
- **Scheduled Castes Sub Plan**: A unique programme, 'Coordinated Programme on Resource Management and Development for the Empowerment of Scheduled Castes in different parts of the country', has been initiated involving the Scheduled caste communities. Scheduled caste communities face a number of development problems even today. Projects are located in Andhra Pradesh, Gujarat, Himachal

Pradesh, Jammu & Kashmir, Kerala, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu and Uttarakhand where the selected SC communities are mostly engaged in unskilled seasonal labour. The target area includes costal villages, hilly areas, and plain/drought areas. The condition of the people varies from village to village but in general they live in extreme socio economic backwardness.

The intervention of the organizations at their respective villages started with mobilizing the community towards a common goal of empowering the community through the application of Science & Technology leading to reduction in poverty, unemployment and improvement in the basic facilities of living. Participation of the community in planning and implementing the programs are ensured from pre project activities onwards. In addition, a leader in the community is made as a project staff and Co PI of the project so as to ensure their ownership of the programme.

The unique outcomes of the programme are:

- Mobilized the community towards a common goal and established people's institutions /developed leaders for the program.
- Networked with local training centers and production/service units for market based skill development and placement of local youth and semi skilled/unskilled workers.
- Local skill based livelihood programs for women has been introduced in target villages which includes Nutrition garden, poultry, goatry, rabbit rearing, azolla, composting, mushroom, soap making etc
- Introduced technologies in the field of rain water harvesting, ground water recharging, open well recharging, soak pit technology, solar water purification, sanitation technologies including two pit and compost toilets, and kitchen waste based bio gas.
- Initiated local resource based livelihood activities /micro enterprises by forming beneficiary (functional) groups viz. cattle feed development unit, herbal production unit, fruit & vegetable based production unit, and Emu rearing units.

Tribal Sub-Plan - Technological Interventions for Tribal Empowerment (TITE): Tribal Sub Plan has been strengthened with a budgetary support of Rs. 58.75 crore for the remainder of eleventh plan period by the Department. Major outcome during 11th plan period includes development and induction of technologies, products and application in the livelihood related sectors, income generation and employment opportunities, promoting micro-enterprise creation at the cluster level in diverse sectors as mentioned above. Formation of no. of SHGs involving tribal communities from areas like North-East who have adopted these technologies in their operational areas itself is a good indicator of adoption of technological intervention and impact of the programme at the local level.

6. TRAJECTORY & SELECTION OF NEW PATHS AND PROGRAMMES:

From implementation point of view for the societal programmes of DST and ensuring local institutional arrangements for hand-holding with visible impact of technology at local level, department should make pro-active efforts to involve following agencies as partners in designing and development of programmme for vertical growth and horizontal spread of technology as complete packages:

- S & T institutions with Local Institutional Arrangements – Panchayat
- Universities/colleges having outreach programmes.
    - KVK's of ICAR.
    - CSR with public sector.

Scheme/prgramme wise details for new paths and programmes envized for 12th Five Year Plan are as under:

Science & Society programme

Long Term Core Support: Technological Advancement for Rural Areas (TARA)

Expanded network (3 fold) of Core Supported S&T based voluntary organizations/Institutions across country side to do innovative and adaptive R & D towards rural application.

Technology Interventions for Addressing Societal Needs (TIASN) including Science and Technology Application for Weaker Sections

Support to about 20 development projects/yr focusing on development/adaptation and delivery of appropriate technologies in farm/non-farm sectors leading towards enterprise creation.

Development and implementation of directed coordinated/networked programmes for development/adaptation of appropriate technologies in difficult sectors of rural economy.

Continuation of Technology Interventions for programme for Elderly and people with disabilities with a focus on development of innovative, cost-effective, preventive & curative technology packages like development of enabling devices, designs of homes, technology package for healthcare of elderly;

Extension of Co-ordinated Programme for gainful utilization of Non-Edible Oils (NEO) bearing plants in other areas.

Development of Technology models for innovative water management (e.g. artificial glacier, dew harvesting, solar aquatics) and purification.

Application of Geo-sciences and other relevant areas for weaker sections of the society.

Co-ordinated programme i.e. for Arid and Semi-Arid Regions (ASAR) ; Hot and Cold Desert Regions with a focus on research, development and adaptation of need based appropriate/innovative technologies in the areas of Habitat, energy, water, livelihood, etc

Development and dissemination of community-based cost effective technologies for water purification and wastewater recycling along with impact assessment on improvement of livelihood opportunities.

Technology upgradation & Skill up gradation of artisans through development demonstration and training in appropriate technologies and its management.

Local area and region specific network programme - Sustainable Agriculture & Rural Transformation Holistic Initiative (SARTHI) for small & marginal farmers (to overcome the micronutrient deficiencies in problematic areas through improved solutions for soil-water management, improved farm productivity, reduce soil salinity and value).

Expansion of Council of Science & Technology for Rural India (CSTRI)

3-4 sensitization/project formulation workshops/yr to create awareness about societal programmes.

Scheme for Young Scientists & Technologists (SYST)

- Implementation of 15 Innovative societal projects/yr by Young Scientists and Technologists to address location specific issues.
- Approx. 2-3 sensitization/project formulation workshops/yr.

S&T for Women

Programme will have following focus in terms of approach of implementation and path to be followed for effective outreach in urban as well as rural areas.

- Gender-focused approaches to support women entrepreneurs to establish formal enterprises.
- Support to about 25 development projects/yr focusing on development/adaptation and delivery of appropriate technologies for women's empowerment.
- Take advantage of the emerging needs and opportunities in the form of climate friendly, low carbon, infrastructure material production and promotion. The niche areas that are opening where women can easily occupy the space with out competing with men in spaces such as:
- Prefabricators of eco friendly / green building material production entrepreneurs,

- Installers of solar heaters and lighting fixtures and other home lighting needs
- As biogas service deliverers
- Entrepreneurs of Clean and safe drinking water supply at door step both in the rural and peri urban settings
- As waste recycling entrepreneurs, waste managers and owners of pre-fab sanitation Marts
- As trained home managers to operate all latest gadgets and as aware workforce to avoid excessive usage of water, detergents

R&D for Women and Child Health

- Non-communicable Diseases – Urban lifestyle disease Metabolic syndrome (Met S), - Intervention package developed in 11th plan to be replicated in different parts of the country-partners Community medicine Departments of Medical colleges
- Vector Control with Community Participation in collaboration -MRC, ICMR, NTIs, Regional Vector Control Research Centre, and Department of AYUSH

Programme for reducing occupational health hazards of women engaged in various industries such as Construction, Cashew processing, Fish processing, Indoor air pollution, etc.

Development of micro enterprises for women such as agricultural produce production, bio-fertilizers including quality control and self life studies, etc will be taken up.

Testing kits developed for estimation of level of cholesterol and sugar in blood will be popularized in remote rural areas.

As a strategy in cover management programmes on involving women in production of Phosphate Rich Organic Manures (PROM), microbial rich compost will be initiated leading to entrepreneurship in these sunlight areas.

Continuation of ongoing programmes including women scientists' fellowships scheme.

Make provision for special schemes from National Housing Banks to encourage all women entrepreneurship along the value chain in the above niche areas where application of latest science and technology is needed.

Encourage Public -Private – Community partnership models to encourage women entrepreneurship.

Scheduled Castes Sub Plan:

- A Coordinated Programme for livelihood opportunities for Scheduled Caste community through pottery
- A Coordinated Programme for Development of Scheduled Caste community in eastern states through Resource management, Technology transfer and empowerment will be launched in States of Bihar, Orissa and West Bengal.
- Support to about 20 development projects/yr focusing on development/adaptation and delivery of appropriate technologies for SC community.
- A Coordinated programme on Production of building elements, construction techniques will be initiated for rural youth with technical support from CBRI, Roorkee, HUDCO voluntary organizations.
- A programme to expose Local Functionaries (sarpanches) of SC majority villages to the S&T based livelihood activities will be initiated with the help of S&T based Voluntary organizations, scientific institutions to help them to formulate schemes and include them in their development plans. This pilot scheme could started in M.P, UP and Bihar.
- Integrated Mission on S&T-driven Sustainable Development of Scheduled Caste (SC) Populations in the top eight SC-populated states in the country i.e., Andhra Pradesh, Bihar, Haryana, Madhya Pradesh, Orissa, Rajasthan, Tamil Nadu and Uttar Pradesh. The Mission intends to address development needs of the beneficiaries by taking up S&T interventions in the following five key areas (according to local specificities) alongwith skill trainings in conventional (like Repair of agricultural tools/equipment/irrigation pumps) and new trades (like Repair of mobile phone/electrical-electronics appliances):

    - ✓ Improved house building technologies
    - ✓ Construction of toilets/ sanitation technologies/recycling
    - ✓ Building non-grid alternate sources of energy: Mini solar energy plants, solar lamps, gobar gas plants and Biomass-based briquette
    - ✓ Reclamation of johads/wells/ponds through rain water harvesting
    - ✓ Water quality testing/filtered drinking water supply.

- Capacity building scholarship programme for SC Youths: Around 500 SC Youth as technology entrepreneurs will be benefited either as self employed or up gradation in the traditional occupations. SC youth with requisite qualifications could be attached to dynamic S & T based

Voluntary organizations/laboratories/ enterprises for upto 3yrs. Support to the candidate and to the host organizations will be provided.

Tribal Sub-Plan - Technological Interventions for Tribal Empowerment (TITE):

For inclusive growth and economic progress of the society, specific initiatives are being proposed in 12th Plan period for application of innovative technological solutions for development of tribal population of the country for equity and empowerment. As a new mechanism, time bound programmes will be implemented involving civil society groups and grassroots level organizations with local institutional arrangements for development and utilization of technologies in central India and in the North-Eastern States having major concentration of tribal population. This will enable to develop a sustainable model for S&T backed entrepreneurships for tribal population at the local level for addressing critical issues of food and nutritional security as well as livelihood security.

Wider Impact Multi-locational Programme for Affordable Technological Solutions

- **Development opportunities for tribal communities in & around** 50 **protected areas/National parks through technology focused alternative livelihoods and conservation for sustainable development**
- Technological Interventions in Backward & Difficult Mountain Areas for Tribal Enterprise development
- **Application of Basic Rural Technology (BRT) for Capacity building (to tackle** persistent problems of low literacy and high drop-out rates**)** to generate alternate sources of income through sustainable cultivation systems/diversified agriculture and the establishment of non-farm enterprises at the micro and small scale level.
- Initiation of local Area Network programme at pilot scale for improved livelihood and nutritional security in select tribal areas (8-10 locations) of Maharashtra and Southern India.
- Livelihood promotion using Agro-biodiversity of Small Millets in some tribal areas of Tamil Nadu and Odhisha based on traditional knowledge and modern S&T.

Project Mode Support in Critical Areas

During the plan period, 80 new inter-disciplinary & location specific projects likely to be supported on technology development and piloting and subsequently, extension and delivery in different tribal area of the country to improve their traditional skills and livelihoods. These projects will involve using

/ augmenting the local resource base, and apply new scientific knowledge to the traditional knowledge of communities.

- Forests – Agriculture Interface and Indigenous people**: Development, demonstration and extension of viable & replicable models of S & T application** that ensures household level food security and improves livelihood opportunities;
- **Improving Crop Productivity by Application of Newer Technology Packages** such as System of Rice Intensification (SRI), tree-based farming systems (Wadi), introduction of newer varieties of conventional crops (Rice, Finger Millet, Pulses), diversifying crops by introducing promising cash crops such as vegetables, floriculture etc.
- Effective and sustainable utilization of available natural resources including MFP and value addition **to products based on traditional skills**: innovative technologies and quality products, integration in the production chain.
- **Initiation of innovative programme/project to harness biomass, solar energy /hydro-power t**hrough appropriate de-scaled energy generation for addressing energy requirements in select tribal hamlets; including water resource management and spring recharge; micro-level Integrated watershed management.

7. <u>NEW APPROACHES FOR THE XII PLAN</u>:

For better outreach and make visible impact of the new programmes envisages above to strengthen prevailing livelihoods as well as generating alternative livelihoods opportunities, **focused approach for multi-locational model programmes may be adopted by the Department for implementation in a cluster of tribal/SC dominated villages to measure the success at the grassroots level - Co-relating the technological outcome of the convergent solutions on progressive development and deployment.** Special efforts should also be made to link S&T support to socio-economic ministries in areas like rural development, Ministry of Tribal Affairs, Ministry of Social justice & Empowerment, Deptt. of Women & Child Development etc. Connecting sources of technologies with social challenges and their customization as per local conditions as focused by various socio economic ministries will be the major paradigm in approaches. To make this into a scaled up programme, there would be efforts to work on developing relevant technologies and packaging technology for field introduction and work on value-chains such as grading and packaging, pulping and making value-added products of forest products and increasing shelf-life of nuts; use of solar technology for drying etc. In this, process system approach will be for:

- Simple or medium term interventions on an initially limited scale at the outset;

- Constant interaction between planning, execution and evaluation;
- Dynamic analysis and more in-depth comprehension of the milieu (Technology users, technology providers and technology developers);
- Increased participation on the part of target groups in decision making, implementation and evaluation;
- Diversification and strengthening of the support given to local capacity for institutional organization.
- Linkages with banking institutions and other support agencies at the state level from sustainability point of view.

Above principles encapsulate the new approach to empowerment of socially disadvantaged section of the society including women, SC, tribal and elderly population.

Thus, for effective implementation of above programmes//schemes having societal relevance, new approach should be towards:

- Proposed shift in approach of accepting and processing proposals
- launch need based initiatives for technological solutions to address real problems –Scheme CHUNATI Partnership NIF and SEED, DST
- Multi-locational model programmes
- Multiplying successful tech packages-partnership S&T councils/Rural council/core groups
- S&T backed entrepreneurship development for rural youth – Partnership NEB & SEED, DST.

To find out the strategy and new approaches, working group in its 2nd meeting held on 7th July, 2011 discussed in detail about the need for refocusing rural strategy in 12th plan period towards increasing per capita rural GDP and to build confidence in people’s knowledge and abilities in rural India. **After detailed discussion, sub-group recommended following measures are needed by DST to develop focused flagship/mission oriented programmes for improving the condition of rural India and disadvantages sections in particular.**

1. To revitalize Indian Agriculture by

- Improving methods of agriculture and forestry (MFP) with extensive value addition
- Providing good quality seeds and fertilizers to the farmers
- Creating water harvesting facilities on extensive scale by dovetailing with NREGA programme to create culture, systems and practices so that usage matches what is captured

- Minimizing the risk of the farmers by introducing suitable insurance package for crop disease, inadequate rainfall, rationalization of market rate
- Providing Agricultural extension services like customized support to farmers, production and distribution of agricultural produce (may be organic with certification system)

2. Introduce innovative livelihood approaches by

- Outsourcing IT services to Rural India
- Outsourcing manufacturing and services to villages and generate wealth & confidence Ex. natural fibre based micro manufacturing units.

3. Rural Industry approaches with product innovation and leveraging locals' knowledge by

- Enlarging scope of Bamboo mission (Affordable rural housing) of DST, improving handlooms with product mix, bring about innovations in micro spinning with small machine to create remunerative value chain
- Strengthen agro-food processing sector through operational structure of SHGs or micro-franchise unit to take up quality production and packaging at village level
- Improving rural infrastructure and communication facilities
- Providing new alternate decentralized power generation and distribution to rural India : Bio-gas, Bio-diesel, Biomass combustion, Solar photo-voltaic, Solar thermal, Bullock-energy energy, Thermal energy

4. Introducing Financial services in villages like ATMs, loan facilities

5. Social approaches

- To provide health care facilities in the villages - Tele-medicine technology: Integration for rural health practitioners, diagnostic tools
- To involve youth to the development process : On problems of informal sector and other disadvantaged groups; to research on location specific problems:
- Drinking water: Potential for use of herbs for purification
- To encourage innovation and entrepreneurship : Leveraging grassroots innovations documented by NIF
- Creating market for rural products like Vyapaar sewa portal

To make better outreach of societal programme, it was also suggested that there is a need for developing analytically advisory document to set up small rural enterprise system with multiple skill development; policy document to involve private sector directly for their investment in these areas to get benefit though Public- People partnership which has to be built with utmost care. He also suggested for developing system design for Good delivery mechanisms with tangible outcome; S & T performance indicators for inclusive development and devising new methods by involving external agencies for call for proposal through public-people partnership. It was felt that societal programme in 12th plan will act as a window through which DST would address the problems and suggest solutions on pilot scale for rural S & T enterprise and production system. However, for large scale interventions of such workable and proven technological interventions, respective ministries have to step in to take it further

Finally, sub-groups concluded that innovation need to be scaled up with *in situ* value addition to create successful enterprises in rural settings for making commercial and social impact with end to end linkages. Sub-group stressed that DST should work on a few specific programmes with quantifiable deliverables by identifying the challenging problems and possible S & T solutions with demonstrable benefits like Decentralized off-grid energy system through solution science. It was emphasized that DST should differentiate itself from others and focuses on outcome rather than activity itself in an unstructured environment. To make this operational and effective, it was felt that there is a need for financial and policy support to create separate entrepreneurship fund and incubators focused on Rural India to redefine development and attain sustainable growth.

SELECTION OF XII PLAN TARGETS

To access visible impacts of the programmes, targets will be set for quantifiable indicators like no. of SHGs formed involving targeted communities in technologies adoption, increase in income level, drudgery reduction & micro-enterprise creation at the local level. Quantitative targets will be developed in consultation with stakeholders and project implementing agencies.

Recommendations for the XII Plan

5.1.1 Encouraging rural S & T enterprise and production system

- Programmes to address optimization of agri-inputs, primary processing at production site, containing post-harvesting losses should be developed and implemented as model initiatives.
- Initiatives on technology development for outsourced manufacturing in rural areas to create a remunerative value chain in indicative sectors such as leather & pottery, handloom, natural products, prefab bamboo

structures, innovations in with small machine capacity of rural youth thereby introduction of innovative livelihood approaches in rural areas.

- IT enabled services for rural India to be enhanced. Rural BPO model to be replicated further for livelihood promotion.
- Rural industry would require decentralized power generation and distribution system prototypes of such models based on hybrid systems to be field tested with community.
- Public- People partnership/CSR could be mobilized for spread of programmes.

5.1.2 Innovations for better quality of life

Health is a major driver of economic development & social contentment in any country. India's unique health challenges due to its large populations, demographic transitions, and social & economic vulnerability of a significant section of its people, require unique initiatives.

- Initiatives as replicable models in Tele-medicine technology, Integration for rural health practitioners, diagnostic tools as Health care models for villages, Agri-health care models.
- Focused Programmes on scientific validation of traditional practices in Nutrition, health care and water purification, especially for women children and elderly should be taken up in collaboration with Science agencies/Deptts.
- Efforts would be on establishing mechanisms to evaluate technologies for improving health care at individual & public health levels.
- Innovation especially those which lead to a better quality of life in rural areas need to be scaled-up with in situ value addition to create successful enterprises in rural settings for making commercial and social impact with end to end linkages.
- Expanded network of Core Supported S&T based voluntary organizations/Institutions across country side to do innovative and adaptive R & D towards rural application and better quality of life.
- A innovative programme Challenges for Unfolding and Augmenting Technological Innovation for society (CHUNAUTI) to be launched and challenges like unsolved problems in rural areas in farm machinery ,drudgery reduction devices, improved energy systems, water purification in villages etc. may be addressed.
- Innovative marketing of rural products should be an integral part of production based enterprises e.g. linking with Vyapaar Sewa portal.

5.1.3 Engaging youth in the development process

- Harnessing the ideas of young inventors and innovators from schools& colleges in each block in the country will lay the foundation for developing future leaders of innovation movement in the country.
- Multi skill development leading to entrepreneurship/absorption in service sector.
- Programmes to engage youth in identifying problems of informal sector, research on location specific problems, biodiversity conservation/NRM and Eco-Tourism and documentation of local knowledge should be developed.

5.1.4 Science and Technology for Social Good

- Interventions for the Scheduled caste and Scheduled Tribe populations should be planned keeping into account the land holding & natural resources in rural areas , level of education and skills, socio-economic conditions, low level of HDI, physical infrastructure.
- Partnership with the community should be an inherent precondition while planning S&T based interventions.
- Role of DST should be to demonstrate workable model(s) of science based solutions to address emerging issues of equity, food & nutrition health and Hygiene.
- Programmes to address nutrition security by diversified packages in horti/agriculture, value addition of produce should be taken up in predominantly tribal areas.
- Introduction of alternative vocation & entrepreneurial skill development for artisans
- Efforts should be will also include improvement of the social contract of science by delivering social value based technology solutions and services to socially disadvantaged population after developing reliable technology packages. Focus will be on supporting small scale enterprises by ensuring a sustainable supply of input materials, providing management and technological assistance and improving access to credit.

5.2 Technology areas:

- agro-horti processing,
- non-traditional fibre composite,
- recycled material –waste utilization,
- value-addition in Ceramic/Pottery wares,
- Solid waste management,

- R&D initiatives for women and child health including non communicable diseases.
- Programmes for reducing occupational health hazards of women engaged in various industries, development of micro enterprises for women etc will be taken up.

5.3 Network Programmes:

- Location specific convergent technology solution based programmes like focused alternative livelihoods and conservation for tribal communities in & around 50 Protected Areas/National parks (Energy, MFP, Livestock & Fodder – New Enterprise creation (100) with Value Chain) should be taken up
- S&T Programmes should be taken up in remote difficult areas and geographically isolated areas. The programme should be designed in partnership with S&T institutions in the area.
- Core support programme (TARA) would be expanded for better geographical spread, effective rural technology delivery and country wide impact.
- 50 model demonstration projects through CSTRI for rural applications would be launched.
- Application of Basic Rural Technology (BRT) for Capacity building of Tribal/SC Youths – should be taken up chosing newer areas.
- Public-Private–Community partnership models would be encouraged to evolve and sustain innovation driven entrepreneurship
- Sound delivery mechanisms for 5% of the allocated budget to weaker segments to be established and impact assessment systems would be developed.
- Network programme for extreme climatic areas, sustainable agriculture/value addition packages for marginal farmers with a focus on research, development and adaptation of need based appropriate/ innovative technologies)
- Local area and region specific Public-Private–People partnership models should be encouraged to evolve and sustain innovation driven entrepreneurship.
- Technology & skill upgradation of artisans through development demonstration and training in appropriate technologies and its management (linking modern S&T with traditional crafts and other artisanal goods – ST Community) should be taken up in a partnership mode.
- Integrated Mission on S&T driven sustainable development models for Populations in the top eight SC-populated states in the country covering key areas such as capacity building conventional and new trades, improved habitat, sanitation & recycling technologies, energy.
- Gender Initiatives

- Ongoing Fellowship schemes for Women scientists to be reenergized and continued with a aim to enhance numbers.
- Available options for capacity building of women scientists to be enhanced to include training in science communication-audio visual, editing of scientific books journals and papers, Quality systems to include NABL,GLP
- New scheme for Women Science & Technology Professionals to address mobility should be developed.
- Women scientists chair to be set up in all National Science Academies.

5.4 National Innovation Foundation: Recommendations for XII Plan

- Coordinated Research Project on soil, plant, and human health.
- Setting up service labs for nutritional characterization of traditional foods.
- Development of technologies for herbal or mineral nutrition and preventive health of children.
- Biodiversity based knowledge systems and grassroots innovations (Nurturing the institutions of common property resources etc).
- Grassroots innovation fund for investment in small technologies for social and commercial market.
- National Innovation Promotion Service : Massive engagement with masses (Railways, Post, School & Colleges)
- Challenges for unfolding and augmenting technological innovation for society (Chunauti): To involve Technology Youth to various problems of informal sector, MSME and other disadvantaged groups (in partnership with SEED, DST)
- Unresolved technological challenges (Paddy transplanter, improving cooking stoves etc.): Optimization of design for commercial scale application and local level adaptation
- Documenting traditional knowledge about climate change, eco-system properties, health and culture

5.5 National Mission on Bamboo Applications: Recommendations for XII Plan

- Skill up gradation and Market Linkage to provide benefits under the Minor Forest Right Act.
- Technology Consolidation
- Rural Housing
- Development of hygiene and health products, Rural agro based development through Bamboo technologies

5.6 National Mission on Geospatial Applications: Recommendations for XII Plan

Infrastructure Development, Flood Modeling & Forecasting, Water shed Management, Cadastral Mapping, and Emergency Response System.

6. Operational changes proposed in XII Plan

- Inviting proposals (in a consortia mode) on select themes.
- Inviting proposals addressing specific problems through input of S&T
- Building network programmes for horizontal spread of successful technology packages
- Concurrent mentoring and monitoring of programmes by an expert group.
- Third party impact evaluation of programmes.
- Involvement of Academies in Fellowship programmes.
- Larger involvement of S&T Councils.

Conclusion:

The Department of Science and Technology needs to focus on Innovations that can be scaled to successful enterprises making social and financial impact in rural areas. The focus should be taking prototypes to the market for which partnership with industry would be required. The Department should prioritize and select sectors where technology solutions are available and need large scale dissemination. The subgroup recommends that one should determine apriori what, if any, financial and policy support is required to scale up and take necessary measures for the same. The engagement of the Department in societal activities should be enhanced so that replicable models are developed and spread throughout the country through line function departments. There is also a need for Entrepreneurship fund and incubators focused on Rural India.

Annexure 8f

REPORT ON SCIENCE & TECHNOLOGY COOPERATION/ PARTNERSHIP AND ALLIANCES

A. International S&T Cooperation

Context

There are new opportunities and challenges for India in the 21st century global knowledge economy for emerging as major international player during the next two decades. In this context, India should be able to strategically leverage ***'international collaborative advantage'*** by building chosen international alliances and partnerships with selected countries that can have measured yields, such as:

(i) R&D outputs through international alliances which can contribute directly to measurable national outcomes;

(ii) enable new paradigms being practiced by other emerging economies for sustainable adoption by Indian R&D and innovation systems;

(iii) evolve modalities and mechanisms for seamlessly connecting Indian research with global efforts particularly in the frontier areas of S&T and in areas addressing global challenges; and

(iv) help India to use the soft prowess of S&T as a tool for international diplomacy;

Strategy

With limitations in resources, infrastructure and manpower available for supporting science & technology, and with global dimensions of challenges facing mankind as a whole, countries are proactively engaging in international and multilateral S&T collaborations, which have become a necessity of the day. In this paradigm, it is noticed that as India's stature grows in the comity of nations, off late several countries across the globe are increasingly trying to engage with India in S&T cooperation. If Indian institutions were to emerge as global leaders in some branches of science, international S&T cooperation would be essential to factor in. Under these circumstances, our engagement considerations, both bilateral and multilateral therefore needs to be selective, output oriented and driven strategically, so as to reap the best benefit.

The broad paradigm of our international S&T engagement can be scoped under the following strategy:

i. ***Technology Synergy* -** symmetrical partnership with co-investment and reciprocity principle with developed nations in non-strategic sectors, but with focused outcome linked to national programs and priorities;

ii. ***Science Diplomacy*** - engaging with developing countries on a donor-recipient model with the aim to use soft prowess of S&T to build long term strategic relationships; and

iii. ***Technology Acquisition*** - international technology transfers using a technology acquisition fund to rapidly develop cost optimized solutions through global partnerships in strategic areas including defense, energy security, food security, homeland security, infrastructure, manufacturing etc.

Approach

1. In order to achieve the above goals through international engagements it is imperative that we should systematically map and profile the science, technology and innovation strengths and potentials including policies of selected countries that can help us to engage with them in a proactive, directed and productive manner.

Accordingly, a strategic document can be generated with country specific models for a basket of countries highlighting their scientific (basic and applied research) technological and innovation strengths. This document should be able to provide a road map of India's future engagement with these nations on chosen areas of strengths.

2. An advisory mechanism through a 'think tank' with scientists, technologists, diplomats and policy analysts can be constituted to provide regular inputs and insights for engaging with different countries and in multi-lateral S&T forums.

3. As a part of international science diplomacy and in order to enhance international presence and impact through S&T on a proactive fashion, India should have Science and Technology Counselors represented in our embassies in some strategically selected countries and regions. The number of such S&T Counselors should be enhanced to at least 20 from the present 4 positions (at Germany, Japan, Russia and USA), in consultation with MEA.

4. Science and Technology diplomacy should be included as an important element in our foreign policy portfolio. This should be enabled through systematic interaction through an alliance office with the MEA and the Foreign Services Institute (FSI). Institution of visiting Science Fellows position in MEA/FSI (like the Jefferson Fellowships in US State Department) can be considered for this purpose.

5. New inter-governmental science and technology agreements whenever entered upon should have allocated funding commitments to ensure their time bound and effective implementation.

6. Attempt should be made to connect bilateral trade with joint R&D efforts (e.g. 1600 technology licensing from Germany in one year throws open enormous challenges and opportunities by Indian Companies for technology networking on a PPP model).

7. Wherever feasible, entity to entity (institutional level) engagements in international S&T collaborations should be also facilitated and promoted by DST.

8. The existing and newly created bi-national S&T bodies/centers should be adequately provisioned to take up the expanding program portfolio in S&T engagements.

9. Create a mechanism of international peer review standards and format through international engagement and consensus. This will facilitate and hasten international cooperation based on accepted norms.

Plan Actions

1. Adopt innovative schemes for promoting joint research with active and leading international schools from developed nations (preferably on a cluster model) in frontier areas of S&T with new approaches to participate in international S&T cooperation based on reciprocity with co investment of resources and devised IPR sharing mechanisms.

2. Some advanced nations have taken advantage of Indian strengths in basic research by direct funding research in Indian institutions with control of IP. India should also invest into unilaterally supporting basic research in other countries on special areas of direct relevance to us with devised IPR sharing arrangements.

3. Provide mechanisms for India's active participation towards formulating and contributing to international scientific campaigns that address issues of global concern and challenge.

4. Create and ensure access for Indian researchers to new global and advanced S&T facilities.

5. Mega facilities are being built and created through international consortium type of funding. India during the 11th Plan period has already started to participate and contribute effectively (through resources and technology) is such campaigns like CERN, ITER, ILHC, etc. India should continue to proactively participate in new mega science initiatives like TMT, FAIR, LIGO (Laser Inferometric Gravitational Observatory) etc. which besides enriching basic research also should enable capacity building in instrumentation and technology development.

6. Allow international participation through proportioned contribution of resources and technology in major national projects like the India based Neutrino Observatory (INO), 3/6 GeV Synchrotron, Neutron Spallation Source, etc. and other such future large national campaigns.

7. Global Technology Alliances should constitute an integral part in the Technology Missions of the 12th Plan with the aim to realize effective technology development and deployment in shortest possible time frame.

8. Creation of a Technology Acquisition fund under a PPP model for effective international engagements in strategic sectors.

9. Integrate global best practices of 'mind to market' or 'bench to bedside' concepts for developing quality national innovation ecosystem aimed at competitiveness and accessibility.

10. To address talent supply chain challenge, provide schemes and policies for attracting the scientists and technologists of Indian origin and other nationalities to relocate both on temporary and permanent basis to R&D and academic institutions in India.

11. Strengthen international linkages for augmenting the quality of human capacity through international fellowship schemes in priority areas of research in selected and leading global institutions for young and mid-career Indian researchers.

12. Provide schemes for PhD students in Indian institutions to undertake research internships in foreign institutions up to one year as part of their doctoral work.

13. On a reciprocal basis, also extend schemes for undergraduate, masters and doctoral students from both developing and developed countries to undertake research internships and exposures in Indian institutions.

14. Establish fully supported visiting fellowships, visitation programs and training opportunities for scientists, academicians, science teachers and research students from developing countries for exposure in Indian R&D institutions.

15. Create a Science & Technology Assistance Fund for up-gradation and strengthening of R&D institutions in developing countries implemented in coordination with MEA.

B. Public-Private Partnership (PPP) in R&D

Context

Share of knowledge-intensive production in India is estimated at only 11.6%, although it has increased from 8.6% in 2005. High-tech content of India's manufactured exports is still low at 17%, (USD 12 billion) though it has almost doubled from 9.6% (USD 4 billion) in 2000. The average technology value addition in products manufactured by Indian industry is around 6%, very low compared to other developed and fast developing nations.

R&D partnerships through public-private engagements help to realise opportunities that would be far beyond the individual grasps of individual entities. University-industry research collaboration as a low risk method of fast tracking innovation and technological growth has long been visualised by the United Sates and other developed nations. Many of the modes of academia-industry R&D interaction in U.S. such as consortium formation, joint ventures, strategic alliances, technology licensing, start-up companies in academia, value-added reseller and collaborative R&D clusters originated before World War II. Such partnerships have yielded sustained innovation and the industry has benefited from academic research and vice-versa. According to US Patent & Trademark Office, about 40% of the industrial patents in the country are attributed to private funded research.

In the Indian context, inclusive growth during the 21st century would require rapid development and commercialisation of new technologies as the driver in the 'knowledge economy'. R&D enabled by hitherto un-availed models of PPP's such as mitigating market risks in selected areas of research, positioning a well-designed innovation eco-system, and also facilitating seamless interaction and co-dependence between public R&D institutions and industry through both policy interventions and fiscal incentives should be considered vital for realising our fullest potential through R&D. The goal of R&D in India under PPP could include the objectives of affordability, cost-optimisation and maximised benefits to people, and address the inclusive growth agenda of the country.

Currently the private sector engagement in R&D is estimated to receive funds to the tune of 24% of total R&D expenditure in India. Sufficient readjustments are required in the 12th Plan to increase the private sector investments into R&D to at least 50% of the national expenditure in R&D. The PPP model of funding industrial research should form a stated priority and an important planning tool for realising our fullest potential through R&D in the Plan period.

Approach

In India more than 80% of the industrial sector does not invest in R&D. Doubling of Indian R&D investments from less than 1% of GDP is possible only when private sector investment in R&D also increases significantly. However, it has been a challenge to change the mindset of industry in investing in technology despite many positive enablers by the government like tax incentives in R&D investment, low cost government fund for technology development and commercialization. Lately, a few big industry houses have started investing in technology. Fiscal incentives alone would not attract industry investment in technology as it needs build its capacity and technology depth. It is time that we need to build the technology depth primarily in manufacturing sectors of India.

Industry's technology depth may be defined by two sets of parameters both in input side and in output side. In the input side the parameters could be quality and number of technical human resource both in R&D and manufacturing, state-of-the-art technology infrastructure both in R&D and manufacturing; investments in R&D and technology, IP acquisition, existence of robust technology strategy and policy etc. Whereas, parameters in the output side can be value of IP assets in the balance sheet, market share, new global products in the market, revenue etc.

Some of the key hurdles that can be identified in the private sector participation in R&D are as follows:

(i) absence of a policy which focus on providing enabling environment and support systems for building up technology depth in Indian industries, big, medium and small, thus leading to non-alignment within in-house verticals and horizontal reach to government departments and public funded R&D institutions; and

(ii) absence of a professional delivery mechanism to reach right incentives and disincentive to the Industries towards this goal of acquiring sustained technology depth.

In contrary, the focus of most public sector R&D work in India is not high in the generation of commercial value or Intellectual Property (IP) generation or in addressing R&D solutions for national challenges. A key divergence is that publicly funded scientists value publishing papers in peer-valued scientific journals, while private R&D is all about managing IP for profit – divergence of motivations limit the interactions to mostly transactional models.

Corrective measures and approaches are needed to address issues like:

(i) Supply chain management of talent in R&D labs. Attraction of talent to R&D functions could be best accomplished through the creation of high value employment in private sector R&D and well-designed incentives in public sector R&D with mechanisms for bi-directional mobility of researchers.

(ii) Lack of incentives and commercial relationships for R&D labs to develop IP with commercial value. There is also a need to promote entrepreneurship amongst the R&D community by position an enabling innovation ecosystem to connect knowledge to wealth and value generation.

(iii) Poor linkages between Government, public-funded R&D labs, higher education institutes and the Industry.

(iv) Planned and holistic efforts are essential for correcting deficiencies of knowledge flow, in the mind-to-market chain, by promoting long term PPPs and relationships amongst Academia-Research-Industry-Government-Society, particularly in solution design for national problems.

(v) Inadequate deployment of public funds into private sector R&D units and private sector funds into the public funded research needs to be promoted to treat the entire knowledge domain in R&D in the country as one.

(vi) Potential benefits of affordable innovation created within the entire knowledge domain of R&D, combining private and public sector efforts as one, cannot be easily tapped under the current policies. The knowledge domain of the R&D sector under public and private sectors are considered as segregated compartments working independent of each other. A change in the policy paradigm for treating the entire R&D sector in the country as one and developing PPP's for R&D to promote public and social good should be developed as new strategies.

Plan Actions

1. Develop a holistic approach to funding socially relevant R&D in India in both private and public sectors as one continuum. Institute a new policy paradigm to treat the entire knowledge domain in R&D in the country as connected, specifically for investment of public funds into R&D for social and public goods and human capacity building. Public funds could thereby be deployed to catalyse R&D, facilitate networking and also create jobs for R&D personnel in the private sector.

2. Create a regulatory and policy environment to support application of indigenous R&D and technology developments.

3. Launch schemes to support R&D consortia for research in five major areas - agriculture and food security, water, energy, environment and affordable healthcare, with a commitment to open source models. Leverage the National Science and Engineering Research Board for servicing the programmes launched under PPP for R&D.

4. Enhance public funding of R&D and improve the policy environment for private sector engagement and investments into R&D. The technology cess funds, yet to be deployed and available with the Government could be leveraged as a catalyst to create a new work culture within the national R&D system. There should be provisions in the financial audit system for not treating honest and grand failures in R&D as negative developments. The fund can be employed towards:

(i) supporting world class R&D clusters through networking in specific fields (e.g. Singapore's success with Biopolis, which can be replicated, if successful).

(ii) creating a competitive grant system of Rs.1,000 crores for R&D in the private sector. The grant could leverage on the existing private sector R&D funding.

(iii) establishing a PPP fund (of about Rs. 5,000 crores), for innovations for inclusive growth, to be managed jointly by the private sector and the Government, for promoting R&D in defined areas of national importance/ projects that can have a national impact.

(iv) implementing a funded mission for affordable innovations for key public and social goods.

(v) making public investments in private sector venture funds for R&D and innovations.

(vi) support PPP activities like consortium formation, joint ventures, strategic alliances, technology licensing, start-up companies in academia, value-added reseller and collaborative R&D clusters etc.

5. Broaden the horizon for public sector R&D professionals to facilitate interactions with the private sector.

(i) implement policy changes that reward, recognise and incentivise public sector R&D professionals who patent their work, especially if the patents are commercialised.

(ii) institute processes to facilitate a seamless movement, networking and exchange of scientists between public and private R&D labs.

(iv) encourage entrepreneurship, especially among public sector scientists, through commercialisation grants, seed funding, incubation of technology and start-ups.

(v) motivate scientists in the public domain to focus on patentability and know-how confidentiality.

(vi) encourage private industry to create R&D-related jobs and create a pull factor for R&D professionals for high value employment.

6. Implement multiple mechanisms to encourage PPP like:

(i) establish a Technology Observatory / Technology Watch Group as a PPP.

(ii) provide for 1:1 investment of public and private sector funds in nationally important goals like industry-ready human resource, support for clinical trials. The private sector fund contribution can be treated as tax exempt.

(iii) establish a mechanism for identifying R&D targets for nationally important goals programmes, with oversight for regulatory processes which lead to creation of advanced technology based products with funding support under special PPP initiatives.

(iv) undertake a policy initiative to promote PPP's for leveraging India's R&D system for reduction of the national subsidy burden (e.g. fertilizers, energy etc).

(v) develop new relationship based participatory models for promoting interactions between private and public sectors at all stages of R&D.

(vi) making public investments into private sector venture fund for R&D and innovations under equity models.

(vii) strengthen ongoing alliance initiatives in PPP on R&D and clean energy, both on national and international levels.

7. To achieve the above goals, simultaneously commission a scoping study of best models globally, for developing a suitable country-specific model for promoting PPP's for R&D.

8. Industry chambers may be entrusted to take the lead to organise the consultation process and develop the vision and expectations of various stakeholders.

C. Entrepreneurship and Innovation

Context

National Science and Technology Entrepreneurship Development Board (NSTEDB) is the nodal body to nurture S&T based entrepreneurship in the country. NSTEDB has played a key role in establishment of Technology Business Incubators at over 50 select institutions during the last few years across the country in to promote innovations and entrepreneurship. Innovation and Entrepreneurship Development Centre, a new model for promoting innovation culture in academic institutions was initiated to support and mentor innovative project ideas by students in engineering colleges.

Opportunities for interaction and networking of incubation managers were provided both at the national and international levels. Global incubation forums were organised in India in association with World Bank in which opportunities for forging alliances and partnerships with incubation and entrepreneurship initiative with developing and developed countries were explored. New platforms for hand-holding were provided through the DST-Economic Times Power of Ideas, DST-Intel, DST-Lockheed Martin Innovation growth programs. To support start-ups, mechanism for seed support system was tried in select incubators. 'India Innovation Fund' in PPP mode has been set up to stimulate technology innovation through seed capital funding for opportunities in emerging technologies. Policy interventions through Ministry of Finance were made to get incubators and incubates exempted from service tax. Overall, a good foundation has been laid for promoting innovations and entrepreneurship in academic institutions.

Strategy

Innovation is the catalyst for growth in the 21st century global knowledge economy. Recognizing this, the Government of India has announced the current decade as the 'Decade of Innovation'. The National Knowledge Commission has also identified the role of innovation as one of the key factors in India's economic growth. A National Innovation Council has been established to promote innovation as a development tool.

India needs a country specific model for promotion of innovation. Whereas most global models are focused on process of innovation, Indian strength in developing affordable innovation addressing grass-root societal needs has to be articulated and fostered aggressively. Innovation ecosystem demands methods and mechanisms for risk management associated with entrepreneurship. Current practices and policies in government do not promote to the desirable extent demand for innovations, especially in the formal sector.

The creation of such innovation ecosystem would require both national consultation and international collaboration. Global Innovation and Technology Alliances with strategic partners should form an integrated approach. For building alliances and partnerships, India may need new structures and mechanisms to create an innovation system which enables indigenous methods for affordable innovations and benchmarking of global best practices for quality innovations for competitiveness will remain the key.

A paradigm shift in approach for the S&T sector would be required which focuses on an output directed development path strategy rather than the present input driven model for making a tangible and traceable change in the socio-economic scene of the country. While basic research would need necessarily an input-led growth path, differences in approach through output directed model would be required for connecting knowledge and wealth generating activities of the country. Supply side approach for promotion of advanced basic research should be further enabled with tools for demand-side planning for innovations and technology development enabled through seamless partnerships.

Approach

Academia - Industry Partnerships

Research sector in India would require conducive mechanisms of collaboration to be created for universities and industry bodies so that research output and innovations can be commercialized and transformed into marketable products and services for societal benefits.

The approach therefore should be to (i) encourage universities and R&D centers to focus expertise and resources on key industrial focus areas, (ii) encourage flow of knowledge created by universities and research establishments into industry, (iii) help universities create industry ready talent pools with practice relevant skills, (iv) develop and scale programmes and projects such as new research parks, that draw on and synergise complementary capacities within research institutes and the private sector and (v) utilize industry infrastructure for up-scaling of technologies.

Incentivizing R&D in Public and Private Sector

While public funded institutions are generating technology leads, their levels of utilization by commercial enterprises have been limited. There is therefore a need to create a vibrant landscape of Public-Private Partnership and an enabling framework for attracting investment from the industrial sector, both public and private sector into R&D system and incentivize the same for linking development with technology sector. This would include, (i) how to help create early 'trial' markets around national priorities and allow private firms to recoup investments in R&D (ii) how to help private companies access the best technical resources – increasing the chances of R&D success, reducing uncertainties, and incentivizing investment, (iii) how to help public and private sector companies to overcome risks in commercialization and value capture (iv) how to make regulatory frameworks less complex and more facilitative for technological innovations.

Improving the Flow of Technology

It is important that the development and results of affordable technology reach and positively affect the people at the bottom of the pyramid in the country. Currently, the technological innovations fail to be inclusive in nature. This is because these technological innovations tend to have a high R&D cost which has to be subsequently recovered when diffused in the economy which makes it unaffordable to the masses. India is in a unique position to mount a strong initiative for affordable innovations for technologies for social and public good by taking advantages of low expertise costs, vast talent base, and a large market. The proposed approach therefore would be to (i) engage multiple stakeholders and creating PPP to develop innovative business / engagement models to include all sections of the economy (ii) increase R&D penetration in the MSME sector by developing institutional linkages with R&D establishments (iii) address the immediate technological barriers in some important needs and priorities of the country by setting up Technology Missions, (iv) create mechanisms for flow of technologies from strategic sector to non-strategic sectors for social and public good applications and vice versa, and (v) enhance the involvement of State S&T agencies to translate the technological developments for local reach.

Promoting Collaborations through R&D Clusters

Collaborations can play a crucial role in stimulating innovations and fostering knowledge transfers which would foster interconnections that link intellectual, financial, human, and creative capital as well as unleash underutilized capital. Such enterprises could take the shape of physical or virtual clusters, which bring together research, business, risk capital, and creativity to turn ideas into products, processes, and services. In the Open Innovation Model, by using an "open source" and collaborative approach, organizations could expect to develop affordable products for the world which otherwise would not be a cost effective option for many organizations. Many clusters and collaborative initiatives to foster innovation have begun to operate in the country. Government needs to take appropriate steps to promote the growth of such collaborative initiatives, both in the physical and virtual domains.

Intellectual Property Rights Management

Management of Intellectual Property Rights (IPR) has become extremely important in the new knowledge economy with global competition. Adequate right on the intellectual property produced by an innovator enables to recoup their investments and make profits. Good national IPR systems also enable knowledge of technological advances to be accessible through the patent system to others who can build on them. Thus good IPR practices in turn spurs innovations.

To obtain both these benefits for innovation, India must improve its management of IPR. On one hand, the administrative machinery for IPR management must be considerably strengthened and professionalized, at the same time, India must engage with confidence in the evolution of international frameworks for improving IPR management. Holders of IPR have incentives to strengthen and extend their monopolies. However monopolies can also restrain competition and further innovation. New models of collaborative innovation are emerging, such as Open Source Drug Discovery - an Indian innovation, that reduce costs of innovation and increase its speed. Concepts of IPR will have to be developed to suit such new models of innovation in which, incidentally, India has great stakes because of their potential to produce 'frugal' innovations for inclusive growth. Therefore, as India aims to become amongst the global leaders in innovation, it will also have to devise an efficient IPR management system.

Platform for Best Practices and Innovations

Currently, there are many enterprises across the country which are delivering benefits to citizens and meeting the challenges of inclusion through innovative solutions. Often these go beyond the formal confines of R&D labs to include innovations in public service delivery or organizational innovations in local communities aimed at inclusion. However, there is no aggregated platform or single repository to collate, replicate and disseminate these best practices and ideas. Most of these workable solutions remain confined to their local contexts and don't achieve economies of scale because of the lack of a single platform for sharing these best practices among multiple stakeholders. Strengthening the innovation eco-system requires a platform for information sharing and dissemination to ensure improved access to knowledge and support in the form of resources, linkages, mentoring and outreach. Greater knowledge of innovations can stimulate their adoptions and adaptations on a large scale. This decentralized, open, and networked model would enable information sharing on innovations and collaboration among stakeholders on an unprecedented scale.

Supportive Financial System

Innovation requires a financial system which is supportive and inclusive and which provides the necessary risk capital to spur innovations and enterprises. Venture Funds are recognized globally as the most suitable form of providing risk capital for the growth of innovative technology and breakthrough ideas. While India is amongst the top recipients in Asia for Venture Funds and Private Equity Funds so far, these investments need to be focused on small early stage start-ups and not only into relatively large and 'safer' investments. To have a greater impact existing funding options, especially made available by the Government need to be increased. India's dependency on foreign VC/PE funds and almost no domestic venture capital needs to be addressed. Despite the growth in the VC industry in India and the complementary increase in government schemes, the seed funding stage continues to be severely hampered. Also, it is especially crucial to provide funding for stimulating innovations that will produce socially useful outcomes for poorer people and enterprises which are focused on delivering this. In light of this, the Indian innovation eco-system requires early stage funds acting as angel investors.

A dedicated fund, seeded by the Government and targeted at promoting innovative initiatives that focus on inclusive growth could play a crucial role. In addition, there is a need to take up policy initiatives for grants to private sector for undertaking R&D in public and social goods, establishment of test beds for indigenous technologies developed by public funded institutions and competitive grant system for States for innovative deployment of indigenous technologies through Centre-State partnerships.

Plan Actions

1. One of the key components during the 12th Plan period would be to take up some major policy level initiatives to strengthen innovation and entrepreneurship agenda across S&T system of the country. The policy imperatives should address and facilitate the following issues:

(a) seamless Public-Private Partnerships for promotion of Technology Business Incubators and innovation clusters in R&D institutions with industry association.

(b) supportive financial mechanisms for risk management - start-up/seed funds in private partnership.

(c) public investments in private equity funds for promoting grass root innovations.

(d) mechanisms for facilitating creation of start-ups by faculty and student innovators in academic institutions.

(e) efficient IPR management regime.

2. Expand the Technology Business Incubator (TBI) network substantially in the country through a competitive support model, participation of State governments, and appropriate Public-Public and Public-Private partnerships.

3. Add more academic institutions in the fold of Innovation and Entrepreneurship Development Centres (IEDC). Some of the IEDCs could eventually graduate to TBIs.

4. Establish Global Innovation Technology Alliances both through bi-lateral and multi-lateral engagements in priority areas like energy, nanotechnology, medical devices, water etc.

5. Set-up a number of new seed funds and start-up funds in tune with policy imperatives.

6. Create enabling platforms for spreading awareness and building an eco-system for innovation and entrepreneurship by partnering with private sector and media.

7. Micro-enterprise development program in the backward regions of the country implemented during the last Plan may be converted to innovation cluster development program.

8. Innovation clusters could be scaled up in consultation with the National Innovation Council. Through S&T interventions, a few potential clusters should be made globally competitive.

D. Partnership with States

Context

Technology and innovation form two established engines of growth in the global knowledge economy. For a balanced national economic growth, diffusion of technologies should form an integral part of the developmental agenda of various States in the country. Several technologies useful for public and social good are being developed in the S&T sector, but they do not reach adequate levels of application and deployment in the state levels. State-Center technology partnerships and interagency platforms for leveraging S&T

capacities of the country have been an area of need which requires vitalization.

Most states have not established suitable mechanisms for fuller utilization of technologies emanating from public funded research in the country. State Councils for Science and Technology in many states remain as weak links between the national science sector and the state governments. Allocation of states in their own budgets for science and technology remains relatively insignificant. State S&T Councils need to have effective interaction with development Departments, Panchayats and some active NGOs to take stock of local problems concerning health, environment, and traditional skills for S&T interventions.

State Science and Technology Program (SSTP) scheme of the Department of Science and Technology is focused on the objective of promotion of S&T at State level. Engagement of various states in research and development in the country however, has been relatively low. States have established State Science and Technology Councils, which are also supported by DST through a limited grant for meeting the cost of man power. Since the support received generally by these Councils are sub-critical, the prevailing Centre-State partnership on Science and Technology remains generally weak.

CII and some State Governments have established an arms-length entity through the Technology Deployment and Promotion Centers (TDC) to link indigenous technologies from the institutions to the industrial development in the states. These entities are mostly engaged in limited number of activities in selected states on account of their need to remain self-sufficient.

DST Initiatives

Primarily, the Department works through partnerships with various state governments as well as other ministries in the Central Government in linking science and technology to the socio-economic development processes. State Science and Technology Councils form the links between the Department and various state governments.

DST has provided catalytic core support to the State S&T councils in all the States to ensure requisite S&T capabilities for implementing State S&T programs. DST has initiated efforts for professional development of S&T manpower in State councils. National meets with several S&T councils and state Chief Secretaries were organized including interaction with the Scientific Advisory Council to Prime Minister and a brainstorming meeting of the Union S&T Minister with State S&T Ministers.

Through various state Science and Technology Councils, collaborative programs have been launched in several states during the Eleventh Five year Plan period. For the last two decades, efforts have also been made to promote entrepreneurship and innovation especially amongst persons with S&T background. Emphasis has also been laid as a strategy to leverage partnerships and build alliances for increasing the current level of penetration to more significant levels.

The Department has played a coordinating role in the preparation of technology compendium and portal enlisting the technologies available with DAE, DoS, MoES, DBT, DST, ICMR, ICAR and as well as CSIR. A new platform for developing a bank of technology assets available with the Government of India has been initiated. S&T partnerships with states are also beginning to develop with a view to promote the application of technologies by the states.

Nevertheless, the initiatives seeded by DST in engaging with the State S&T Councils have been sub-optimal as the potential to connect States with indigenous research and development systems for gainful deployment and absorption of technologies for societal impact is yet to be fully realised. State S&T councils remain subcritical also for want of funds and leadership support.

Strategies and Proposed Actions

1. Strengthen various State S&T Councils for their vertical growth and horizontal linkages with central scientific departments and agencies through proactive enrollment of the states into the R&D agenda of the country. Extend core support to establish professional S&T secretariat in all State S&T Councils with focus on strengthening S&T manpower in new and emerging areas relevant for developmental activities.

2. State S&T Councils should play a catalytic role in providing technology solutions to problems faced by the citizens of the State. This can be achieved by helping states to develop state specific S&T vision and people centric technology missions, thereby attracting states to make specific allocations for the S&T sector in the state budget.

3. A fundamental approach would be to connect States with indigenous research and development systems for gainful deployment and absorption of technologies for the good of the people. This can be achieved either by:

(i) strengthening the existing structures and mechanisms like State S&T Councils and State Technology Development and Promotion Centers or

(ii) establishing new mechanisms and entities for connecting intra mural technology development with central science agencies like DST, CSIR, DBT, DARE, DRDO, DAE and ISRO.

4. It is recognized that most States do not provide adequate resources for science and technology. Centrally sponsored schemes should be initiated for backing state-center technology partnerships to deliver defined deliverables and state specific goals leveraging state councils and other autonomous institutions in states for linking technologies for social and public good. Technology Compendium prepared recently can be made available to all State S&T Councils to elicit State support for implementation.

5. State Science and Technology Program (SSTP) scheme is focused on the objective of promotion of S&T at state level. There is a need to establish vibrant state-center technology partnerships with at least 5 states with state specific technology interventions in two selected districts in each state and assess the impact of technology interventions on per-capita income levels in the district. The programs should be enabled with required resources to undertake projects for proof of concepts on technologies of interest to their own states. It is important that a finite and critical level of funding support is extended for facilitating this.

6. Several technologies are being developed by research institutions under various central Departments. Some research laboratories do develop partnerships with the local institutions or the respective State Governments and work on specific projects to link technologies developed in their laboratories. However, this model does not often offer opportunity for penetration and holistic development on account of the absence of structured mechanisms. Translation of such technologies into products and services for use by states should be enabled by:

(i) extending test beds towards demonstration of pilot scale technologies;

(ii) instituting a technology transfer and deployment fund for delivering technologies to the states;

(iii) creating demand pool for technologies, establish a special competitive fund for states for absorption of indigenous technologies.

7. The State Councils should be encouraged to build state-centre partnerships in people centric technologies like (a) safe drinking water; (b) off-grid power generation; (c) decentralized solid waste management; (d) remunerative utilization of regional and local natural resources; and (e) E-governance tools.

8. Confederation of Indian Industries with the support of some State Industries Departments has established State level entities the Technology Development

Centers (TDC), to relate technologies from the public funded institutions to the users in the industry. Such TDC's are currently operational in limited number of States and they work in close collaboration with DST. Expansion and further strengthening of this mechanism through formal understanding with States and CII may be considered. This entity should be supported through a self-sustaining membership based service model. The R&D institutions developing technologies could use these entities as service providers in the States, where they are located.

9. An annual report of successful technology demonstrations in the States should be submitted by the State S&T Councils to the States and Ministry of Science and Technology. The State S&T Council Cell in the Department of Science and Technology in turn would submit annual reports of successful technology demonstrations to other State S&T Councils for possible replication of successful case studies and to the Planning Commission for providing State specific budget for replication of successful technologies and also to other socio-economic Ministries for possible replication under various Centrally Sponsored Schemes.

10. S&T partnerships could be formalized through MoU between States and the Ministry of Science and Technology. Standing committee can be constituted and facilitated through DST to monitor state-center ties in S&T on a periodic basis. These MoUs could be supported through mutually identified grants for technology utilization and States may have the option to select best technologies from the public funded bodies, through competitive models.

11. Ministry of Science and Technology could commission a knowledge institution to design, develop and maintain a continuously up-gradable technology portal with authorization for a nodal officer in each State to access the portal and establish a viable two-way partnership with all the scientific departments and agencies through the portal. The nodal officer in the State could also pose technology challenges to the scientific bodies to solve in a time bound manner through the portal mechanism. The information technology enabled technology portal could emerge as one of the most viable tools for building partnerships between States and Central Scientific Departments and Agencies. States could name an officer from that would remain connected to the portal for period of at least five years.

12. Similarly, "Bhuvan portal – Beta version", which is already hosted with lot of scientific inputs on natural resources with recent/current satellite images and vector thematic layers could serve as a one-stop-shop for respective States to utilise the same for better resource management purposes. The portal at present is providing services specific to land, water, ocean and weather which could further be strengthened with specific inputs from States.

E. S&T Partnership with other Socio-Economic Ministries

Context

DST in its roles and functions is charged with the responsibility of formulating on policies, coordination with other ministries and promotion of science and technology in the country. Accordingly, the cross departmental and cross functional roles of the Department are embedded in several programs and schemes. The Technology Policy Implementation Committee in the Planning Commission recommended setting up of Science and Technology Advisory Committee (STACs) in all socio-economic ministries with DST as the nodal agency to oversee the programs of STACs. A coordinating committee was set up within DST chaired by Secretary DST comprising of member secretaries of all STACs, with the following objectives:

- provide inter-disciplinary inputs in S&T programs of socio-economic ministries.
- exchange information on work of STACs in different ministries
- act as focal point evolving multi-partnership joint technology projects.
- organize interactive meets and undertake studies in the area of common interest.

S&T based societal interventions for promoting gender empowerment, applications of technologies for elderly, remunerative employment of tribal population and weaker segments of the society through technology led entrepreneurship are critical areas of national needs. Several Ministries are engaged in societal interventions relating to employment and empowerment through various schemes. The Department within its limited extension network of NGOs and other state agencies has been engaged in technology extension for societal interventions. Primarily, DST works through partnerships with various ministries in the central government as well as state governments in linking science and technology to the socio-economic development processes. Notable partnerships have been developed with the Ministry of Steel, Department of Heavy Industries, Department of Agriculture and Department of Drinking Water supply of Ministry of Rural Development of the Government of India.

An important milestone of STACs has been the initiation of several multi-partnership projects. DST, drawing from its strength in promotion of science and technology, set of guidelines for R&D funding support to emerging areas and tacit knowledge base of scientific and technical human resource base, sought participation of other ministries in funding of multi partnership Research Development and Demonstration (RD&D) projects in the areas of their concern. As there is large untapped potentials to set-up cross departmental and cross functional roles, the mechanism and strategy of STACs merits a revisit in order to make it more contemporary and impactful.

Ongoing Initiatives

The Department after review of the ongoing programs has taken a large number of new initiatives to enhance its cross departmental and cross functional roles in order to assume a horizontal function in building the inter-connections in a matrix management structure of the Governmental processes by working with other socio-economic ministries.

There exists an ongoing mechanism for mounting PAN-India R&D demonstration projects with other ministries called the Joint Technology Projects (JTP). Some Joint Technology Some major projects executed under STAC are Helium isotopic ratio as precursory signal to earthquakes; establishment of national facility for semi solid forming to produce Rheo-casting billets; study on clean coal initiative for coal washing to reduce the thresh- hold ash level; carbon recycling, capture and sequestration; agro-forestry etc.

Through the Technology Development Program, DST has played a catalytic role in initiating the STAC mechanism in 24 socio-economic ministries. Under this program proposals having "proof concept" are supported. This has carved a clearly identified niche role in technology development chain. One of the pre-requisites of the program is that sufficient R&D knowledge base should exist from which technology development efforts can be initiated. The notable achievements are: technology systems for water purification, arsenic removal; development and application of micro wave technologies for indigenous applications; development of ceramics, bio-molecular and optical sensors; technology for up-gradation of glass & ceramic industry, application of engineering techniques for value addition to traditional products; etc.

DST is currently developing establishment of test beds for proving convergent technology solutions to major national challenges in fertilizers, water, home land security, solar energy, decentralized power generation systems, etc. Some recent initiatives of relevance to the cross departmental and cross functional roles played by DST in these functions includes promoting the establishment of Test-bed for Potash fertilizers based on CSIR technology in association with the Ministry of Fertilizers; implementation of a Technology Mission “Winning, Augmentation and Renovation (WAR)” for water in different locations in the country etc.

The Department has also played a coordinating role in the preparation of technology compendium and portal enlisting the technologies available with DAE, DoS, MoES, DBT, DST, ICMR, ICAR and as well as CSIR. A new platform for developing of bank of technology assets available with the Government of India has been developed for use by both State governments and other central ministries. DST has also formed an alliance office with the

Ministry of Human Resources Development to bring in synergy between higher education and research activities in science and engineering.

Some other mechanisms available with the Department of Science & Technology for empowering cross functional roles and cross departmental functions are:

- Formation of a standing committee under the chair of Cabinet Secretary for linking technology to stake holders and states. In this role, DST has been assigned the task of coordinating with all the nine science departments of the country and play servicing functions in establishing linkages with other socio-economic ministries and states;
- Promote the establishment and development of test beds for proving convergent technology solutions to address national challenges in areas like fertilizers, water, homeland security, solar energy, distributed power generation systems, etc.;
- Cross departmental technology missions and programs like Core Automotive Research, Geo-spatial technology missions, National Bamboo Application Missions, Drug and Pharmaceutical Development Program, etc.;
- Providing innovation enabling platforms and creation of entities like Global Innovation and Technology Alliances with industrial partners. Establishment of Innovation funds with venture financing systems under PPP models for promoting innovation eco-system in the country;
- Joint centers under bilateral and multi-lateral S&T cooperation in select areas of national significance like clean energy research, etc.;
- Promotion of public-public partnerships between selected R&D institutions under the science ministries and R&D bodies under the socio-economic ministries of the Government of India for strengthening the nearly 700 R&D institutions in the country through internal networking;
- Special funding schemes to promote academy-research-industry partnerships for playing cross functional roles more effectively; and
- Coordination responsibilities for National Mission for Sustaining Himalayan Ecosystems and National Mission on Strategic Knowledge for Climate Change.

Plan Initiatives

(a) Strategy:

Strategic Plan approach of DST demands a more effective functioning in the cross departmental and cross functional roles through its repositioning. In order to play a more proactive role, changes in structure to deliver the S&T linkages demanded by the cross departmental and cross functional roles needs to be built into the system during the next Plan period by:

- Promoting the establishment and development of test beds for proving convergent technology solutions to address national challenges like energy, water, food, health, homeland security, transport & infrastructure, etc. through linkages with other line ministries with possible involvement of community based partnerships;
- Leverage mechanism of establishing alliance offices with other sister ministries for linking R&D outputs and more effectively promote synergistic programs;
- Creation of Technology Deployment Fund for co-investments into joint research programs with other ministries and sectoral industries; and
- Complementary participation through scientific and technological value addition in capacity building and institutional strengthening programs of other socio-economic ministries.
- Seek specific allocation of ~2% for R&D in the budget of different ministries that promote cross departmental coordination and investment into joint missions and PAN India programs.
- Adequate financial provisions for the PAN-INDIA programs in DST that can be taken up jointly in key sectors along with other ministries/departments under the STACs.

(b) Selections of challenges for cross Departmental Programs:

DST has addressed several challenges likely to be addressed in the 12th Five Year Plan. There will a possibility to align some of these schemes for better for cross departmental programs and linkages. These could be as follows:

- **Enhancing capacity for growth:** DST has proposed in its strategic Plan stimulation of investments of the private sector into R&D through policy initiatives and developing PPP models for the promotion of R&D. This would entail enhanced R&D infrastructure and nurturing capacity building across certain sectoral areas with opportunities for the involvement of various line ministries of the GOI. In particular, strengthening IT institutions in partnership with DIT, forensic sciences program with MHA etc.
- **Technology and Innovation:** DST will address the need for technology and affordable innovation for solving people centric needs. This should provide horizontal connectivity with socio-economic development programs of other ministries, as well as various State governments in areas like affordable health care & biomedical devises (Ministry of Health); portable water technologies (Ministry of Water Resources); technology development programs

(MSME, State governments); security and infrastructure development technologies (MHA, Railways, NHAI, Civil Aviation, Heavy Industries, Steel & Coal) etc.

- **Securing energy future for India:** DST has taken solar energy research initiative which aim to harness solar energy through innovative R&D breakthroughs and ingenuity in system integration that culminate in various options ranging from an incremental improvement to completely leapfrogging the existing state of art technology. This will feed into the major National Solar Mission of MNRE.
- **Improved access to quality education**: DST has addressed the challenge of manpower shortage in S&T sector and initiated several programs for strengthening education base of the country. In order to provide access to quality education, DST has established several centers of excellence in the country as one of the priorities of the next plan. Synergy between education and research can be best achieved through alliances built with MHRD.
- **Managing the environment**: The Department has been entrusted with responsibility co-coordinating two of the national missions launched under National Action Plan on Climate Change. They are the mission on strategic knowledge for climate change and mission on sustaining Himalayan ecosystem. Linkages with both MOES and MOEF will be possible through these missions.
- **Enhancing skill and faster generation of employment:** DST under its societal intervention programs has initiated several initiatives for the benefit of the disadvantaged sections of the society which will generate employment opportunities for the rural poor and disadvantaged. Cross cutting linkages with Ministries of Rural Development, Tribal Welfare and MSME can be established.

F. Science and Technology Communication

Context

The strength of a nation lies on the application of science and technology at the grass root level. India has an impressive infrastructure and contribution, particularly, in the realm of basic sciences. Despite the impressive economic growth of the country, social impact of such growth on different segments of the society is divergent. Similarly, the fruits of science and technology and its processes have not penetrated to all nook and corners of the country. The complexity of Indian culture and civilization, its diversity and ancient genesis of beliefs, rituals, practices and thought processes are at variance with modern concepts of science. As a result, many infirmities have crept into the society over the time and are widely practised. The political leadership was aware of this handicap and, therefore, the first Parliament of independent India adopted "Science Policy Resolution" making inculcation of "scientific temper" in the masses as a driving engine for social and economic transformation.

The National Council for Science and Technology Communication (NCSTC) was established in early 80s to accelerate the awareness about science and technology and inculcating scientific temper amongst the people and polity through various innovative modes including folk media, *Jathas*, development of scientific kits and modules, media - print and digital and newer systems of reaching out to the people.

DST Initiative

NCSTC had many challenges confronting it, including paucity of trained manpower, prevalent illiteracy among masses, barriers of languages and so on. It has to take science and technology to the people by employing various modes such as Jathas, radio/TV and direct communication in the language understood by the people and implemented training programs, awareness programmes, field projects etc. A lot of myths related to celestial events and day-to-day life are created and believed in society. Eclipses, super moon, Comet Hale-Bopp, transit of Mercury & Venus etc. were the occasions exploited well to communicate science behind such natural events demolishing the myths weaved around such events. During the "Year of Astronomy", training programmes were conducted to generate quality manpower and various field projects including competitions for children, observation camps, night sky watching etc. were supported. Number of training and awareness programmes were also conducted giving scientific explanations about so-called miracles. Mobile planetariums were put in service to popularize astronomy in many states including *Haryana, Orissa, Madhya Pradesh, Rajasthan* and *Uttarakhand* etc.

"Year of Planet Earth" was celebrated during the years 2007-09 to sensitize field level organizations & masses on issues such as weather and climate change, disaster preparedness, soil, water, map reading and resource optimization etc.

To excite and motivate children, to be inquisitive towards nature and S&T, Children's Science Congress, is organized for the age group of 10-17 years. Around a million children participate in this activity through various models, field work, predicting hypothesis etc. *Rashtriya Kishore Vaigyanik Sammelan,* various motivational/contact programs were launched for school students, *Agrasar* Lecture-cum-demonstration series were exclusively organized to boost scientific temper among students at primary and secondary level.

Demonstration and exhibitions are very effective means to reach to the people. "Science Express" was a very effective mobile exhibition which was visited by 65 Lakhs of students, teachers and general public.

The science of health & nutrition – particularly for women, were communicated through mediums such as community radio, R&D projects to tackle occupational health hazards for women.

To strengthen science teaching, NCSTC launched a program titled National Teachers' Science Congress. Workshops were conducted to develop modules, software, CDs and DVDs. Training and vacation camps were organized for improvised classroom teachings.

To strengthen innovative spirits, Indian Innovation Initiative is under implementation using the Public Private Partnership (PPP) model with Agilent Technologies Ltd., Department of Science & Technology and Confederation of Indian Industries (CII). Initiative for research and innovation in science wherein students participate on the merit of their research project, in international science fairs at United States and Netherlands.

In order to create quality manpower to enhance coverage of science and technology in various media, short & long term training programmes, long term courses such as Masters' Diploma, semester courses etc., including correspondence and online courses, were implemented in science communication.

Popular science magazines, periodicals including the half yearly research journal on science communication "Indian Journal of Science Communication" are brought out in Hindi and English.

To strengthen awareness, National Science Day is celebrated on February 28th, every year across the country. National and international conferences, seminars and workshops are supported exclusively on science and technology communication. NCSTC has instituted many Awards in various categories to recognize outstanding contribution in the field of S& T communication at national level. The prestigious UNESCO Kalinga Prize for popularization of science is also being supported partially. *Rajat Jayanti Vigyan Sancharak* Fellowships are offered to young science communicators to work with established ones to sharpen their skills.

Strategies and Proposed Action

1. Contribute to the public understanding of science at different age groups and social strata of people with the aim to popularize science and effectively use science as a vehicle for social enlightenment. Various contemporary tools such as conducting science congress, awareness programs, fostering science communication and popularization, publications and media campaigns, innovative exhibits & exhibitions, effective tools for science

teaching etc. may be employed to achieve the above goals. Communication of science and technology could entail the following components:

(i) Capacity building through national & international training, interaction meetings, demonstration through static and mobile exhibitions etc.

(ii) Field & survey based research projects.

(iii) Schemes for generation of awareness through brainstorming sessions, seminar, symposia and conferences, publication of journals/ magazines, software development and programs through radio & digital media etc.

(iv) Catalyzing and inspiring younger generation through visits of research and industrial establishments, to opt careers in science and technology.

(v) Celestial events for demystification and occasional issues of public interest.

(vi) Motivate our scientists for applying their knowledge and expertise to address problems of weaker communities in rural areas.

(vii) Strengthen existing institutions, field groups, science based voluntary organizations, etc. involved in research and application of grass root innovative S&T solutions.

(viii) Establishment of platforms for assessing and absorbing best scientific practices.

2. The programs should be oriented to address issues such as gender equity, health & nutrition for women & children, detection of adulteration in food stuff, water, sanitation and hygiene, promoting innovation in formal and non-formal sectors, initiating better appreciation of science and mathematics, good living programs, conservation of resources and sustainable development or issues of immediate concern to the society, and building educators and communicators in Science & Technology etc.

3. A substantial multi-disciplinary academic and practical contribution to the idea of ‘science for all’ has to be effectively propagated amongst our scientific fraternity. The skill to improve communicating abilities of our scientists and technologists in a manner which is understood and appreciated by the common man has to be inculcated as a part of the professional upbringing. To make the interaction two-way, forming a group of semi-experts that could act as mediators between scientists and laymen could be one strategy.

4. In order to ensure seamless flow of S&T knowledge from the Center of Excellence to the grass root workers – appropriate alliances and linkages

needs to be developed among national and international S&T organizations and governmental or non-governmental entity at village level. The agencies active at village level have limited capabilities which ought to be enhanced and it is only possible when a formal or non-formal alliance is established with the nearby academic institution such as Post Graduate colleges, state and central universities and national laboratories etc.

5. A new scheme with adequate scope and scaled for national level penetration of improved and inspired methods of hands-on science teaching needs to be designed, developed and commissioned during the 12^{th} Plan period. Initiation of a pilot scheme for “Building Educators for Science Teaching” (BEST) is a way forward.

6. Effective linkages with science popularization programs promoted by various State S&T Councils and the National Council for Science Museum (NCSM) of the Ministry of Culture should be mounted. This should be aimed to strengthen Planetariums, Science Centers & Museums, Science Cities, Ocenariums, etc. which have become a part of the social fabric in disseminating knowledge of S&T to the people in a non-formal and inclusive manner.

7. Means and methods to explore public - private partnership particularly in achieving the objectives under the Corporate Social Responsibilities (CSR) programs of various private companies could be used as an effective mechanism to promote the outreach of science, showcasing its relevance and benefits.

8. Linkages and alliances with governmental and non-governmental organizations abroad such as, National Aeronautics and Space Administration (NASA); Smithsonian Institute, United Nations Educational, Scientific and Cultural Organisation (UNESCO); South Asian Association for Regional Cooperation (SAARC); National Science Foundation (NSF), US; Max Plank Society, Germany; Smith Foundation Society and Deutshce Forschungsgemeinschaft, Germany (DFG) etc. will be established. India may establish donor and recipient relationship with a few Asian and African countries, wherever, there is a scope for initiating or strengthening S&T communication and popularization amongst people.

9. We may provide opportunities for participants from other countries in Children's Science Congress, and National Teachers' Science Congress. Science camps, bilateral workshops, conferences, exchange programs, lab visits etc. can be organized in collaboration. DST can establish fellowships, research grants, impart training to the S&T communicators from abroad and establish mechanism for the to and fro flow of knowledge, expertise and manpower.

10. Information and communication technology has made a significant impact on the life of common man in India. Information technology has become one of the key factors of economic growth and international competitiveness for our country. The use of IT as a powerful and pervasive media tool in promoting knowledge oriented reforms should be effectively employed to propagate the potential and understanding of science and technology to the people of the country. Digital library, information kiosks, multi-media kits, tele-linkages, broad band highway, video-conferencing, mobile phones, etc. needs to be further exploited as effective vehicles of outreach.

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