Report of
The Steering Committee
on
Science and Technology
for
Eleventh Five Year Plan
(2007-12)

सत्यमेव जयते

Government of India
Planning Commission
December, 2006

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Planning Commission
December, 2006

Office of the Principal Scientific Adviser to the Government of India
Vigyan Bhawan Annexe, Maulana Azad Road, New Delhi-110 011

C O N T E N T S

Chapter	Description	Page No.
	Executive Summary	1
	Annexure	i-iv
1	Approach to S&T During Eleventh Five Year Plan	7
2	Policy Issues	13
3	Financial Aspects	27
	■ Proposed Plan Allocation: Central S&T Departments / Agencies	60
4	Review and Assessment of the Eleventh Five Year Plan of Central S&T Departments / Agencies	61
	■ Department of Atomic Energy (R&D Sector)	62
	■ Department of Biotechnology	68
	■ Ministry of Earth Sciences	71
	■ Department of Scientific and Industrial Research (DSIR) including Council of Scientific and Industrial Research (CSIR)	76
	■ Department of Space	81
	■ Department of Science and Technology	82
5	Attracting Young People to Careers in Science and Retaining them there	89
6	Basic Research	95
7	Mega Science Projects	103
8	Cross-Disciplinary Technology Areas	111

9	Leveraging International Collaborative Inputs	123
10	Academia Industry Interaction	127
11	Science & Technology for Small & Medium Enterprises	135
12	Rural Technology Delivery	137
13	S&T in States and Socio-Economic Ministries	141
14	Eleventh Five Year Plan Programme - Atomic Energy (R&D Sector)	145
15	Eleventh Five Year Plan Programme - Department of Biotechnology	153
16	Eleventh Five Year Plan Programme - Ministry of Earth Sciences	159
17	Eleventh Five Year Plan Programme - Department of Scientific and Industrial Research (DSIR) including CSIR	169
18	Eleventh Five Year Plan Programme – Department of Space	181
19	Eleventh Five Year Plan Programme - Department of Science and Technology	185

Annexure

No. 12018/72/2005-S&T
Government of India
Planning Commission

Yojana Bhawan,
Sansad Marg,
New Delhi-110001.

Dated: 21.02.2006

OFFICE MEMORANDUM

Subject: Constitution of Steering Committee on Science and Technology for the Formulation of the XI[th] Five Year Plan (2007-2012).

In the context of the formulation of the XI[th] Five Year Plan (2007-2012) for the Science and Technology Sector, it has been decided to constitute a Steering Committee on Science and Technology under the Chairmanship of Dr. R. Chidambaram, Principal Scientific Adviser (PSA) to the Government of India. The composition and the terms of reference of the Steering Committee would be as follows:

I Composition

1.	Dr. R. Chidambaram, Principal Scientific Adviser to GOI	-	Chairman
2.	Prof. V.L. Chopra, Member, Planning Commission	-	Co-Chairman
3.	Dr. Anil Kakodkar, Secretary, Department of Atomic Energy	-	Member
4.	Dr. G. Madhavan Nair, Secretary, Department of Space	-	Member
5.	Dr. V.S. Ramamurthy, Secretary, D/O Science and Technology	-	Member
6.	Dr. R.A. Mashelkar, Secretary, D/O Scientific and Industrial Research	-	Member
7.	Dr. M.K. Bhan, Secretary, Department of Biotechnology	-	Member
8.	Dr. P.S. Goel, Secretary, Department of Ocean Development	-	Member
9.	Shri M. Natarajan, Secretary, DRDO & Scientific Adviser to RM	-	Member
10.	Dr. N.K. Ganguly, Director General, ICMR	-	Member
11.	Dr. Mangala Rai, Director General, ICAR	-	Member
12.	President, Indian National Science Academy	-	Member
13.	President, National Academy of Sciences,	-	Member
14.	President, Indian Academy of Sciences	-	Member

15.	President, Indian National Academy of Engineering	-	Member
16.	Prof. P. Balram, Director, Indian Institute of Science, Bangalore	-	Member
17.	Chairman, University Grants Commission	-	Member
18.	Prof. Deepak Pental, Vice Chancellor, University of Delhi	-	Member
19.	Prof. M.S. Ananth, Director, Indian Institute of Technology, Chennai	-	Member
20.	Prof. P. Venkatarangan, Vice Chancellor, Amrita Vidyapeeth, Coimbatore	-	Member
21.	Dr. A.E. Muthunayagam, Executive Vice President, Kerala State S&T Council	-	Member
22.	Dr. V. Sumantran, Ex-Executive Director, Tata Motors Limited	-	Member
23.	Dr. Kiran Majumdar Shaw, CMD, Biocon Ltd.	-	Member
24.	Prof. (Ms) Rohini Madhusudan Godbole, Centre for Theoretical Studies, IISc, Bangalore	-	Member
25.	Prof. M.V.S Valiathan, National Professor, Manipal Academy of Higher Education, Manipal	-	Member
26.	Dr. M.S. Bamji, Emertius Scientist, Dangori Charitable Trust, Hyderabad	-	Member
27.	Dr. Sudha Nair, Director, MS Swaminathan Foundation, Chennai	-	Member
28.	Dr. Indira Nath, INSA Senior Scientist.	-	Member
29.	President, CII	-	Member
30.	Prof. Anand Patwardhan, Executive Director, TIFAC	-	Member
31.	Dr. S.K. Sikka, Scientific Secretary to PSA to GOI	-	Member Secretary
32.	Dr. S. Chatterjee, Senior Scientist, Office of PSA to GOI	-	Convener

II Terms of Reference

1. To evolve a vision and develop an approach for Science and Technology for the XIth Five Year Plan in the light of global developments and our country's needs.
2. To make an analytical assessment (SWOT) of the performance of schemes / programmes pursued by Central S&T Departments.
3. To identify thrust areas for the XIth Five Year Plan and suggest their *inter-se* priorities.
4. To suggest ways by which inter-agency and inter-institutional collaborations are leveraged for higher efficiencies and better outcomes.

5. To suggest means of catalyzing Industry-Academia collaborations for development, application and flow of technologies from lab to the market place and for the industry to invest more in strengthening national level S&T infrastructure.

6. To recommend strategies for developing high quality S&T human resource including attracting the bright to a rewarding career in science.

7. To suggest strategies for expanding and strengthening societal applications of technologies for improving the quality of life of the Indian population.

8. To suggest measures for kindling innovative spirit so that scientists translate R&D leads into scalable technologies which yield wealth generating products and processes.

9. To identify areas of international S&T cooperation / collaboration and setting up of world class R&D facilities in the country with participation from other countries.

10. To suggest parameters for scientific audit and performance measurement of scientists and scientific institutions to inject efficiencies and maximize impacts.

11. To suggest plans and programmes for the various Central S&T Departments based on the policy, vision, approach, thrust and priorities of the S&T Sector. These should take into consideration the concept of Zero-based budgeting, convergence of ongoing schemes, weeding out of the schemes which are no-longer relevant and completion of ongoing schemes on a priority basis. To suggest an optimum outlay for the S&T sector, comprising of the on-going commitment and new programmes proposed to be undertaken.

III. The Chairman may constitute Working Groups / Sub-groups as considered necessary and co-opt members for specific inputs.

IV. The expenditure on TA / DA in connection with the meetings of the Steering Committee in respect of the official members will be borne by their respective Ministry / Department. However, in the case of non-official members, they will be entitled for TA / DA as admissible to Grade-I Officials of the Government of India and the expenditure in this regard would be met by the Planning Commission.

V. The Secretariat support for the Steering Committee meetings would be provided by the Office of the PSA / Technology Information, Forecasting and Assessment Council (TIFAC).

VI. The Steering Committee would submit its report before 31st August, 2006.

(R. Sridharan)
Joint Secretary to the Government of India

Copy forwarded to:

1. Chairman, Co-Chairman and all Members, Member-Secretary and Convener of the Steering Committee
2. PS to Deputy Chairman, Planning Commission
3. PS to Minister of State (Planning)
4. PS to all Members, Planning Commission
5. PS to Member-Secretary, Planning Commission
6. Ministry of Finance (Plan Finance)
7. All Principal Advisers / Advisers / HODs, Planning Commission
8. Director(PC), Planning Commission
9. Administration (General-I) and (General –II), Planning Commission
10. Accounts-I Branch, Planning Commission
11. Information Officer, Planning Commission
12. Library, Planning Commission
13. PS to Joint Secretary, Planning Commission.

(R. Sridharan)
Joint Secretary to the Government of India

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16. PS to Minister of State (Planning)
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18. PS to Member-Secretary, Planning Commission
19. Ministry of Finance (Plan Finance)
20. All Principal Advisers / Advisers / HODs, Planning Commission
21. Director(PC), Planning Commission
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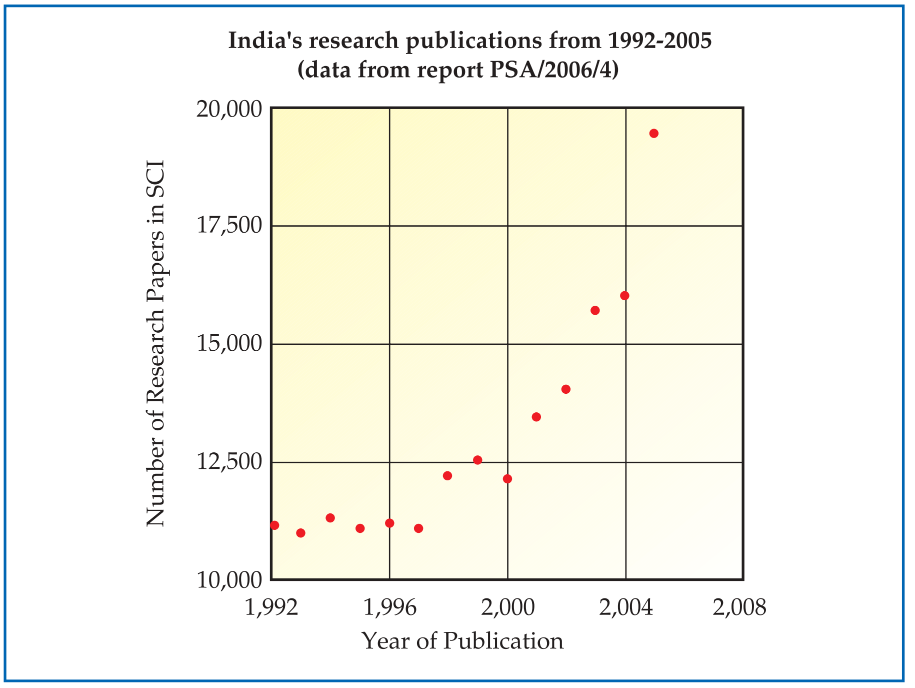
23. Accounts-I Branch, Planning Commission
24. Information Officer, Planning Commission
25. Library, Planning Commission
26. PS to Joint Secretary, Planning Commission.

(R. Sridharan)
Joint Secretary to the Government of India

Executive Summary

A steering Committee on Science & Technology was constituted in February 2006 by the Planning Commission under the Chairmanship of Dr. R. Chidambaram, Principal Scientific Adviser to Government of India with Prof. V.L. Chopra, Member, Planning Commission as Co-Chairman to evolve an Approach on S&T for the XIth Five Year Plan and to suggest plans and programmes of the S&T sector. The copy of notification is at ***Annexure***. The Steering Committee further constituted 17 Working Groups, 6 of which are for the Central S&T Departments / Agencies and the remaining 11 were for specific areas: Attracting young people to careers in science; Thrust areas in basic sciences; Mega science projects; Cross disciplinary technology areas; International collaboration; Academia industry interaction; S&T for SMEs; Rural technology delivery; S&T for socio-economic ministries; Policies and administrative reforms and resources for the S&T sector in the XIth Plan. As may be seen, the Working Groups have been constituted to look at specific areas of concern in the S&T sector of the country (see Chapter 1 of this report). Intensive discussions of the Working Groups have resulted in very specific recommendations, which have been appropriately included in the report (see Chapters 5 to 19). The full report of each Working Group is being sent to the Planning Commission separately.

The mission mode agencies, central and state S&T ministries / departments, national laboratories and R&D institutions have made many significant achievements during the Xth Plan (see Chapter 4). A brief mention is only made here of some major ones. A new Ministry of Earth Sciences has been formed recently to concentrate on programmes related to earth and atmospheric sciences. DAE successfully commissioned two 540 MWe indigenously designed PHWRs at Tarapur, a major landmark in the development of PHWR technology. First light was also obtained from Indus-2 synchrotron in 2005. A countrywide environmental radiation monitoring network called Indian Environmental Radiation Monitoring Network (IERMON) with 37 monitoring stations across the country has been set up. DBT established a “Board for Bioresources Conservation and Utilization”, and introduced public private-partnership schemes such as Small Business Innovative Research Initiative (SBIRI) and Biotechnology Parks in collaboration with State Governments. After the devastating tsunami that hit the southern states, Department of Ocean Development has set up an interim early tsunami & storm surge warning system. Ocean observation network has also been strengthened by deployment of state-of-the-art technology data buoys and Argo floats. Maiden flight of SARAS, a multi-role civilian aircraft, was a landmark achievement of CSIR. CSIR operated a New Millennium Indian Technology Leadership Initiative (NMITLI) scheme considered to be India’s largest public private partnership R&D programme. Under the scheme 42 projects were undertaken involving 65 industrial partners and 222 research groups in the attempt to capture global technology leadership position and development of technology through consortia of the "best" academic / R&D and industrial partners. Operationalisation of GSLV, development and qualification of indigenous cryogenic engine, establishment of the state-of-art second launch pad facilities at Sriharikota and operationalisation of KALPANA (Metsat-1), Resourcesat-1 and Cartosat-1 / HAMSAT by PSLV, augmentation of INSAT system with INSAT-3A, 3E, GSAT-2, EDUSAT and INSAT-4A satellites are some of the important achievements of the Department of Space. DST started the Nano Science and Technology Initiative (NSTI) to support research in the field of Nano Science and Technology. *FIST (Fund for Improvement of S&T Infrastructure in Higher Educational Institutions) and SAIF (Sophisticated Analytical Instrument Facilities)* schemes have helped a large number of scientific institutions / science, engineering and medical departments in universities / colleges to improve their infrastructure and their laboratory facilities for teaching. A novel programme support has been provided to women scientists to re-enter mainstream research after break / s in their career due to family responsibilities. All the departments have reported a growth in the number of papers published in peer-reviewed journals. This has contributed to the increasing trend in the total number of research publications (one of the measures of progress of science) from India in the Xth Plan as shown in the figure below (data have been taken from the report of the Office of Principal Scientific Adviser (PSA / 2006 / 4) "Measures of Progress of Science in India-An Analysis of the Publication output In Science and Technology" prepared by NISTADS). Similarly patenting activity has also picked up, especially in CSIR (for details, one may see the report PSA / 2006 / 1 on "Indian Patenting Activity in International and Domestic Patent System", again prepared by NISTADS).



During the XIth Plan, many of such successful programmes would be expanded further and vigorously pursued. Additionally, new and challenging areas of research and important new programmes / projects have been identified by agencies / departments concerned. DAE proposes to provide R&D support to continually improve capacity utilization, environment & safety and economic competitiveness and also to upgrade technology based on latest developments in the entire PHWR fuel cycle. Fast Breeder Reactors (FBRs) are to be set up backed by reprocessing plants and plutonium-based fuel fabrication plants. A 500 MWe fast breeder reactor (FBR), the first indigenous reactor in the series of FBRs, is already under construction. They are also essential for establishing use of thorium on a large scale in the next stage of our nuclear power programme. DBT proposes a major initiative towards human resource development and promotion of SMEs in the biotechnology sector. New institutions are also proposed to take up focussed and specialised research in areas such as stem cell, animal biotechnology, plant health, etc. CSIR is proposing CSIR-University R&D centres for excellence where universities would have access to state-of-art infrastructure and expertise available in various CSIR laboratories to enable universities to generate quality manpower in frontier areas of S&T. CSIR would set up programmes for "open source drug discovery" through national and international collaborations involving national laboratories and academia. Department of Space plans to complete the development of GSLV Mk III capable of launching 4T class INSAT satellite and operationalise the vehicle. Disaster Management Support System will be a vital area of space application during this plan. Demonstration flights of Reusable Launch Vehicle and development of Critical technologies for Manned Mission are also to be taken up. Department of Ocean Development is proposing setting up of an Advanced Research Centre for Drugs from Ocean. Demonstration of Ideal Coastal Protection Measures, Coastal circulation, Ecosystem modeling, Marine Ecotoxicology, Carbon cycling in coastal waters and preparation of Coastal Risk Atlas would be other critical activities of the department. Restructuring of NCMRWF and also IITM has also been suggested. DST is planning new initiatives in the areas of security technologies, safe drinking water, and has proposed establishment of a National Foundation for Technology for Rural Enterprises and Employment.

Apart from the programmes of the 6 scientific departments, the other working groups have made far- reaching recommendations relating to initiatives that are needed to address some immediate and also long term issues relating to nurturing scientific and technological research and development. Massive revitalization of the university system, expanding post graduate and Ph.D level programmes in select institutions and bringing these up to global standards, assured careers to talented young students who opt to remain in science, collaborative programmes between colleges / universities and proximate national laboratories for sharing of infrastructure and also faculty support are proposed primarily to develop highest quality human resource and simultaneously improve the standards of the institutions. Funds are proposed to be allocated for improvement of Indus-2 synchrotron and for preparing a DPR for the next synchrotron source. A number of large or mega science research projects have been proposed. These include projects with international collaboration as well. Many of these projects cut across a number of departments and cover more that one disciplines. Managing these programmes would require a different system than what has been practiced so far.

India is too big a country to absent itself from any field of Science and Technology. Recognizing that basic research is the foundation on which all technologies stand, that basic research is also a cultural necessity in any civilized country and that scientists must have the freedom to work on important problems of their choice, support to basic research will have to be substantially stepped up. Some of the current 'exciting' areas of basic research are often, though not always, 'directed' by the interests of the industries in the developed countries or their strategic interests. We must also remember that what is "directed basic research" for the developed countries inevitably become a frontier area of 'basic research' for us, if we want to publish in front-line journals. We must be in these areas because usually they also involve excellent science and perhaps also help Indian technology in the longer term. We should also select areas of 'directed basic research' in an Indian perspective. The approach could be from the side of societal interest or from the side of industry interest. The concept of "*Directed Basic Research*" has been elaborated upon to ensure that basic research is taken up in areas of manifested needs of national importance.

A new approach has been suggested for international collaborative programmes to ensure that national priorities are taken care of. In academia- industry interaction the successful examples of consortia R&D projects promoted by CSIR (i.e. NMITLI) and in the Automotive Sector (through the office of PSA) need to be standardized as models for replication in other sectors. The Committee recognized that many science and technology areas are increasingly becoming cross- disciplinary in nature requiring specialized inputs from a large number of departments / ministries / agencies. A few such areas have been identified and specific allocations recommended. The Committee also felt that new and emerging areas are likely to come up continuously in the future which would need support during the plan period and a block grant has been suggested to cover this purpose. In spite of concerted efforts, successful rural enterprises based on state of art technologies are rare. It has therefore been proposed to set up Rural Technology Delivery Centres involving voluntary organizations and also support demonstration models of rural enterprises based on availability of local resources.

The recommendations relating to Policies cover a wide range of issues. The Committee strongly felt that the suggested new and innovative programmes could only be effectively implemented if adequate reforms are introduced in the administrative system particularly relating to the governance of the S&T sector. Scientific Departments have to be treated differently in administrative matters. The recommendations already made by SAC-C and SAC-PM should be implemented.

Specific suggestions have been made on involvement of women in science, reducing bureaucracy in S&T administration, bringing in more flexibility in functioning of institutions, mobility of scientists, funding mechanism, etc. For multi-sectoral programmes involving more than one ministry / department, a mechanism of Oversight Committees has been suggested to synergise the inputs from various partners / stakeholders and also effectively monitor the progress of implementation of such projects. Such Oversight Committees would be applicable in programmes such as Desalination, Health Care Technologies, Advanced Computing, Security Technologies, etc. Such Committees with domain experts would also be needed in basic research areas like photonics and cyber security. It has also been recognized that new areas of research could suddenly emerge which may have to be addressed rather quickly and accordingly a mechanism has been suggested in the form of Standing Committees, particularly in the areas of Basic Sciences and Cross-Disciplinary Technology Areas. These Committees will have a specific mandate to identify emerging areas and suggest new programmes of research as appropriate.

The Steering Committee also endorsed the proposal regarding the setting up of a "National Science and Technology Commission" contained in the XIth Plan approach paper of the Planning Commission. It will be responsible for all matters relating to S&T in the country: administrative, financial, scientific and scientific audit, etc. It will evolve S&T policy for India and managerial structure in the Science Departments. It will also plan a model for deployment of resources.

Regarding budgetary allocations (see Chapter 3), the scientific departments have asked for increases for continuation of ongoing programmes as well as initiating new ones. Funds have also been asked for setting up new mechanisms of funding the research activities, creating new institutions, etc. Additional allocations have also been suggested programme- wise to cover the new initiatives proposed particularly in the areas of basic sciences, mega science projects and cross- disciplinary technologies, for the nodal ministries / departments. If all these allocations are agreed to, it will take India very near to the target of 2% expenditure of GDP on S&T.

1

Approach to S&T During Eleventh Five Year Plan

1.1 The XI^{th} Plan approach paper highlights the objectives and challenges for achieving a broad based higher economic growth rate in agriculture, industry and services, as also the initiatives needed to be taken for a more inclusive development that includes better health, clean drinking water, rural infrastructure, etc.

Twenty first century marks the beginning of the knowledge era. Major scientific discoveries in quick succession, new technologies arising out of these discoveries, a range of products and services based on these technologies, a technology driven economy across the world, all characterize this knowledge era. Scientific knowledge and expertise, high technology industrial infrastructure and skilled work force are the currencies of the knowledge era. Following sustained efforts over more than five decades since independence and a more focused thrust during the X^{th} Five Year Plan period in higher education, scientific research, and technology development, the country has now attained a recognized potential to emerge as a Global / major player in the knowledge era. The XI^{th} Five Year Plan needs to focus on enlarging the pool of scientific manpower and strengthening the S&T infrastructure and converting this potential into reality, pushing India into the knowledge era as a global player and raising the Indian economy to the level of developed nations. India will certainly become a "Developed Country" sooner or later, and sooner rather than later if we use 'technology foresight' to make the right technology choices and introduce 'coherent synergy' in our S&T efforts. Technology Foresight helps in the selection of critical technologies for development at any point of time. India is a large country and its technology requirements also correspondingly span a wide range from nuclear to rural. It has to continue to develop strategic technologies- nuclear, space and defence related. Technologies related to energy security, food and nutritional security, health and water security, environmental security, advanced manufacturing and processing, advanced materials, etc., are all important for us. So are the so-called "knowledge-based" technologies (Information Technology, particularly hardware; Nanotechnology, particularly Nanoelectronics; Biotechnology; and convergence of these technologies like Nanobiotechnology for drug delivery.

India must try to become ***"Global Innovation Leader"*** across the board in all S&T areas. A part of the innovation ecosystem is courage to take risks on the part of the scientist and support of risk taking by the S&T system. Greater the innovation, higher is the risk in converting it into a marketable product or process. A strong and vibrant innovation ecosystem requires an education system, which nurtures creativity; an R&D culture and value system which supports both basic research and applied research and technology development; an industry culture which is keen to interact with academia; a bureaucracy which is supportive; a policy framework which encourages young people to enter into scientific careers; and an ability to scan scientific developments in the world and to use technology foresight to select critical technologies in a national perspective.

In our approach to prepare the S&T plan for the next five years, appropriate projections, programmes and implementation strategies have been made in order to address the important issues mentioned above.

1.2 Attracting Young People to Careers in Science

There has been a growing concern that many talented and bright young persons in India do not opt for a career in science. At the 2005 Indian Science Congress, the Prime Minister Manmohan Singh had observed: "I am concerned by the fact that our best minds are not turning to science, and those who do, do not remain in science." It is felt that if this trend is not checked at this stage, India will face a serious shortage of talented researchers and teachers in a few years and symptoms are already visible.

A whole range of interventions are needed spanning from reforms in the educational institutions to revision of syllabus to designing integrated courses in science to offering assured career options at 10+2 stage. Many suggestions/ recommendations are already with the Government and some are under implementation. However, a consolidated list of recommendations is being made for taking up holistic corrective measures during the XIth Plan. Priority needs to be given to restructure the scientific research and higher education in the universities. The university system underwent a steady overall decline for almost three decades, beginning with the 1960s, though the last decade has seen many commendable initiatives by the UGC to revamp the system. The time is now ripe to complement these efforts with massive new inputs to revitalize the universities. One of the key suggestions is the "15-year Career Support Programme". This scheme suggests selecting brightest of the students at 10+2 stage and providing them support through scholarships/ fellowships till they complete their Ph.D and then guarantee a job for at least 5 years afterwards. The scheme also proposes a number of very attractive incentives along with the assured support.

1.3 Basic and Directed Basic Research

India is too big a country to absent itself from any field of Science and Technology. Recognizing that basic research is the foundation on which all technologies stand, that basic research is also a cultural necessity in any civilized country and that scientists must have the freedom to work on important problems of their choice, support to basic research will have to be substantially stepped up. Some of the current 'exciting' areas of basic research are often, though not always, 'directed' by the interests of the industries in the developed countries or their strategic interests. We must also remember that what is "directed basic research" for the developed countries inevitably become a frontier area of 'basic research' for us, if we want to publish in front-line journals. We must be in these areas because usually they also involve excellent science and perhaps also help Indian technology in the longer term. We should also select areas of 'directed basic research' in an Indian perspective. The approach could be from the side of societal interest or from the side of industry interest.

The culture gap that exists between the practitioners of basic research on the one hand and applied research and product development on the other (this gap also exists, though to a lesser extent, even in already developed countries) could be closed through 'directed basic research' and 'pre-competitive applied research'. In its execution, and in the requirement of no other deliverables than knowledge generation, 'directed basic research' is no different from 'self-directed' basic research. So the university academics should be comfortable with this kind of research. Sustainable economic development in the future requires strong and increased funding of basic research. While directed basic research should be encouraged, self-directed basic research should also receive substantially increased support.

1.4 Mega Science Projects

These projects would be very large in terms of outlays or the complexity involved. Thus a user group, institution or even individual countries would need to join hands with other similarly interested groups. Implementation of such projects would involve multi-institutional teams, including possible international collaboration. The projects should also be such that they appeal to the scientific curiosity of the researchers in search of answers to some of the important questions facing the world of science, and should be of interest to a large scientific community from various research groups within the country and outside. Such projects, both national and international are likely to increase in the future and multi-institutional / agency collaborative programmes have been proposed.

1.5 Cross-Disciplinary Technology Areas

Modern technology development is increasingly becoming dependent on research inputs from a large number of disciplines. A seamless and multi-sectoral flow of technologies and inputs from scientists and engineers from various disciplines is essential for making a visible societal impact and economic prosperity. The R&D being pursued in S&T departments and mission programs, which have followed a multidisciplinary approach, have contributed to our self-reliance in strategic sectors. In addition, there exists a strong scientific and technological base, spread over various academic institutions, R&D laboratories and industries that can be leveraged for the economic prosperity of the nation. Efforts have to be made to identify those S&T areas, cutting across the traditional divides of sciences, engineering and medicine, where investments can pay rich dividends.

Working in cross-disciplinary technology areas is about inculcating the culture of translating the scientific knowledge to practical gains. Towards this, there is a need for building the interfaces amongst Academia, R&D laboratories and industries to create an environment for innovation and invention. This calls for adequate infrastructure for focused R&D, as also establishment of methodologies for financing innovation in the early stage of technology development.

1.6 Leveraging International Collaboration

In today's world, self-reliance does not mean avoidance of international scientific and technological cooperation. In fact, the latter is a must and today's India must take and must give in equal measure in international cooperation. That is India must go for international cooperation on an 'equal partner' basis and must also participate in international 'mega-science' projects. In the nuclear field, for example, India needs the world in the short term, but there is no doubt that the world will need India in the long term. To make international cooperation maximally effective- rather than starting *ab initio* every time, we must supplement already allocated resources with international co-operation. A great deal of effort is involved in selecting important scientific and technological areas and later further efforts are made to select the groups which are to be supported through projects. International cooperation should be used to leverage these projects selected in a national perspective. There could, of course, be some exceptions where new activities / initiatives based on bilateral or multi-lateral cooperation may be called for.

1.7 Academia Industry Interaction

We have success stories in Atomic Energy, Space, CSIR, etc. – the outcomes of successful interactions between academia (including both the university system and the national laboratory system) and industry. However, the driving force for these interactions came from mission-oriented agencies. Can we have a similarly strong academia–industry interaction when the driving force has to come from the industry? The mindset problem in scientists and industry leaders, which has prevented this from happening in significant measure in the past, is changing in the current liberalized environment. Technology transfer from abroad is becoming more and more difficult because foreign companies can set up industries here and are, therefore, less willing to share technologies. Secondly, Indian companies are becoming more and more globally competitive. Even in joint ventures, the foreign companies are trying to buy out the Indian partners! Indian industry in the future will, therefore, have no option but to invest more and more in Indian R&D for new technology development. If industry begins to interact actively with academia, it can also play a greater role in guiding academic activities in the direction of industry interests, be it human resource development, R&D prioritization, or the choice of areas of international co-operation.

1.8 Rural Technology Delivery

The issue of effective rural technology delivery has been widely discussed over the years and at various levels in Government, research institutions, universities, and also among voluntary organizations. In spite of a great deal of rural development-related technology efforts, their impact, particularly in the non-farm sector, has not been very significant. Experience with much of past technology transfer has shown that often technologies developed in laboratories but not tested and proven under field conditions were disseminated on a large scale with naturally poor results, non-acceptance by intended beneficiaries, under-performance and unsuitability for rural conditions. Subjective preferences of developmental agencies, research laboratories and even NGOs had on many occasions been allowed to prevail over the needs of the target population. Experiences of successes, and more importantly of failure, have been poorly documented and inadequately shared among stakeholders leading to unnecessary repetition, infructuous expenditure and considerable de-motivation among both technology providers and users. It needs to be realized that active scientists are not the best people for grassroots technological intervention. This is because they are busy in their own areas of research and development. However, if some voluntary organization or a government agency has recognized a problem in a rural area and implemented a technological solution up to a point, the higher-level R&D institutions and universities can carry it further. Keeping these issues in view, some very specific suggestions have been made to initiate a programme "S&T for Rural Industrialisation, Development & Employment (STRIDE)" involving voluntary organizations, R&D institutions and a few government departments. The objective is to demonstrate in adequate numbers replicable models of rural production centres based on locally available resource and skill set. It is also proposed to set up 5 Technology Delivery Centres with S&T voluntary organizations to demonstrate a model of technology transfer mechanism in rural areas.

1.9 Policy Issues

For effective implementation of the recommendations made by the Steering Committee covering the important issues mentioned above, policy support would be essential in terms of greater accountability, administrative support, flexibility and in many cases systemic changes. There have been many a recommendation made to the government on organizational and administrative reforms for optimal use of S&T resources and these are under consideration. Additionally, a number of new policy issues have been identified covering a very broad span of areas such as animal experiments, women in science, cyber infrastructure for S&T, encouraging S&T based entrepreneurs, mobility of scientists between organizations, multi-ministerial funding and implementation mechanism of projects, etc. The role of socio-economic ministries in mainstreaming S&T in their programmes is also an important policy issue as many of the programmes/activities relating to S & T would fall within the purview of these ministries. The mindset has to be changed and the entire system has to be geared to be alive to the role of S&T.

1.10 Mechanisms

Apart from recommending specific and seperate budget for aforesaid initiatives, suggestions have also been made regarding the nodal Ministries / Agencies through which the funds are to be routed. Suggestions have also been made regarding possible implementation mechanism of large budgeted multi agency projects through Oversight Committes wherever necessary.

2

Policies, Administrative Changes for Improvement in S&T Research Environment and Resources

2.1 Introduction

Scientific research, technological developments are crucial factors in the growth and development of a nation. Over the years, there have been serious concerns raised about Indian science not being able to attract bright young science students. The status of research and education in the university system and the contributions they make to research and development is an area that requires urgent attention.

The process of globalization, liberalization and privatization has lent a complex dimension to the expansion of education, the degree of professionalism and the nature of employment. The growth of career opportunities in the emerging fields like the IT, biotechnology, manufacturing technology, management and law, where the level of specialization is at the graduate level, have seriously hampered the recruitment and retention of students and scholars in the fields of basic science disciplines like Mathematics, Physics, Chemistry and Biology.

Given the range of problems involved with the development of S&T in the nation, it is important to take stock of the situation and develop strategies and plan to address them. It is important to find ways and means of strengthening the S&T system and also make efforts to provide synergy between S&T infrastructure and industry to tackle key issues affecting S&T.

2.2.1 Administrative Reforms

The need for organizational and administrative changes in S&T Departments/ Agencies/ Institutions to create a conducive environment for research and development (R&D) and ensuring optimal use of pubic R&D resources has been discussed in various forums. It is essential to dispense with hierarchical bureaucracy in the R&D institutions. SAC-C had constituted a Committee on Organizational and Administrative Changes for Optimal use of S&T Resources in March 2002 and some of the recommendations were:

a) Enabling institutions to convert knowledge to equity

b) Providing flexibility to S&T Departments for modification and/ or extensions of projects

c) Powers to S&T Ministries/Departments to sanction expenditure upto Rs. 2 crores without obtaining consent of the Finance Ministry

d) Enforcement of economy instructions in S&T Departments after consultation with the Principal Scientific Adviser to the Government of India

e) Restoration of powers to S&T Departments for creation and filling up of scientific posts

f) Non-application of the provision for abolishing of posts in S&T Departments/ Ministries and Autonomous institutions under their administrative control even if a post is held in abeyance or remains unfilled for a period of three years as applicable in other Government Departments

g) Creation of a Science and Technology Audit Board in C&AG Office.

More recently, SAC-PM has also made a number of recommendations on similar and some more issues. Some of these are as follows:

a) The scientific departments should be able to implement new projects that are under an already approved planned scheme without any further procedure for obtaining "***in principle approval***", as at present, for each component of the scheme/ project.

b) Manpower being critical for successful implementation of research projects, approval of the scheme/ project needs to be *accompanied by* approval of the scientific and technical manpower requirements, as projected.

c) Delegation to the individual Departments and the Governing Bodies of the scientific institutions, the administrative power to reorganize total sanctioned scientific and technical posts into various categories of scientists positions. Similar delegation is needed for administrative/secretarial staff.

d) The Secretary to the department could sanction projects up to a value of Rs.25 crore with the concurrence of the Financial Adviser.

e) Projects costing more than Rs.25 crore, but not exceeding Rs.50 crore, could be within the powers of the Minister concerned. Only projects costing above Rs.50 crore should need the approval of the Expenditure Finance Committee followed by that of the Cabinet.

f) The Department concerned should have powers to re-appropriate allocations, without any ceiling, between budget heads as long as the approved total budget is not exceeded.

g) The provision of rollover of budget similar to that made for the Defence Purchases should be extended to S&T Departments and Institutions, to allow savings in the annual allocation being permitted to be carried over to the following financial year, without detriment to the allocation for the next year. Alternatively Government may establish a "Non lapsable fund for S&T Departments".

h) Issues relating to mobility of scientists, etc.

All these recommendations of SAC-C and SAC-PM are already with Government.

2.3 Sound Cyber Infrastructure for S&T

This had become essential for modern-day research and even Singapore and Taiwan have much better cyber infrastructure than India. PSA had requested Dr. Dhekne from BARC, Dr. Gairola from NIC and Dr. S.V. Raghavan of IIT, Madras to submit a paper on this item. The final proposal has been received. It is proposed to be implemented in association with the National Knowledge Commission.

2.4 Security aspects related to R&D being pursued by foreign companies in India

A number of foreign companies have opened their R&D Centres in India and this is expected to further pick up in future in view of the cost advantages that India offers. While this is a very welcome development, there are hardly any security regulations about the intellectual property and knowledge-related activities of these enterprises. There is ample scope for these activities being misused by other countries if they so wished. While we do not want to curtail the increased opportunities that such enterprises offer to our youth, we need to put in sufficient safeguards so that the country's interests and priorities are not compromised. This is an area of urgent attention and needs to be addressed adequately.

2.5 Projects involving more than one Ministry/ Department

Various mechanisms exist at present for consideration, approval and monitoring of projects in individual departments / ministries. The process followed is fairly similar, usually based on peer review and followed by consideration by an expert committee. The progress of implementation of approved projects is monitored / reviewed by another expert group. However, for projects involving multiple ministries there are at present no standard guidelines for consideration and approval of projects. As a result, the project gets reviewed more than once at different levels / ministries and approval gets unduly delayed. In such cases, therefore, there should be an Inter-ministerial Apex / Oversight Committee, which should be the final authority for approving a project and its budget. Thereafter, the project should not be placed before any other internal committee of any ministry / department for further consideration. This Oversight Committee would also help ministries concerned to set up Project Review and Monitoring Committees (PRMCs) for providing guidance during implementation of the project.

2.6 Public Private Partnerships and Private R&D

A Public-Private Partnership is a contractual agreement between a public agency (federal, state or local) and a private sector entity. Through this agreement, the skills and assets of each sector (public and private) are shared in delivering a service or facility for the use of the general public. In addition to the sharing of resources, each party shares in the risks and rewards potential in the delivery of the service and / or facility.

Important issues are:-

1. It must be a real partnership, with shared burdens and shared rewards for both the public and private participants
2. There must be real incentives for the private sector or they will not participate
3. The public-sector must use its resources effectively and judiciously, focusing on projects where there can be success
4. The mechanisms needs to be simple for the private-sector by minimizing the bureaucratic procedures that can cripple a project

2.7 Animals in research

Animal experimentation is vital for biomedical research, testing, training and education. Ethical issues and best management practices in animal experimentation are extremely important both, from the point of animal rights, as well as reliability of results. During last fifteen years there has been considerable improvement in standards of animal facilities and quality of experimentation, particularly with regard to small animals, but serious problems persist with regard to experimentation on large animals like cats, dogs, primates, etc., which are crucial for drug development, testing and discovery of new molecules. This research has become vital since the advent of new patent laws (product patent), which can increase the price of existing drugs under patent. Hence new drugs and molecules have to be discovered, particularly for orphan diseases, typical of the developing countries in which the developed world and multinationals may not be interested.

2.7.1 Problems faced

1. **Delays in getting permission for experiments:** India is unique in having a statutory committee called Committee for the Purpose of Control and Supervision of Experimentation on Animals (CPCSEA), which has to permit all experiments done on large animals. This despite the fact that every institution has an Institutional Animal Ethics Committee (IAEC), on which there are representatives of CPCSEA. In addition, there is a Sub Committee on Large Animals (SCLA), Institutional Bio safety Committee, RCGM Committee of the Department of Biotechnology (for biotech products), whose approvals are also needed. Such complex procedures mean delay of sometimes almost a year, resulting in not only financial loss but also loss of opportunity in a competitive scenario where others would be working on similar drugs or molecules. In case of patented drugs/molecules the delay can cost dearly. **In this connection it may be mentioned that for experiments on humans (clinical trials), approval of Institutional Ethics Committee is enough to get started.**
2. **Confidentiality of commercially sensitive drugs and molecules.** CPCSEA officials demand information on identity and sometimes, even chemistry of the molecule/ drug, procedures, etc. This information is commercially sensitive and has to be confidential, but the application submitted to CPCSEA is in the open domain and can leak out to any one.

3. **CPCSEA demands use of colony-bred animals, and bans use of trapped animals:** India does not have accredited good facility for breeding large animals. This means that animals have to be imported. After getting the approval for conducting an experiment, complicated import procedures have to be gone through for importing the animals. This problem is there even for importing small animals. There have been instances where after going through the procedure, animals imported by reputed companies are confiscated and sent to rehabilitation centres run by NGOs, on the whim and fancy of a member of CPCSEA. There is total and unreasonable ban on trapping animals from the wild saying; they would be of doubtful health and unknown pedigree. Populations of certain types of large animals like monkeys have exceeded the carrying capacity of the forests and are a threat to human beings. China earns through export of animals. India did so earlier. Health of animals can be ensured during quarantine period, and many experiments do not need pedigree. Thus there is lot of scope for using trapped animals, and saving on time and money. Even for movement of animals like monkeys from one animal facility in India to another, (both registered for housing large animals), permission of the Chief Ministers of each state is needed (Case of transfer of monkeys from the Indian Institute of Science in Bangalore to the National Brain Research Institute).

4. **Huge amount spent in sending drugs/ molecules outside for testing.** In view of the above-mentioned difficulties, government agencies and pharmaceutical companies are spending large sums of money in getting their products tested for toxicity, etc. in other countries. This means loss of money and time for cutting edge scientific research.

5. **Rehabilitation of animals:** After experimentation, animals have to be rehabilitated rather than culled. This imposes tremendous strain on animal facilities. Even small animals like rats, mice guinea pigs have to die natural death after experimentation. They cannot be culled. Old animals are prone to diseases and stocking of old animals, besides infected animals, threaten the health of other animals and personnel working in the facility, besides straining the carrying capacity of the animal facility. Larger animals are sent to rehabilitation centres often run by NGOs and the cost has to be borne by the research institution. Some of the rehabilitation centres are run badly, and vested interest is involved.

6. **Lack of trained personnel:** There is tremendous paucity of personnel trained in animal handling and experimentation. Even in medical colleges, teaching of subjects like pharmacology and physiology is being done without any hands on practical training. Such doctors and scientists are poor human resource both for teaching science and for animal experimentation for research. Handling of animals by untrained people can be stressful to the animals.

2.7.2 Recommendations

1. **Redefine the scope and functioning of CPCSEA, IAEC, and Scrap SCLA.**

   a) If a committee like CPCSEA has to be there, its members should have understanding of biology and need for animal experimentation. There should be greater representation of scientists who have proper understanding of the subject. Fortunately, unlike in the past, the present committee does have good representation from scientists. This practice should continue regardless of the government in power. b) More powers should be given to IAEC, (especially since it has two members appointed by SPCSEA) if necessary by inclusion of members of the judiciary like in the case of human ethics committees, so that the recommendation of IAEC becomes mandatory and final as in the case of human experiments/clinical trials. c) SCLA, which decides about experimentation on large animals, should be scrapped. d) The CPCSEA should be a higher body, not burdened with day-to-day approvals, which can be given by IAEC. It should play a proactive, facilitator role by providing guidance, training, advice, educational material, and troubleshooting, so that the cause of science as well as laboratory animals is served. It should provide policy framework and be involved in major legislative decisions, as well as recognition of facilities, protocols, appointment of members to IAEC etc., e) Instead of including representatives of industries on CPCSEA, where there can be conflict of interests, government agencies which regulate each industry e.g. pharma, agrochem, etc., who may understand the needs of industries can be on the committee. f) **CPCSEA should be brought under the Ministry of Science and Technology rather than Ministry of Environment and Forests.**

2. **Repeated approvals for routine studies unnecessary:** Routine toxicology studies for the registration of drugs/ molecules/ agrochemicals, with standardized methodology and protocols, should not have to go through repeated approvals by different committees like IAEC, IBC, etc. Institutions should be granted one-time permission for such studies.

3. **Single window clearance for importing animals (large or small):** Instead of scientists having to run around different institutions and agencies like the forest department, DG foreign trade, customs, etc. besides the committees mentioned, the procedures should be streamlined for single window clearance.

4. **Investment in internationally accredited large animal-facilities: Country needs to invest in good, internationally accredited facilities for large animals.** At present ICMR's concept paper on one such facility in the Genome valley in Hyderabad is under consideration. Government should either invest identifying resources from within or there can be public private partnerships with sufficient safe guard for research and testing on drugs and vaccines for orphan diseases, which may not fetch as much profit as the more elitist drugs.

5. **Rehabilitation of animals:** Rehabilitation of small animals like rats, mice guinea pigs should not be a requirement. For large animals also there should be standardized procedures (and costs) with NGOs organizations identified in each state for the purpose. The standard of the rehabilitation centres run by NGOs should be good, otherwise the animals are sent from a better environment of good animal facility to poor standard rehabilitation centres.

Summary of major recommendations: 1) Setting up of internationally accredited facilities for large animal to ensure availability of genetically and microbiologically defined animals. 2) License to specific institutions (and trappers) to trap animals from the wild. 3) Scrapping SCLA and empowering

IAEC to take decisions on large animal experimentation. 4) Single window clearance for importing animals- large and small. 5) Redefining the functions of CPCSEA, to make it a facilitating body. 6) Removing the requirement for rehabilitation of small animals and defining the standard for the rehabilitation centres for large animals.

2.8 Women in science

A knowledge society demands participation of every individual to her/his full potential. Conscious or unconscious gender discrimination, which marginalizes females from being equal partners in acquiring knowledge, particularly scientific knowledge and worst still –being sidelined after acquiring knowledge, is not only a loss to the society but also violation of human rights. Women tend to shy away from careers in science and engineering; particularly research because it tends to be more demanding than other vocations. Some specific problems and recommendations to address them follow.

2.8.1 Recommendations

Recommendations are divided into three categories: A) Special provisions and programmes to encourage study and practice of science and engineering by women. B) Steps to reduce the stress on women scientists and students, and facilitate career in science. C) Proposal for special scheme for Women scientists to aid their re-location.

A. Special provisions and programmes to encourage study and practice of science and engineering by women.

1. Residential science schools for class X and XI girls in rural areas and counselling girls on career opportunities in science, and life skills.

2. Establishment of women's universities, (even a central university) for women particularly in North and NE India. Though some women's universities are there in South and Western India, all of them do not offer science subjects except perhaps computer science (e.g. Mother Teresa University in Tamilnadu). All women's universities should offer courses in natural sciences, besides technical courses. Emphasis should be on matching education with job opportunities.

3. Selection of faculty even for girls' schools and women's colleges should be on merit, slight preference for women can be given only if they are equally good.

4. Special free coaching and merit scholarships for girls from resource poor families. With privatisation, science education is going to be increasingly more expensive, and the axe will fall on girls.

5. Travel support to girls from resource poor families and where necessary for one escort to enable them to come to city to write competitive exams.

6. Gender sensitisation programmes in all institutions including schools and for parents.

7. Illustrations in science books should be gender neutral.

8. Fellowship to eminent women scientists to visit, give lectures, and interact with students and teachers in universities to inspire them.

9. A Web site and a directory of women scientists, giving their professional profile. This can be used to identify speakers for conferences, appointment to committees, etc.

10. Opportunity for women who have suffered a break in career to return to science career. More programmes like the one DST has started.

11. Enterprennuership and Self Emlpoyment for women scientists.

Economic improvement of the nation would occur in a knowledge-based society if there is conversion of knowledge to commerce. Most women scientists are unable to harness this quality and need a formalized system to empower them. Special science parks where equity- based help is provided and training is given in marketing are recommended. Such training may be targeted for both urban and rural based technologies. Local economic factors, investment modalities suitable for a stated technology require to be communicated. Successful women entrepreneurs may be inducted to provide advice and encouragement. Special loans with favourable payment options are available, however, women scientists need to be educated for optimum use of these facilities.

B. Steps to Reduce the Stress on Women Scientists and Students, and Facilitate Study and Practice of Science by Women.

Sr. No.	Issue	Implementing Agency
1	Flexible working hours, and part time jobs	UGC, Institutions
2	Facilities like well-run crèche, day-care centre for the elderly, campus housing, transport, proper toilets, ladies rooms, etc.	As above
3	Age relaxation in recruitment, and 2 mid-career breaks	As above
4	Freedom for husband and wife to work in the same institution	As above
5	Transfer to enable the wife and husband to work in the same city	Science agencies
6	'Grievance cell' for gender-related and sexual offences at the level of the institution as well as at a higher level.	UGC, Science agencies
7	Inclusion of women in selection and other policy making committees	As above
8	Transparency in the process of selections. Reasons for rejection should be included. Performance assessment for a woman should be done on the basis of years spent in professional life, rather than biological age.	As above
9	More rigorous effort to identify meritorious women and objectivity in selection for fellowships and awards, as well as invitations to speak in conferences.	Academies, awarding agencies

C. Proposal for special scheme for Women scientists to aid their re-location:

Women scientists in India who are married are often forced to give up their jobs due to the relocation of their husbands and families. It is generally difficult for such women to find employment in new scientific institutions despite being well qualified and talented. Furthermore, if there is a long delay in getting employed, it is even harder for them to get back into active research again. To prevent the loss of this source of highly trained and specialized human resource, it is proposed to initiate a new scheme that will help their transition to a new environment, give them a place a to continue their on-going research and at the same time provide a small window of time to explore new employment opportunities. The proposal called “Relocation fellowship for women” is as follows:

1. Based on their track record and current research interest, women scientists who have had to relocate may be provided a consolidated salary equivalent to their last pay for a period of 2 years.
2. In order to facilitate their research activities they may also be provided with funds for purchase of chemicals and essential supplies for the period of 2 years.
3. This fellowship would be tenable at all academic and research institutions.
4. If the women scientist desires she may also work in the R & D labs of private companies provided they are recognized by DSIR. In the case of women joining private R&D centres under DSIR, they should be provided only salaries without the contingency grant.

These measures would help women to continue their research with the least liability to the host institute and help the relocation of women scientists with their families without compromising their research careers.

2.9 Promotion of entrepreneurial ventures by scientists

Several policy measures are required to promote mobility of scientists from one institution to another or from an institution to industry. Another important issue is the need for enabling mechanisms to encourage scientists in educational institutions and research labs to open companies and hold concurrent positions in the two organizations. This would enhance the entrepreneurial spirit of the scientists, help accelerate technology development and commercialization and generate wealth and employment opportunities.

Some suggestions in this regard are given below.

2.9.1 Mobility of Scientists between Organizations

When we talk of mobility of scientists, there are several possibilities. A *scientist (which includes teaching faculty in higher educational institutions)* may move from one *lab (lab also means an educational institution)* of one agency to another lab of the same agency; he may move from one lab of one agency to another lab of another agency; he may move from a government lab to an industrial R&D organization;

or, he may move from an industrial R&D organization to a government lab. Of particular interest is the movement for a medium-term in terms of time, say 3-5 years wherein the scientist can either impart his knowledge to the host organization or bring enhanced knowledge from the host organization to his parent organization.

The only thing which needs to be emphasized is that, in case of medium-term relocation, the scientist moving from one organization to the other should be compensated with a “relocation allowance” to absorb his perks in the parent organization and to offer some incentive to him to go through the trouble of relocation. Even today, persons on deputation in Government do get a deputation allowance, but the amount is not large enough to motivate brilliant scientists to move from one organization to another to share their expertise. The question of sharing the financial liability because of “relocation allowance” will be best left to the organizations concerned. The issue of promotions in the parent department / institution / laboratory while on deputation needs to be formalized and it should be ensured that the scientists concerned get their promotions as and when it becomes due.

2.9.2 Starting of entrepreneurial ventures by scientists/faculty in labs and educational institutions

Another important issue of even greater importance is to find ways to encourage scientists working in a lab to open a “technology company”. At the present time, there are several roadblocks on the way. First, it is generally viewed as a distraction for the scientist’s duties. Then, the profit-sharing arrangements between lab and the scientist are not attractive. Also, there are no structured arrangements in most places to allow a scientist to be the CEO of his company concurrently with his position in the laboratory. The net effect of this is that technology development projects in labs are not taken to the commercialization stage by scientists who may be interested in doing so and who may have the commercial acumen. Secondly, for lack of financial incentives, the scientist is not interested in commercialization of technologies available in the market. As an example, it may be mentioned that even a country like South Korea was equally conservative in this regard. But, then, they liberalized the administrative and incentive structure to enable scientists to also become businessmen.

What a scientist is usually looking for is the security of his job in the parent institution so that the risk in case of failure of his business venture can be absorbed. In case of success, it is most likely that he would himself like to relinquish his position in the lab. What we need to have in place is an enabling mechanism.

The following possibilities could be considered –

- It should be made clear by the labs that it is not only respectable, but also desirable that the scientists think of starting technology-intensive business ventures.
- The scientists should be guaranteed continuation in their jobs including promotions. In other words, their engagement in starting and subsequently running the business venture should be treated as part of their bonafide duty.

- If the technology on which the commercial enterprise being set up by the scientist belongs to the lab, the lab should also provide or arrange for venture capital and stand as a guarantor after satisfying itself of the risk factors in association with the scientist. Each lab should have funds at its disposal for doing this. The lab should demand profit sharing only after certain incubation period and after the company having reached a certain level of performance in terms of quantifiable parameters like profit, turnover, etc. These may be clearly spelt out in the Agreement. The lab should not dictate the salary and perks of the scientist as part of his job as CEO of the company, which will anyway be governed by Company Laws. The total income of the scientist will also be anyway subject to the tax laws. The only constraint the lab should put is that the scientist continues to perform his designated duties in the lab. While this may seem incongruous, it may not be so in practice. After all, a scientist will like to launch a company only in his areas of expertise and he will not like to lose his R&D edge, for which a new company may not be able to provide support, but facilities for which may already exist in the parent lab.

- If the technology on which the commercial enterprise being set up by the scientist does not belong to the lab, the lab need not stand as guarantor of the venture capital. Also, the lab may demand a different % of profit-sharing and the incubation period may also be different. Other aspects may remain the same.

2.10 Policy Issues Related To S&T

It may be emphasized that the development in S&T should not be treated in isolation. It should be in tune with the nation's aspirations. Any new approach would call for much faster growth of GDP, doubling of exports and much faster growth of agriculture and education. India is not first in any field and such a situation should not continue for long. Therefore, our attempt should be to become first in a few of the chosen fields whether it is in agriculture or in export or in certain sectors of technology (Biotechnology, Nanotechnology) or in industrial field. In such areas the role of S&T should be defined and vigorously pursued .The key issues in such a development process for S&T include the following:

1. The entire system has to be geared to be alive to the role of S&T. The mindset has to be changed in various administering and evaluation systems to focus on timely inputs / outputs rather than the processes and minimization of inputs. There has to be time accountability of the managers and administrators besides financial accountability by scientists.

2. There is an urgent need for improving the existing S&T infrastructure in order to accelerate economic growth and to derive social benefits. While considerable amount of such up-gradation and expansion will take place through major investment by industry including foreign ones, there are areas of S&T, which can considerably enhance availability of infrastructure and its quality. This is an area in which S&T should play a dominant role.

3. Many of the programmes / activities relating S & T fall within the purview of socio-economic ministries. Therefore it is essential that the existing level of interaction between S&T system and

the socio-economic ministries cannot continue on the same mode. So far it has been on a limited scale through a few projects and through a few technology projects on Mission Mode. The latter has enhanced considerably the involvement of socio-economic ministries. Multipartnership projects between socio-economic ministries and S&T departments/institutions and industry should be a welcome step.

4. In addition to having quantitative and qualitative expansion of Mission mode and multi-partnership projects, the socio-economic ministries should also set apart a definite percentage of their overall budget as a matter of policy for technology related development as suggested in the "Science & Technology Policy 2003". It is not necessary to transfer these funds to S&T institutions or S&T departments. It is for the socio-economic ministries to make an overall S&T plan, and encourage R&D in key sectors of infrastructure. Such programmes on R&D, technology up-gradation and development may be done even by industries and/or non-governmental organisations; S&T institutions may also participate in them. The key is to increase the demand of the socio-economic Ministries for indigenous S&T efforts. They should set the pace of technology up-gradation and development in key sectors. The management of funds will be under the overall control of the socio-economic ministries and no diversion of the earmarked funds for S&T should be done by them, except with the explicit approval of the Planning Commission. This will ensure the targets and the quantified goals could be achieved by the socio-economic ministries by themselves taking command of the S&T projects.

5. In the coming years, emphasis on clean technologies will increase. In order to face such emerging future challenges, without being reactive, the S&T programmes would need to have a goal of having zero toxicity, zero environmental impact, etc., in general, having an orientation for full eco-friendliness.

6. In the health sector various crucial issues relating to epidemiology and disease surveillance; clinical trials require special attention with special reference to reemerging as well as new or emerging diseases. Research infrastructure in these areas would have to be provided by organizations. It is also essential to build infrastructure (including human resources) for evaluation of new products including diagnostic kits, products of biotechnology drugs (including vaccines) and various devices (including contraceptives). This is particularly important in view of the advances in the field of biotechnology and healthcare, Nanotechnology, and the new ones expected in the coming 5 to 10 years.

7. There is a need to strengthen surveys of various nature like Survey of India, Geological Survey of India, Botanical Survey of India, Ocean Surveys, etc., in order to sustain our national resources. Similarly, there should be strengthening of National Resource Bureaus like National Bureau of Plant Genetic resources, Animal Genetic Resources and Fish Genetic Resources who are involved in conservation and planned enhancement and utilization of agro bio-diversity.

8. S&T system includes the infrastructure, human resources, programmes and methods of functioning. There is a clear need to restructure and reengineer most of these to meet the challenges

of the XIth Plan and subsequent periods. It is well recognized that it is not an easy task as it involves overall issues like changes with mindsets, to changes in various rules and methods of functioning.

9. There could be a few experiments of initiating a few joint projects with international companies and their R&D centres in India and based on this experience our future course of action can be decided on such projects.

10. There is a crisis in human resource management in the S&T system. Human Resource Development and motivation are the key issues in addition to re-engineering, reconstructing and empowering of institutions / personnel. These are also necessary for qualitative growth as distinct from quantitative growth. These call for bold experiments with a backing from the highest level. The entire area of science education and research, with focus on Human Resources, needs to be at the top of the agenda in the XIth Plan.

11. It may also be essential to have a few new S&T institutions with new culture and motivation; they should have elements of long-term sustainability even at the time of starting.

12. Research should be carried out on mission mode rather than on discipline mode. Time has come to introduce the concept of "Directed Research". In this process, partnerships between departments, clientele, industry, users should be institutionalized. Multicentric projects would be a norm for large projects. There may also be a few smaller projects, which are usually open ended, and individual based.

13. In the restructuring exercise, the role of applications of S&T in the States is of vital importance. There is a need to increase the demand from the State governments and their agencies for S&T inputs and to facilitate generation of joint programmes with industry, NGO's, etc. Central Government agencies should also facilitate easy flow of S&T personnel to implement State Government tasks / programmes. The administrative / financial packages available in State Governments for S&T personnel should be made attractive. The recent discussions between SAC-PM and various State S&T Councils are important. The recommendations would be sent to Planning Commission.

14. The resource for S&T is a complex issue. There is a merit in considering quantitative targets of inputs at macrolevel such as the national expenditure on S&T being raised to atleast 2 %of GDP. However, it is also realized that this cannot be through the Government budgetary support alone. While Government's role in supporting basic research, technology development and application, as well as for S&T infrastructure should continue and also considerably be enhanced, efforts need to be made to elicit support and financial resources from the Private sector. Time has come, where industry needs to join hands with the Government to enhance the prestige and image of the country, internationally, in the field of science and technology.

2.11 National Science & Technology Commission

The need for a separate structure for administering the S&T system in the country has already been recognized in the XIth Plan approach paper of the Planning Commission wherein setting up of a National Science and Technology Commission has been proposed. The Commission will be responsible for matters relating to S&T in the country as mentioned below:

1. Evolution of Science and Technology Policy for the country

The S&T policy has to integrate the activities of science and technology with education and research based on the demands of industry, service, agricultural sector and other societal requirements. The Commission should be entrusted with the responsibility of providing the necessary foresight for periodical revision and promulgation of S&T policies. The commission must also be entrusted with the task of developing and structuring a personnel policy suited to a creative endeavor like science and technology which provides scope for continuous talent renewal and renovation. S&T policy may need to be based on approaches of plan mode rather than on non-plan function.

2. Evolution of appropriate Managerial Structure in Scientific Departments / Organisations

The Commission should be responsible for positioning a system, which nurtures critical leaderships to the scientific community and for evolving appropriate organizational structures, managerial systems, and procedures. It should set also performance standards for scientific Departments / Organisations. It should be empowered to create a facilitating environment for creative endeavors with inherent risks of failures. The systems should facilitate without compromises in accountability.

3. Responsibility for Allocation of Funds

The Commission should be responsible for planning and allocating resources inclusive of funds to different organizations engaged in scientific and technological research based on quantifiable performance and the national outcomes delivered during the previous four years. A progressive rather than deterministic planning model is necessary for deployment of resources. The oversight mechanism for the deployment of resources should include a performance and technical audit and led by scientists of eminence and supported by financial management personnel. The processes adopted may use global bench marking practices and ensure transparency as the fundamental principle.

4. All measures required to make the health of Indian Science very robust and to improve and sustain India's position in the world of Science.

3

Eleventh Five Year Plan Programmes - Financial Aspects

3.1 Atomic Energy (R&D Sector)

Table 3.1: Department of Atomic Energy (R&D Sector), Major Programme (MP) wise Outlay

MP No.	Title	XIth Plan CS	XIth Plan NS	XIth Plan Total	Spill over to XIIth Plan
1	Nuclear Power Programme Stage-1	85.39	678.05	763.44	35.00
2	Nuclear Power Programme Stage-2	10.91	399.48	410.39	31.37
3	Nuclear Power Programme Stage-3 and Beyond	133.60	1799.12*	1932.72*	1166.38*
4A	Advanced Technologies and their Applications	729.15	1670.15	2399.30	750.95
4B	Radiation Technologies and their Applications	121.83	363.26	485.09	125.00
5	Basic Research	227.70	2345.18	2572.88	468.20
6	Research Education Linkage	56.40	1360.59	1416.99	203.00
7A	Infrastructure	64.11	771.22**	835.33**	23.62**
7B	Housing	3.83	190.57	194.40	6.32
Total DAE + AERB		**1432.92**	**9577.61**	**11010.53**	**2809.84**

Table 3.1A: DAE R&D Sector. Unit-wise Outlay (including Grant-in-aid*)

Sl. No.	Unit	Proposed Outlay			
		XIth Plan			Spill over XIIth Plan
		CS	NS	Total	
1.	AEES	0.00	115.00	115.00	0.00
2.	AMD	26.32	196.50	222.82	5.00
3.	BARC	1041.00	2615.00	3656.00	1043.30
4.	RRCAT	75.10	605.04	680.15	36.15
5.	DAE	0.71	73.50	74.21	3.00
6.	DCS&EM	53.00	109.16	162.16	0.00
7.	*Grant-in-Aid	0.00	701.75	701.75	0.00
8.	HRI	0.00	78.21	78.21	0.00
9.	IGCAR	27.53	646.61	674.14	55.81
10.	IMSc	5.00	24.04	29.04	0.00
11.	IOP	1.60	351.90	353.50	205.00
12.	IPR ITER India	0.00 0.00	457.00 1489.62	457.00 1489.62	0.00 1010.38
13.	SINP	0.00	703.28	703.28	360.20
14.	TIFR	43.12	672.23	715.35	29.00
15.	TMC	48.00	226.00	274.00	0.00
16.	VECC	111.54	499.76	611.30	60.00
Total DAE		**1432.92**	**9564.61**	**10997.53**	**2807.84**
AERB		**0.00**	**13.00**	**13.00**	**2.00**
Total DAE + AERB		**1432.92**	**9577.61**	**11010.53**	**2809.84**

CS - Continuing Scheme

NS - New Scheme

Table 3.2: Department of Biotechnology

SI. No.	Name of Programme/ Scheme/ Project	Eleventh Plan Outlay
1.	Promotion of innovation	1000.00
2.	Industrial promotion and development	1500.00
3.	Human Resource Development	750.00
4.	Biotech Infrastructure	750.00
5.	Mission-mode programmes	1000.00
6.	International Cooperation	200.00
7.	Sectoral R&D	3500.00
8.	Biotechnology for Societal Development	300.00
9.	Autonomous Institutions	3000.00
	(i) ***On-going***	1500.00
	(a) N.I.I.	400.00
	(b) N.C.C.S.	250.00
	(c) CDFD	200.00
	(d) NBRC	250.00
	(e) NCPGR	150.00
	(f) IBSD	100.00
	(g) ILS	150.00
	(ii) ***New Institutions***	1500.00
	Total	**12000.00**

Justification for the increase in budget outlay of the Department of Biotechnology for the XIth Plan compared to the Xth Plan

(Rs. in crores)

SI. No	Name of Programme/ Scheme /project	11th Five Year Plan (Outlay)		
		Commit-ments for ongoing schemes	New initiatives	Total
1.	**Human Resource Development**			
1.1	Biotechnology Education and Training ***Ongoing*** ● M.Sc., M.Tech & Ph.D. ● Short-term training programmes ***New initiatives*** ● Star life sciences colleges ● Teachers / technicians training Institute ● Training centres in universities/institutes ● Creating of new department for M.Sc., M.D., Ph.D., ● Biotechnology education council ● Capacity building in Medical schools, university, IITs and SAUs	200.00	250.00	450.00

SI. No	Name of Programme/ Scheme /project	11th Five Year Plan (Outlay)		
		Commit-ments for ongoing schemes	New initiatives	Total
1.2	Biotech Popularisation ***Ongoing*** ● Seminar and Symposia, Publication of books, Popular lectures, Advertising and publicity ● Travel grant ● All Fellowships (excluding associateship) ● All awards ***New initiatives*** ● New fellowships ● Promotion of biotechnology	150.00	150.00	300.00
1.3	Biotech Associateship and Training Abroad ***Ongoing*** ● Biotech Associateship (short-term and long-term) ***New initiatives*** ● Rapid International Grant	40.00	60.00	100.00
	Total (HRD)	390.00	460.00	850.00
2.	**Programme for Promotion of Excellence and Innovation**			
2.1	Centres for Excellence & Innovation ***Ongoing*** ● Centres for Excellence ● Programme support ***New initiatives*** ● Translational centers especially designed for technology development in Health, Agriculture and Food sectors and strategically located within or in the vicinity of a University Campus with effective industry linkages. ● Molecular Medicine Centers in at least two medical colleges.	400.00	400.00	800.00
2.2	***Ongoing*** ● IPR facilitation ● IPR awareness ***New initiatives*** Techno Management and IPR capacity building ● National Technology Management Centre with net work of local centres. ● Centre for appropriate technologies and delivery	—	200.00	200.00
	Total (COE)	400.00	600.00	1000.00
3.	**Biotech Facilities**			
	Biotech Facilities ***Ongoing*** ● IDA facility of microorganisms ● Repository on filarial and reagents ● Marine Cynobacteria facility ● BSL3 facility ● NMR facility ***New initiatives*** ● Biotech Facilities (generic and subject matter) ■ Clinical trails centres	100.00	300.00	400.00

SI. No	Name of Programme/ Scheme /project	11th Five Year Plan (Outlay)		
		Commit-ments for ongoing schemes	New initiatives	Total
	■ DNA and stem banking facilities ■ Virus research centres ■ DNA microarray and biomarker facility ■ Large Animal Facilities ■ Primate facilities ■ GMP facilities ■ GMO / LMO testing / validation ● Programme support for universities for remodeling of life sciences departments to make them interdisciplinary			

Table 3.3: Ministry of Earth Sciences

	Scheme	2007-08	2008-09	2009-10	2010-11	2011-12	Total
OCEAN DEVELOPMENT	Continuing	790.615	1021.855	1031.53	938.61	995.08	4777.69
	New	180.70	531.05	495.88	175.52	111.00	1494.15
Total (Ocean Development)		971.315	1552.905	1527.41	1114.13	1106.08	6271.84
Atmospheric Sciences-IMD	Continuing	740.40	952.41	1006.56	1023.61	1023.99	4746.97
	New	24.79	89.64	54.87	65.82	73.76	308.88
	Total (IMD)	765.19	1042.05	1061.43	1089.43	1097.75	5055.85
Atmospheric Sciences-NCMRWF	Continuing	16.97	18.91	21.07	21.39	20.57	98.91
	New	116.79	41.08	35.4	73.03	16.01	282.31
	Total (NCMRWF)	133.76	59.99	56.47	94.42	36.58	381.22
Atmospheric Sciences-IITM	Continuing	33.00	21.00	20.00	19.00	20.00	113.00
	New	107.80	22.50	20.20	18.90	17.60	187.00
	Total (IITM)	140.80	43.50	40.20	37.90	37.60	300.00
Total (Ocean Development)		**971.315**	**1552.905**	**1527.41**	**1114.13**	**1106.08**	**6271.84**
Total (Atmospheric Sciences)		**1039.75**	**1145.54**	**1158.1**	**1221.75**	**1171.93**	**5737.07**
Grand Total (Ocean Development+ Atmospheric Sciences)		**2011.065**	**2698.445**	**2685.51**	**2335.88**	**2278.01**	**12008.91**

Justification for the increase in budget outlay of the Ministry of Earth Sciences for the XIth Plan compared to the Xth Plan

The projections of the Ministry for the XIth Plan period has been made after critically assessment of essential requirement of the Ministry of Earth Sciences created recently by merging ocean, atmospheric and seismological related institutes. The allocations of MoES (now consisting of 8 centres) are substantially higher compared to the previous Plan of the Department of Ocean Development which had 4 centres. The XIth Plan allocations are primarily intended to strengthen various programmes/schemes in the field of ocean, atmospheric and seismic sciences to harness the capability and move ahead with speed. The objective of XIth Plan proposal is to primarily equip the country to deal with several natural disasters viz., Tsunamis, Floods, Storm Surges, Earth Quakes, Cyclones and other climate & weather related disasters and bring the observation systems of Indian Meteorology Department from practically nil today to world standard.

Earth Commission: Considering the importance of delivering a wide range of services, the Government has created the Ministry of Earth Sciences by integrating certain Institutes dealing with Ocean and Atmosphere. The formation of Earth Commission is in the pipeline which is primarily to address various societal beneficial programmes. Some of the centers of the Ministry did not implement full fledged schemes in the past to meet the requirement which are now being planned to be initiated during XIth Plan period. It is important to unravel the interlinking forces playing within and influencing the weather, climate and the environment around us. India has a coastline of about 7500 kilometers, and the seas around India influence the life of about 370 million coastal population and particularly, 7 million strong coastal fishing community. Understanding our ocean and weather is therefore vital to their livelihood. As a result several new schemes are being formulated for implementation which requires considerable budgetary support.

A Ocean Science and Technology

Gathering adequate knowledge of the potential of ocean space especially within our Exclusive Economic Zone (EEZ) of about 2.02 million sq km (our landmass area being about 3.27 million sq km) forms a key area for multidisciplinary research. These are to be expanded and oriented towards exploration and exploitation of living and non-living resources within our EEZ and beyond for socio-economic benefit and sustainable development of the marine sector. There has been considerable progress in these programmes which are now delivering the services to the benefit of the common man. viz., Desalination, Potential Fishing Zone advisories, Lobster fattening technology, assessment of living resources, development of drugs from sea, ocean state forecast, coastal engineering projects. Some of the details are given below.

i) **Front ranking research in Polar Science**: The importance of Antarctica as a pedestal for front-ranking scientific research was recognized by India way back in 1981 itself, when the first Indian Antarctic Expedition was launched. Since then, India has made great strides both in Polar Sciences and related logistics, through a judicious and harmonious blend of multi-institutional expertise brought together under the umbrella of the Ministry of Ocean Development. The major endeavors for XIth Plan under this programme include (i) Launch of research expeditions to Arctic preferably through international cooperation, (ii) construction of a new Antarctic Research Station to enhance research activities (iii) establishment of a dedicated satellite based communication and data transmission system between the Antarctic and India (iv) undertake southern Indian Oceanographic studies both in terms of assessment of living and non-living resources

(v) Collaborative projects during International Polar Year (2007-08) (vi) Establishment of a dedicated facility at CCMB to undertake studies related to microbial prospecting and biotechnological applications (v) acquisition of an ice-class research cum logistic vessel.

ii) Consolidation of **Desalination Technology**: Aim will be design and development of 10 MLD barge mounted plant whose design has been taken up. During the XIth Plan, NIOT would take up a scheme to design, develop, and demonstrate the large scale desalination plants (25-50 MLD). To realize such a large number of LTTD plants, NIOT will explore industry partnership in a big way during XIth Plan. The ultimate goal of the endeavour will be to establish such desalination plants along the coast and island territories of India to alleviate drinking water problem of coastal region.

iii) Providing of reliable **Coastal Ocean Services**: INCOIS being the responsible agency providing Ocean Information, would provide all possible reliable services pertaining to ocean sector during XIth Plan on operational basis, such as Tsunami, Potential Fishing zone advisories, Coastal Ocean State Forecast, using a wide range of media for dissemination of information. These include setting up of electronic display boards, information kiosks in every coastal village covering the entire coast of India for providing information including storms, cyclones, weather, sea state, etc., INCOIS would focus on development & dissemination of effective early warnings of oceanogenic disasters such as Storm Surges and Tsunami.

iv) World Class – **Ocean Technology**: NIOT would concentrate mainly on: (i) Design, development and demonstration of underwater technologies for deep sea mining (ii) Development of underwater materials and sensors (iii) Creation of sea front technology and other research infrastructure for testing of oceanographic equipment (to support facility and component development, offshore structures, offshore operations, development of SGS, XCTD, XSV, ultrasonic current, etc.).

v) **Coastal engineering**: Demonstration of coastal protection measures, Sediment transport atlas, Rates and Constants Measurements for Mathematical modeling, Geomorphologic studies for Siltation control in Hooghly, Monitoring and Modeling of Thermal and Oil Spill Modeling Resource Site, Deep water survey capability, Capacity Building for Marine Archaeology and Saltwater Intrusion, conduct marine corrosion and antifouling studies and other ocean and coastal engineering related projects.

vi) **Ocean Science and Technology for Islands** (OSTI): OSTI would take up development of Fish Aggregating Devices, Continuation of lobster and crab farming activity, Island resource information & GIS mapping materials for marine application, Open ocean aquaculture of marine organisms under controlled conditions to meet the increasing demand and dwindling capture of fishery resources. Further, it is planned to take up development of technology for micro algal culture and value added products using deep ocean water along with the utilization of bioprocess engineering technology for commercial production of phycocolloids, chemicals and polysaccharides.

vii) **Integrated Coastal Marine Area Management** (ICMAM) & Coastal Ocean Monitoring Area and Prediction Systems (COMAPS): During XIth Plan, ICMAM would concentrate on Demonstration of Ideal Coastal Protection Measures, Coastal circulation, Ecosystem modeling, Marine Ecotoxicology, Carbon cycling in coastal waters and Preparation of Coastal Risk Atlas. COMAPS should bring out periodical bulletins indicating the levels of these pollutants in various regions particularly in the hotspot regions.

viii) **Resource Mapping and Technology Development for Gas Hydrate**: NIOT would identify suitable technology devices for supporting offshore activities, developing the submersibles and other tools suited for various applications, Developing skill base and infrastructure to support and maintain the deep ocean systems. It is proposed to develop 6000m depth coring, Human Operated Vehicle (HOV), Autonomous Underwater Vehicle (AUV), and Hybrid Submersible (HYSUB).

ix) **Drugs from the Sea:** Complete clinical test of two compounds (antidiabetic, antidyslipidemic) derived from marine organisms are in the advanced stage of drug development. Lead compounds found to be having potential activities such as antibiotic, antiviral, antileukemic would be taken up for toxicity and clinical trials during XIth Plan.

x) **Marine Living Resources** (MLR) & CMLRE: During XIth Plan CMLRE should undertake projects such as (i) Semi-Commercial Exploitation of Myctophid Resources of Arabian Sea which has an estimated potential of 100 tons (ii) Resource assessment of demersal stocks (200-1500m depths), Refine Harvest technology for deep sea fishing, Squid jigging (iii) Monitoring & surveillance of Harmful Algal Bloom (HAB), Setting up HAB centre and R&D on HAB (iv) Marine Benthos in the Indian EEZ (v) Fishery Oceanography (vi) Biodiversity & census of marine life & (vii) Survey, assessment and semi-commercial exploitation of krill and fishery resources from Southern oceans, and related studies.

xi) **Sustained Ocean Observation Network**: During XIth Plan, the major work would be (i) integration of all the existing and planned observations network Data Buoys, Tide gauges, Drifters, HF Radar, XBT, Current meters, automatic Weather Stations, Argo Floats under one umbrella for wider utility, (ii) upkeep of existing 40-buoy network & possibility of augmentation of the network using low cost buoys to meet the requirement of operational weather services, (iii) setting up of 4 maintenance centers, 2 each on west coast and east coast of India for logistical operation and maintenance of observation network in addition to the routine work elements.

xii) **Marine and Atmosphere Research Technology Development & Capacity Building** (MRTD): During XIth Plan, the programme mainly would focus on (i) developing National Oceanarium (ii) increasing the number of OSTCs: 9 to 20 (iii) Upgrading another one / two cells into Centre of Excellence (CoE) (iv) augmentation of all the continuing programme including Coastal Ocean Monitoring and Pollution Control Non Marine Living Resources, Integrated Coastal and Marine Area Management.

B. Atmospheric Science and Technology

i) **Up gradation of Observation Networks**: The India Meteorological Department has been rendering various services relating to weather and climate to the public and other specific sectors like Agriculture, Aviation, Hydrology, etc., with the existing observational systems. Most of these equipments are obsolete and require replacement / up gradation. In order to provide better services, continuous monitoring systems with state-of-art technology are essential. Towards acquiring accurate and online information about various weather relating parameters IMD has taken a big step to up grade the Observation System and Network for which about Rs.2500 crores would be required during XIth Plan.

ii) **Development of expertise**: In addition to the observations, we need trained manpower for development of assimilation models. Both numerical models and assimilated models are essential for making an accurate forecast of local scale weather which is highly diverse in India due to its climatic and topographic condition. Currently, there are few experts available in India in the field of Global Circulation Models. This needs to be strengthened by providing training to the existing staff and inducting fresh qualified manpower. Besides right ambiance needs to be provided for conducting world-class research in the field of weather and climate.

iii) **Strengthening of infrastructure facilities:** Currently, the centres of MoES are equipped with little computation facility with respect to running the global scale models and assimilation models. Numerical weather modeling, state of the art climate and atmospheric research are the necessary supplementing mechanisms to act as a dynamic feedback to improve weather forecast and services. In addition, a large volume of data would also be acquired from both ground truth and satellite data through both national and international efforts. These data are required to be archived and processed for operational weather forecast to cater to the service sector. Thus the computational system needs to be acquired in all the centres of the Ministry, which requires substantial budget resources.

iv) **Climate Research and Monitoring**: Future climate information on seasonal to inter decadal and century scale in bolstering climatic preparedness especially if it is available early because many of the corrective actions may require extreme persuasion to be accepted in society. The modeling efforts that are the basis for such a science need attention in the official meteorological agency of the country. The focus would be on the computing and data requirements that are required to build a credible climate service facility in India.

v) **Numerical Weather Prediction (NWP)** system based on a global Atmospheric General Circulation Model (AGCM) of horizontal resolution of 25 km would be useful to generate district / taluk level Agromet Advisory Service (AAS). This involves use of voluminous global meteorological and oceanographic data, their assimilation to provide initial conditions, numerical models, and high end computing resources. The NWP system would enhance the forecasting capability of Agromet Advisories. Location specific agricultural weather information plays a vital role towards projected target of agricultural growth in the XIth Plan.

C Seismology and Geohazards

It is proposed to separate the seismology related activity from the IMD and create an independent unit under the Ministry of Earth Sciences. The following programmes will be conducted in the XIth Five Year Plan:

i) ***Seismic monitoring for earthquake detection*** and support to Tsunami Warning System and other related hazards. A state of the art network with real time connectivity with major analysis and decision support centre will be established at Delhi.

ii) ***Microzonation :*** Microzonation has been started in the Xth Five Year Plan as an activity to study hazard potential in a few cities. The work is very satisfactory and this should now be taken up to all major cities and hot spots with respect to seismigenic areas.

iii) ***Geohazards :*** A few specific geohazards have been organized in project mode like Tsunami Warning System and microzonation. However, there are many hazards to be addressed like land slides, inundation and damage potential by cyclones, floods, etc. It is proposed to setup a unit with international collaboration for Geohazards.

Considering the above, the allocations Rs. 12008.91 crore and Rs.2011.065 crore have been proposed for the XIth Plan and Annual plan 2007-08, respectively.

Table 3.4: Department of Scientific and Industrial Research (DSIR) excluding CSIR

(Rs. in Crore)

S.No	Programme	XIth Plan Outlay
	TPDU (On-going)	
1	Industrial R&D Promotion Programme	2.5
2.	Technology Development and Innovation Programme Technology Development & Demonstration Programme Technopreneur Promotion Programme (TePP)	 60 30
3.	Int'l Technology Transfer Programme including APCTT	30 14
4.	Consultancy Promotion Programme	30
6.	Technology Management Programme	50
7.	Technology Information Facilitation Programme	29
8.	IT Activities	5
9.	Women's Programme	6.5
	TOTAL	**257**
	New Initiatives	
10.	SBIRI other than Bio-technology	500
11.	Fund for Accelerating Start-ups in Technology (FAST)	75
12.	IPR Programme	100
	Total	**932**
13.	**CEL**	**43**
14.	**NRDC**	**168**
15.	**CDC**	**10**
	Grand Total	**1153**

Table 3.5: Council of Scientific and Industrial Research (CSIR)

(Rs. in Crore)

S. No.	Head	2007-12	2007-08	2008-09	2009-10	2010-11	2011-12
1.	National Laboratories **						
	(i) Sectoral Requirement	8710	2450	2550	1700	1260	750
	(ii) Ongoing Commitments of Xth Plan	600	200	200	150	50	0
	(iii) Creating, nurturing & sustaining the core knowledge frontier	1000	200	200	200	200	200
	(iv) Scale-up and validation of leads developed in-house	500	50	100	125	150	75
	(v) Open source drug discovery programme for infectious disease	500	50	100	100	125	125
	(vi) Laboratory modernisation for eco-friendly sustainable growth	500	100	100	125	125	50
	(vii) Civil infrastructure renovation, Staff Quarter & Amenities	1000	150	250	300	200	100
2.	National S&T Human Resource Development	1490	220	270	300	325	375
3.	Intellectual Property & Technology Management	230	30	60	60	40	40
4.	R&D Management Support	850	150	250	200	150	100
5.	New Millennium Indian Technology Leadership Initiative	1200	150	200	250	300	300
6.	Setting up Institute of Translational Research	1000	150	200	300	200	150
	TOTAL	**17580**	**3900**	**4480**	**3810**	**3125**	**2265**

Table 3.5 A: Distribution of Outlay for National Laboratories (CSIR)

(Rs. in Crore)

S.No.	Heads	XIth Plan Proposed: Projected	XIth Plan Proposed: % of total Allocations
	(i) Sectoral distribution		
1	Aerospace Science & Engineering	1294	10.10
2	Agro, Food Processing& Nutrition	430	3.36
3	Biology & Biotechnology	700	5.46
4	Chemical Science & technology	263	2.05
5	Earth System science	687	5.36
6	Ecology & Environment	335	2.62
7	Energy Resources & Technology	628	4.90
8	Electronics & Instrumentation	372	2.90
9	Engineering Materials, Minerals & Manufacturing	850	6.64
10	Pharma, Healthcare & Drugs	927	7.24
11	Housing, Road & Construction	445	3.47
12	Information Technology	737	5.75
13	Leather	180	1.41
14	Metrology	270	2.11
15	Rural Development	382	2.98
16	Water Resources & Technology	210	1.64
	Total	8710	67.99
	Others		
	(ii) IX / X Plan commitments	600	4.68
	(iii) Creating,nurturing & sustaining the core knowledge frontier	1000	7.81
	(iv) Scaleup and Validation of leads developed in-house	500	3.90
	(v) Opensource drug discovery programme for infectious disease	500	3.90
	(vi) Laboratory modernisation for eco-friendly sustainable growth	500	3.90
	(vii) Civil Infrastructure & Refurbishment	1000	7.81
	Total	**4100**	**32.01**
	Grand Total	**12810**	**100.00**

Justification for the increase in budget outlay of Department of Scientific & Industrial Research (including CSIR) for the XIth Plan compared to the Xth Plan

1. CSIR has a network of 38 research establishments undertaking research to address the needs of socio-economic sectors in diverse fields ranging from high technology Aerospace to Agriculture. CSIR's activities are more diverse unlike other R&D organizations catering to specific sectors.

2. During the X^{th} Plan, CSIR was the first publicly funded organization to implement 56 projects in a network mode involving anywhere from three to thirteen laboratories as partners. CSIR has learnt a valuable experience with these network projects on which it wishes to build on in the XI^{th} Plan.

3. In the XI^{th} Plan, with the experience drawn from the X^{th} Plan, CSIR is emboldened to launch **MEGA Flagship projects** of multi disciplinary nature under a network mode. **It has proposed 4 fold increase in the number of projects (226) covering wide areas of socio-economic sectors. It is also pertinent to mention that the networks in the XI^{th} Plan have been extended to cover various academic institutions/ universities, research establishments, private industries, etc.,** as well. In addition, for the first time CSIR is giving a major thrust to sectors such as rural development and North-East, Energy, and Water. **To implement these MEGA Flagship projects covering 16 sectors CSIR has proposed a budget of Rs.8710 crores**, which is nearly 50% of the projected demand.

4. Some of the MEGA Programmes proposed are:

- **National S&T Human Resource Development: Rs. 1500 crore**

CSIR has been rendering yeoman's service by fostering, sustaining and helping the specialist scientists in diverse disciplines of S&T in the country. There is a need to progressively increase the rate of generation of high quality skilled human resource at all levels. CSIR currently provides support to 1200 JRFs through NET. For India, this number is quite small and has to be substantially increased. A major plan scheme has been initiated towards this goal.

- **Public private partnership programme (NMITLI): Rs. 1200 crore**

During the X^{th} Plan, the NMITLI Scheme was launched with 65 private sector companies and over 200 institutions. It is the largest PPP in post independent India. NMITLI has created a brand image for itself. This is viewed today as a benchmark of PPP schemes, which is being emulated by various other government departments. The partners especially from the industry were of the view that industries, which partnered NMITLI projects, have demanded a major expansion of these projects. In this context it is proposed to expand the programme with new approaches of innovation development. Following are among the other concepts to enlarge under NMITLI:

- Pre and post NMITLI programmes
- Funding with industry (50:50 Initiative)
- Co-financing with Venture Capital funds
- NMITLI innovation centres
- Acquisition of early stage relevant knowledge / IP for portfolio building.

To continue the success stories of NMITLI, CSIR has proposed Rs.1200 crore under the XIth Plan as against the Xth Plan allocations of Rs.205 crore.

- **Institute of Translational Research: Rs. 1000 crore**

A new institute dedicated to carry out translational research *in mission mode* would be more productive than trying to network scientists with diverse interests from different cities. The institute aims at:

❖ Application of knowledge of modern biology into clinical care.

❖ Systematic collection and analysis of large amounts of clinical data.

❖ Development of ways and means of Personalized medicine.

❖ Development of specific stem cell populations to treat a variety of illnesses.

❖ Development of new diagnostic markers / tools / methods and providing the services of the same and genetic counseling.

- **Creating and nurturing knowledge frontiers: Rs. 1000 crore**

CSIR needs to build-up its core competencies spread over different fields. Strategic development in frontier and inter-disciplinary areas, for example, aero-acoustics, nano-biotechnology, post-genomic medicines, cell & tissue engineering, nano composites, engineering geophysics, etc., will be pursued.

- **Design and development of a regional aircraft: Rs. 700 crore (Phase1)**

For a large country like India, a regional aircraft with an intermediate capacity (typically 70 passengers) and the range of about 2000 km is best suited to meet the requirements of establishing connectivity between regional centres and main cities.

Such an aircraft development programme to realise a certified aircraft would be a multi disciplinary and multi institutional programme to optimize the input resources. NAL's experience with the HANSA and SARAS programme and technologies currently available in the country give sufficient confidence for such a programme to be taken up. However, many of these technologies will have to be upgraded and new ones will have to be developed along with state-of-the-art methodologies for success of the programme.

- **Up-gradation and Creation of Aerospace related facilities: Rs. 630 crore**

The proposed programme is to strengthen its R&D core competence aimed both at supporting the technology development and enhancing the long-term knowledge base. It is therefore, proposed to take up new technology initiatives in the XIth Plan in the areas of Supersonic Combustion; Small gas turbine engines; MAV development and related technologies; Special composites fabrication technologies; Structural Health Monitoring; Damage tolerance technologies; Advanced Total Technical Life Extension Studies (TTLE), etc.

- **Scale-up and validation of leads developed in-house: Rs. 500 crore**

CSIR at its various constituent laboratories has developed promising leads, especially in drugs and pharmaceuticals that require scale up / validation. However, many of these cannot reach industry unless they are designed at scales acceptable to industry for assessing the techno-commercial feasibility.

- **Open source Drug discovery programmes for infectious diseases: Rs. 500 crore**

In the Eleventh Plan it is proposed that CSIR would set up programmes for open source drug discovery through national and international collaborations involving National Laboratories and Academia. **"Open Source Drug Discovery Movement" is a new concept and has major advantage of reducing the cost of development by bringing like-minded scientists with complementary diverse skill set together under a single umbrella.**

The discovery and development of drugs by pharmaceutical companies are driven by market size and price. Such companies do not wish to invest in diseases of the third world, particularly the infectious diseases. The remarkable success of the open source movement in IT Sector (like development of Linux operating system and World Wide Web) has given enormous benefit to the developing world. The success of open source movement in IT sector gives confidence to the potential success of a movement on open source drug discovery programme in healthcare sector.

- **Civil infrastructure & Laboratory modernization for eco -friendly sustainable growth: Rs.1500 crore**

Many of the CSIR laboratories were built or acquired in fifties / sixties some even earlier. While some of the laboratories were started from the buildings meant for palaces, educational institutions and in rented places, some of them built R&D facilities of the contemporary period. Most of them are not appropriate for modern day R&D activities.

In view of the above, modern building infrastructure and related facilities to take into consideration the eco-friendly and cost-effective maintenance technologies such as energy efficient air conditioning systems coupled with energy efficient lighting devices have to be built. In the XIth Plan CSIR proposes to adopt eco-friendly building components, such as, energy efficient air conditioners, solar panels for lighting and other uses, rain water harvesting, recycling of waste water, etc. This approach will not only help CSIR in minimizing the operating expenses but would also find solution to problems like shortage of water and electricity.

- **Ongoing commitments: Rs.600 crore**

Thirteen network projects of Xth Plan which would realize the desired high value outcomes will spill over to XIth Plan. CSIR needs Rs.600 crore in the XIth Plan to complete these projects.

Thus the demand projected for XI[th] Plan is of the order of Rs.17,580 crores to meet the above macro objectives of CSIR is fully justifiable.

Table 3.6: Department of Space

(Rs. in Crore)

		XI[th] Plan Outlay	Sub Total	%
A	**TECHNOLOGY DEV. & PROJECTS**			
1	**OPERATIONAL MISSIONS**			
	● SATELLITE MISSIONS			
	(a) Satcom missions	4700.00		
	(a) Navigation missions	2420.00		
	(a) EO missions	2730.00		
	● LAUNCH VEHICLES	4468.00	14318.00	36%
2	**ADVANCED TECHNOLOGY MISSIONS**			
	● GSLV MK III	1000.00		
	● RLV & ABP RELATED	534.00		
	● MANNED MISSION INITIATIVES	5000.00		
	● SEMI-CRYO DEVELOPMENT	1800.00		
	● 600KN CRYO DEVELOPMENT	700.00		
	● SRE & OTHER MISSIONS	120.00	9154.00	23%
3	**R & D / TDP / INDIGENISATION /**		4821.00	12%
	INFRASTRUCUTRE / CAPACITY BUILDUP			
	TOTAL – TECHNOLOGY & PRJOECTS		28293.00	71%
B	**SPACE SCIENCE / ATMOSPHERIC** SCIENCE PROGRAMME.			
	● PLANETARY EXPLORATION	1050.00		
	● ASTRONOMY & ASTROPHYSICS	325.00		
	● SPACE WEATHER	300.00		
	● CLIMATE & METEOROLOGY	125.00		
	● ATMOSPHERIC SCIENCE RELATED	358.00		
	● AUXILIARY SPACE SC. ACTIVITIES	387.00	2545.00	6%
C	**SPACE APPLICATIONS** (DMS, VRC, Tele-education, Tele-medicine NR Management, etc.,)		1752.00	4%
D	**ORGANISATION & MAINTENANCE**		7160.00	18%
	GRAND TOTAL	**Plan**	**36750.00**	
		Non-Plan	**3000.00**	**100%**

Table 3.7: Department of Science & Technology

(Rs. in Crore)

Sl. No.	Name of Scheme/Project/ Programme		Proposed Outlay XIth Plan
1	Research & Development Support (including Foundation)		8000.00
2	Technology Development Programme		550.00
3	S&T Programme for Socio- Economic Development		
	3.1	Science and Society Programme	150.00
	3.2	Special Component Programme (SC)	50.00
	3.3	Tribal Sub-Plan	50.00
	3.4	S&T Entrepreneurship Development	280.00
	3.5	S&T Communication and Popularisation	240.00
4	International Cooperation		450.00
5	State Science and Technology Programme		160.00
6	Survey of India (Modernization Package)		1000.00
7	NATMO		20.00
8	**Autonomous Institutions**		
	8.1	IACS, Kolkata	265.00
	8.2	Bose Institute, Kolkata	185.00
	8.3	Raman Research Institute, Bangalore	120.00
	8.4	Indian Institute of Astrophysics, Bangalore	240.00
	8.5	Indian Institute of Geomagnetism, Mumbai	170.00
	8.6	Sree Chitra Tirunal Institute for Medical Sciences & Technology, Trivandrum	350.00
	8.7	Birbal Sahni Institute of Palaeobotany, Lucknow	95.00
	8.8	S.N. Bose National Centre for Basic Sciences, Kolkata	95.00
	8.9	Agarkar Research Institute, Pune	90.00
	8.10	Wadia Institute of Himalayan Geology, Dehradun	90.00
	8.11	Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore	180.00
	8.12	TIFAC	350.00
	8.13	Vigyan Prasar	40.00
	8.14	Advanced Research Centre for Powder Metallurgy, Hyderabad	310.00
	8.15	NABL	50.00
	8.16	Liquid Crystal Research Centre, Bangalore	35.00
	8.17	Aryabhatta Research Institute of Observational Sciences, Nainital	85.00

Sl. No.	Name of Scheme/Project/ Programme	Proposed Outlay XIth Plan
	8.18 Planned new Autonomous Institutions in the areas of Molecular Materials, Glaciology, Textiles, Drug&Pharma and ICT	200.00
	Total Autonomous Institutions	**2950.00**
9	Professional Bodies	
	9.1 Indian National Science Academy, New Delhi	45.00
	9.2 Indian Academy of Science, Bangalore	28.00
	9.3 INDIAN Science Congress Association, Kolkata	13.00
	9.4 Indian National Academy of Engineering, New Delhi	14.00
	9.5 National Academy of Science (India), Allahabad	21.00
	9.6 Other Professional Bodies, Seminar, Symposia	25.00
	Total Professional Bodies	146.00
10	Technology Management Project	22.00
11	Schemes Introduced in the 10th Plan	
	11.1 Technology For Bamboo Products (Mission Mode Project)	300.00
	11.2 Synergy Projects (O/O PSA to GOI)	50.00
	11.3 Information Technology	22.00
	11.4 National Training Programme for Scientists/Technologist Working with Govt. of India	10.00
	11.5 Drugs & Pharmaceuticals Research	1400.00
	11.6 National Mission on Nano-Science and Nano-Technology	1000.00
12	New Schemes Proposed in XIth Plan	
	12.1 Water Technology Programme	300.00
	12.2 National Campaign for Talent Fostering and Innovation Building	1300.00
	12.3 S&T Innovation Clusters	500.00
	12.4 Security Technology	200.00
	12.5 Creation of State of Art facilities for Basic Research on a National Scale	150.00
	Total Plan	**19,300.00**

Justification for the increase in budget outlay of the Department of Science and Technology for the XIth Plan compared to the Xth Plan

The Department of Science and Technology, Government of India has projected a budget demand of Rs 19300 crores for supporting the science and technology programmes of the country. The department has emerged as the major Extra Mural Funding agency of India with a 44% of all EMR funding of the

Government of India. DST bears the responsibility of projecting the needs and mobilizing adequate resources from the Government of India. The department has been delivering the mobilized resources into the research and development system of the country using robust processes and systems since 1971.

The department has been engaged in promoting research and development proactively. The sanctioned outlay of budget for the programmes overseen by DST for the Xth Plan period has been Rs3400 crores. The actual funds realized and released during the Xth Plan period inclusive of the sanctioned amount for the period 2006-07 are Rs 4930 crores. The ratio of the projected outlay for the XIth Plan period over the funds actually delivered during the Xth Plan period is 4.4. The department is obliged to share with the basis of the projections and present the justifications for the scale up factor of 4.4.

DST has been engaged in supporting total of 36 line items in research and development areas during the Xth Plan period employing the total funds of Rs 4930 crores. The annual budget sanctioned for the year 2006-07 is Rs 1300 crores. It is expected that for supporting the ongoing R&D initiatives nearly at the same levels at those employed during the Xth Plan period, an annual rate of increase of 15% is necessary. This is based on the plan fundamental that the growth rate of Science and development budget needs to be least the levels of GDP growth rate plus the inflation rate. Assuming that Indian GDP will grow at about 10% p.a. during the XIth Plan period and the inflation rate will be maintained at 5% p.a, an annual increase of at least 15% for growth sector like science and technology will be considered essential. The cost of not growing at the levels of 15% p.a for India in R&D sectors could be serious. At the annual rate of growth of 15% over the 2006-07 allocations of Rs 1300 crores, DST would require funds of Rs 1500, 1700, 2000, 2300 and 2600 crores for the years, 2007-08, 2008-09, 2009-2010, 2010-11 and 2011-12, respectively for maintaining the current levels of satisfaction of the ongoing programs. DST has also mounted a Nano mission initiative during the Xth Plan period. The mission is under advanced stage of commissioning. In principle approval for the budget outlay for the mission has been obtained at Rs 1000 crores. The fund flow planning for this approved mission has also targeted an annual growth of 15% p.a with the first year provision of Rs 150 crores. Therefore, at the annual, rate of 15% over the 2006-07 budget including the newly launched nano technology mission would call for a minimum budget of Rs. 11,100 crores for DST.

Two important initiatives have been strongly advocated by the scientific community in recent times. There is a wide recognition that talent attraction to study and careers with science is essential. The Department has proposed a new initiative with a suitable scale for criticality. It is called “Innovation for Science Pursuit for Inspired Research, (INSPIRE)”. The scheme targets a major thrust to attract children in the age group of 10-17 for excitements with innovative experience as well as an assured opportunity scheme for the youth in the age bracket of 17-32. This is considered an essential scheme with a foresight into increasing the preparedness of India for leveraging the talent supply chain. Another initiative of the country to be implemented through DST is Science and Engineering and Research Board (SERB) with a budget outlay of Rs 5000 crores for the XIth Plan period. The budget demands of the new emerging foundation will be maintained at least 5% above the 15% level of other programs. The total first year allocation for the SERB, INSPIRE, Security technology and other new initiatives is planned at Rs 1000 crores which includes an allocation of Rs 620 crores for SERB and Rs 380 crores for all other new programs including INSPIRE, respectively.

The basic approach of DST in the preparation of the eleventh plan period has been as follows. The ratio of ongoing initiatives to the new program focus is maintained at 60: 40 in terms of funding. There is a compelling reason and justification for both SERB and INSPIRE and related programs to be launched during the XIth Plan. Already, there have been concerns that Indian competitiveness in science and technology is eroding on account of an inadequate ratio of R&D investments as a percentage of GDP namely 0.8% in comparison to those of 1.3% in China, 2.9% in Korea, 2.67% in USA, and 4.27% in Sweden. DST, as the main extra mural finding agency of the country cannot afford not to invest into programs like the rejuvenation of research in university and special programs for attraction of talents to study and careers with science.

The Steering Committee constituted by the Planning Commission to develop the approach paper of Indian S&T system has recognized the criticality of several programs for the urgent and time bound rejuvenation of the university and research and development infrastructure. The committee has recognized that DST has made a moderate demand for grant and has recommended that additional support programmes be mounted into the scope of planned programmes of DST in the SERB related initiatives and recommended an additional Rs 11600 crores over and above Rs 19300 crores.

Investment into the programmes of DST is related to the future of the health of science and technology base of India. With technology-led GDP growth having emerged as the national agenda of India, there is compelling need to invest into the planned new programmes of the DST. The ratio of demands for the XIth to Xth Plan period may seem large, only if the funds invested into R&D during the Xth Plan period were considered optimal. There are perceptions in both scientific community and the representatives of the public that the budget allocations in the previous years may have been suppressed and a correction is necessary in the allocation of the XIth Plan period.

DST plans to spread the viable R&D base from the current ~300 institutions into >1200 institutions during the XIth Plan period through more efficient outreach programmes. It is estimated that about 40 institutions generate the major research publications output of India currently. DST plans to strengthen the S&T system such that at least 120-160 institutions will start delivering intellectual products of global average standards. In other words, the budget planning of DST is based on increasing the outreach by more than four times and is based on the target of enabling the country to improve the relative rank from the current 14th to 7-8th in number of publications in Science Citation Index in several key areas through improved EMR funding. Therefore, the seemingly larger ratio of demands for funds for the two successive plan periods may need to be viewed with a mind set of investments and output directed development path of India rather than as expenditure and input-led growth model.

TABLE – 3.8: Attracting and Retaining Young People to Careers in Science and Technology

Topic/ Programme	Funds Proposed XIth Plan (Rs. In Crore)	To Be Routed Through	Mechanisms/ Remarks
A. Massive Revitalisation of University Sector			
1. Select 10 premier universities in the country for major support to bring them on par with global standards.	**2000**	**DST**	**Recommended to be included in DST's budget**
2. Select about 20 universities other than those in item (1) above.	**1500**	**DST**	**-Do-**
3. Special grants to IITs and leading PG universities (total about 20) for starting quality undergraduate courses in sciences.	**200**	**DST**	**-Do-**
4. Expanding PG and Ph.D level programmes in IITs and NITs to bring R&D strength to global standards.	**1200**	**DST**	**-Do-**
5. Each State to eventually have at least one centrally funded university. 10 State Universities to become centrally funded.	**1000**	**MHRD/ DST**	**-Do-**
6. Initiate post B.Sc.-2 year B.Tech programmes (followed by M. Tech degree courses) in 20 universities.	**1500**	**DST/DBT 1000/500**	**Recommended to be included in the budget of DST and DBT**
7. Additional one-time grant to the three Inter- University Centres (IUCAA,IUAC,UGC-DAE Consortium).	**300**	**DST**	**Already reflected in the budget of DST**
8. Infrastructure support to about 400 colleges identified for their potential for excellence.	**400**	**DST**	**-Do- (FIST to be enlarged)**
9. Strengthen INFONET in the university system massively.	**500**	**DST**	**To be allocated from the proposed programme of Knowledge Commission**
10. Involve major scientific institutions/ universities in a big way for Satellite/EDUSAT-based higher education programmes for large scale use.	**100**	**DIT/DST (50), Department of Space(50)**	**Already reflected in the budget of DST and Dept. of Space**
B. Support to Science Academies			
11. Strengthening the initiatives of Academies and rewarding excellence **i) Educational Programmes** (summer programmes/ refresher courses, etc)	**30**	**DST**	**Recommended to be included in the budget of DST**

Topic/ Programme	Funds Proposed XI[th] Plan (Rs. In Crore)	To Be Routed Through	Mechanisms/ Remarks
ii) National Professorships (100) (Compensation at the level of INSA Professorship) research grant may also be awarded.	**30**		
iii) National Post-doctor Fellowships (500) (This includes 100 Fellowships for outstanding young researchers)	**100**		
C. Individual Schemes for Teachers and Students			
12. Promoting research and mobility among teachers and students.			
i) Support to individual college teachers for research	**200**	**DST**	**Already included in DST's budget**
ii) Support for Visiting Teacherships	**10**		
iii) Support for retired scientists teaching at colleges / universities.	**5**		
iv) Permit direct admission of B.Tech degree holders to Ph.D. in Science.	**—**		
13. Scholarships for students			
i) NTSS Total number of scholarships after Class VIII to be raised to 10,000 (from the current 1000) for the hole country.	**100**	**MHRD (NCERT)**	**Not included in S&T budget**
ii) KVPY Number of Fellowships to be tripled. Nurture camps to be essential part of the programme, as at present.	**50**	**DST**	**Already includedin DST's budget**
iii) National Scholarships (For1500 UG & 1000 PG students)	**50**	**DST**	**Already included in DST's budget**
iv) Olympiads (6 subjects)	**10**	**DAE**	**Recommended to be included in DAE budget**
14. 15 Years Assured Career Support Programme Phase I, II and III each for 5 year periods	**150**	**DST, Office of PSA**	**Already included in DST's budget**
Total	**9435**		

Summary

DST- Rs. 7460.00 crores

DBT- Rs. 500.00 crores

DAE- Rs. 10.00 crores

TABLE – 3.9: Thrust Areas in Basic Sciences

Topic/ Programme	Funds Proposed XIth Plan (Rs. In Crore)	To Be Routed Through	Mechanisms/ Remarks
1. National Science and Engineering Research Foundation (NSERF)	**5000**	**DST**	**Already reflected in DST budget**
2. Initiative for Recruitment of New Faculty/ Postdoctoral Fellows			
a) New Faculty (1000 positions over 5 years)	**50**		**Included in Table 3.8**
b) Start-up grants for new faculty (~20 lakhs per faculty)	**200**		
c) New Postdoctoral Programs (500 Research Associates/ PDF per year)	**80**		
3. Special Scheme to upgrade Select University Departments (25 Universities at 40 crores per university).	**1000**		**Included in Table 3.8**
4. Inter-Institutional Linkages to promote National Institution/ University Collaborative Programs.	**100**		**Included in Table 3.8**
5. Cyber Security	**100**	**DST (excluding MIT, NTRO)**	**Recommended to be included in the budget of DST**
6. New Research Infrastructure			
a) Nanofabrication facilities (5 Centres at 80 Crore per Centre)	**400**	**DST**	**Already reflected in DST budget**
b) Synchrotron for Basic Research in Material Biology, Chemistry, Physics and Particle Accelerator Based Research	**200**	**DST**	**Recommended to be included in the budget of DST**
c) High Magnetic Field Laboratory	**50**	**DST**	
d) Molecular and Medical Imaging Centres (2 Centres)	**200**	**DBT**	**Already reflected in DBT budget**
e) Institutions to bridge the gap between biological and clinical research (Transnational facilities) (2 institutions)	**200**	**DBT**	**Already reflected in DBT budget**
f) Facilities for inter-disciplinary areas like Nanobiology, cognitive science and systems biology	**500**	**DBT/DST**	**Already reflected in DST/ DBT budget**
g) Analytical instrumentation for Chemical/ Pharmaceutical/ Forensic Sciences	**150**	**DST**	**Already reflected in DST/ DBT budget**

Topic/ Programme	Funds Proposed XIth Plan (Rs. In Crore)	To Be Routed Through	Mechanisms/ Remarks
h) Photonics	**200**	**DST**	**Recommended to be included in the budget of of DST**
i) Centres for Mathematical and Computational Sciences including Computer Clusters and Centre for Cryptology	**500**	**DST (250)/ DAE (250)**	**Already reflected in DAE budget**
j) Directed Basic Research involving collaboration of academic laboratories and mission oriented laboratories (Technology Utilization Centres) five centers	**350**	**DAE/DBT/ DSIR(150) (100) (100)**	**Recommended to be included in the budget of DAE, DBT, DSIR**
k) Basic Research in Earth Sciences (Advanced Centres for Seismology, Ocean Research, Atmospheric Sciences including long range weather forecasting)	**250**	**Ministry of Earth Sciences**	**Already reflected in Ministry's budget**
l) Special initiative at the interface of biological sciences and agricultural sciences to promote collaboration in plant molecular biology and transgenic animal research.	**200**	**DBT**	**Already reflected in DBT's budget**
m) Science Initiative in Ayurveda (This activity is based on the outcome of a SAC-C coordinated meeting and will bring methods of modern science to further our understanding of Ayurvedic practices, hopefully triggering research in "Ayurvedic Biology")	**50**	**DST, Office of PSA**	**Recommended to be included in DST's budget**
Total	**10480**		

Summary

DST- Rs. 600.00 crores **DAE- Rs. 150.00 crores**

DBT- Rs. 100.00 crores

DSIR- Rs. 100.00 crores

TABLE – 3.10: Mega Science Projects

Topic/ Programme	Funds Proposed		To Be Routed Through	Mechanisms/ Remarks
	XIth Plan (Rs. In Crore)	XIIth Plan		
1. High Energy and Nuclear Physics				
a) International Linear Collider and related programs	**43.5**	**10**	DAE(38.5), DST (5)	**All items included in DAE/ budget**
b) India based Neutrino Observatory (INO)	**320**	**350**	DAE	
c) National Radioactive Ion Beam Facility	**75**	**495**	DAE	
d) Facility for Antiproton and Ion Research (FAIR)	**35**	**10**	DAE	**DST budget**
2. Astronomy based Research	**-**	**-**	TIFR	
3. National Hetero-structure Facility	240	60	DST	**Already included in DST's budget**
4. Indigenous passenger Aircraft Development	635		CSIR	**Already reflected in CSIR budget**
Total	**1348.5**			

TABLE – 3.11: Cross Disciplinary Technology Areas

Topic/ Programme	Funds Proposed XI[th] Plan (Rs. In Crore)	To Be Routed Through	Mechanisms/ Remarks
1. Desalination & Water Purification Technologies.			
i) For setting up a few medium size demonstration plants for seawater desalination in coastal zones	**75**	**DAE, DST, CSIR and Ministry of Earth Sciences**	**DAE has allocated Rs 44 crores, DST has projected a budget of Rs 300 crores for Water Mission. CSIR and Ministry of Earth Sciences have also earmarked funds for this programme**
ii) For retrofitting waste head based seawater desalination plants of 1 MLD capacity	**20**		
iii) To install and operate several small size brackish water desalination plants.	**50**		
iv) To install IMLD plants for water recovery and recycle	**20**		
v) Towards development & demonstration of point of use and small sized community water purification system.	**10**		**To be implemented and monitored by an Oversight Committee**
vi) For development of solar energy / other renewable energy driven desalination plants	**25**		
	200		
2. Nutrition : Referral Nodal Centre for Nutritional Analysis.			
i) Analysis of Macro Nutrients ii) Analysis of Micro Nutrients iii) Analysis of Water, Total Dissolved Organics, Analyzer Intelligent Water Analyzer Assembly, Turbidity and Conductivity Transducer, Chlorophyll and Algae Detector, Ion-Chromatograph. iv) Calorific value : Isoperibolic Bomb Calorimeter v) Basal Metabolic Rate : BMR Indirect Calorimeter vi) Food allergens : ELISA Spectrophotometer vii) Food Pathogens viii) Pesticide residue		**DBT**	**Reflected in DBT's budget**
Total	**25**		
3. Healthcare Technology – Medical Devices & Vaccines			
Mission mode for Orthopedic Devices and Implants i) Development of new materials , especially composites, for innovative designs.			

Topic/ Programme	Funds Proposed XI[th] Plan (Rs. In Crore)	To Be Routed Through	Mechanisms/ Remarks
ii) CAD/CAM and rapid prototyping – capacity building iii) Clinical evaluation and testing Infrastructure iv) "Enabling Technology Centres" for pilot production and incubation v) Precision fabrication and special purpose machining capability vi) Rehabilitation engg. – materials for better quality prosthetics and orthosis vii) Rehabilitation engg. – better manufacturability with automation and quality control in cottage industry mode and low cost of operations viii) Rehabilitation engg. – new centers for clinical delivery and user training ix) Academic-industry consortium for rapid product development.		**DBT/ Ministry of Health and Family Welfare**	**To be implemented and monitored by an Oversight Committee DBT-RS 50.00 crores**
Orthopedic Devices and Implants	**70**		
Mission mode for Medical Instrumentation and Diagnostics; telemedicine. i) Instrumentation for improved, low-cost, clinical monitoring and diagnosis. ii) Clinical Engineering Programme iii) Medical diagnostic kits and consumables		**DST**	**DST-Rs. 50 crores**
Medical Instrumentation & Diagnostics	**100**		
Low cost (to scale to all villages) tele-diagnostic kits supporting telemedicine initiatives	**20**		
Mission on Diabetes Technologies i) Novel Delivery systems ii) Footwear and foot care products for diabetic patients iii) Rehabilitation of diabetic patients with disabilities iv) Improved wound dressings for treating diabetic ulcers.		**CSIR**	**Can be adjusted in CSIR's budget**
Focus on Diabetes Technologies	**30**		

Topic/ Programme	Funds Proposed XIth Plan (Rs. In Crore)	To Be Routed Through	Mechanisms/ Remarks
Mission on Vaccine Development & Tissue Engineering : Initiatives & Programmes i) Modernisation of existing vaccines & newer vaccines ii) Vaccines against HIV, TB Malaria & Cancers, etc iii) Combination vaccines development iv) Vaccine Stabilization and delivery		DBT	Reflected in DBT's budget
Focus on Vaccine Development	50	DBT	Reflected in DBT's budget
Tissue engineering: replacement for cartilage, cornea, skin, heart valves, etc	30	DBT	Reflected in DBT's budget
Mission on Medical Device Regulation i) National Bio-medical Devices Regulatory Authority ii) Testing and evaluation infrastructure	 120 30	DST	DST-100 crores
Total	450		
4. Advanced Computing Hierarchical cyber-infrastructure supporting Grid Computing with the following five layers of computing and communication set ups i) Single processor workstations (with 100 Mbps connectivity) ii) Multiprocessor Computing System iii) Clusters, each node comprised of several SMPs connected by a state-of-the-art high-speed switch with 1Gbps network iv) One very large Cluster for the most demanding computational modeling activities v) A global computing layer built upon the collection of Campus Clusters interconnected to a Terabit All-optic Network	500	DST	DST- Rs. 250 crores To be implemented and monitored by an Oversight Committee
5. Advanced Manufacturing i) Material Development ii) Materials Processing iii) Manufacturing	 15 35 50	DST	DST- Rs. 80 croresTo be implemented and

Topic/ Programme	Funds Proposed XI^th^ Plan (Rs. In Crore)	To Be Routed Through	Mechanisms/ Remarks
iv) Human Resources v) Development of Magnesium Components for Automobile applications vi) Manufacturing Technologies and others	5 5 50		**monitored by an Oversight Committee**
Total	**160**		
6. Robotics & Automation i) Centre for Robotics ii) Design and development of Vision Guided Mobile Robotic Systems iii) Development of self-learning adaptive controller on embedded platform		**DST**	**DST- Rs. 70 crores to be implemented and monitored by an Oversight Committee**
Total	**150**		
7. Combustion Research Establishing a center for excellence in Combustion Research comprising of i) Facilities for Combustion and Instruments for : Velocity Measurement, Spray Diagnostics, (Droplet size and velocity), Temperature measurement, Time resolved temperature Fuel-Air Mixing, Reacting Zone Imaging, Major Species Measurement, Soot Measurement, Particulate Measurement, Engine Pressure and Emissions Measurement Systems, Flow and other auxiliary measurement devices, Engine dynamometer, Data Acquisition System, Image and Data Processing Software ii) Computational Facilities including CFD Codes			**DST- Rs. 100 crores**
Total	**100**		
8. Sensors and Integrated Systems R&D on High Sensitivity, Sensors and Systems i) Physical Sensors (SQUID, CMR, Piezo, MEMS..) ii) Chemical Sensors iii) Terrahertz Technology iv) Miniaturisation Packaging, instrumentation and validation		**DST**	**DST- Rs. 100 crores to be implemented and by an monitored Oversight Committee**

Topic/ Programme	Funds Proposed XIth Plan (Rs. In Crore)	To Be Routed Through	Mechanisms/ Remarks
v) National facility for VLSI Testing and Failure Analysis vi) Thin Film Transistor Technologies			
Total	**250**		
9. Distributed Sensors & Networks i) Electric Design Automation Tools ii) Customs built Production of Chips at Fabs in India and Outside iii) Packaging iv) Integration with front end electronics		**DST, CSIR**	**DST-Rs 100 crores CSIR- Rs. 100 crores to be implemented and monitored by an Oversight Committee**
Total	**200**		
10. Security Technologies i) Basic Technologies for Surveillance systems, Distributed and Mobile systems security, Network and information security which includes cryptology and crypto analysis and fast searching of massive remote distributed data bases.			
Total	**450**		
11. Advanced Functional Materials i) Centre for synthesis of advanced functional materials in a variety of forms ii) Processing of materials iii) Materials integration for devices, Micromachining, etc. iv) Computer simulation and design of materials		**DST, CSIR**	**DST-Rs 100 crores CSIR- Rs. 100 crores to be implemented and monitored by an Oversight Committee**
Total	**200**		
Grand Total	**2685**		

Additional (based on brainstorming session on specific topics) Rs. 2000 Crores to be placed under DST

Summary

DST- Rs. 2950.00 crores, DBT- Rs. 50.00 crores, CSIR- Rs. 200.00 crores

TABLE – 3.12: Science & Technology for SMEs

Topic/ Programme	Funds Proposed XIth Plan (Rs. In Crore)	To Be Routed Through	Mechanisms/ Remarks
1. Ongoing Schemes and Programmes	**6500**	Various Ministries mainly SSI	Not to be considered in S&T budget
2. 170 Technology Business Incubators & 50 Technology Innovation Centres	**1100**	DST	Partly projected in DST's budget
3. Mission mode programmes for S&T interventions in 7 SME clusters	**50**	TIFAC	Included in TIFAC's budget
4. Technology Profiling of SME clusters	**50**	TIFAC	Included in TIFAC's budget
5. Information & Communication Technology	**160**	(ICT) for SMEs (Ministry of SSI)	Not to be considered in S&T budget
6. Development of Special Purpose Machines	**50**	TIFAC/ INAE	Included in TIFAC's budget
7. Promoting Academia-SME interaction in Innovation	**120**	INAE/ TIFAC, Engineering Colleges, Community Polytechnics, ITIs, etc.	
	8030		

TABLE – 3.13: Effective Rural Technology Delivery (including partnership with Voluntary Organizations)

Topic/ Programme	Funds Proposed XIth Plan (Rs. In Crore)	To Be Routed Through	Mechanisms
1. 500 Enterprises covering 100 districts	100	DST	To be implemented through the office of PSA.
2. 5 Rural Technology Delivery Centres	50	DST	Recommended to be included in Sl. 12.3 in DST's budget

Summary

DST- Rs. 150 crores

Table-3.14: Strengthening Academia Industry Interface

	Topic/ Programme	Funds Proposed XIth Plan (Rs. In Crore)	Mechanisms/ Remarks
1.	Five Centres of Relevance and Excellence (CORE) in areas of direct relevance to Industry	250	
2.	Student internship for industry	100	
3.	Next Generation innovation Missions on the lines of CORE	500	
4.	Core shared facilities with industry	1000	
	Total	1850	

Table-3.15: S&T for Socio-economic Ministries

	Topic/ Programme	Funds Proposed XIth Plan (Rs. In Crore)	Mechanisms/ Remarks
1.	STACs in Techno-economic and Socio-economic Ministries	2% of total allocation to the Ministries	
2.	STAC-Department of Science & Technology	5% of total allocation to DST	
3.	State S&T Councils (Total allocation recommended for various planned intervention)	5000	

Table - 3.16: Summary of Additional Budget Allocations by other Working Groups

Rs. in crores

S. No.	Project Name	DST	DBT	DAE	DSIR
1.	**Attracting and Retaining Young People to Careers in Science and Technology**	7460.00	500.00	10.00	-
2.	**Thrust Areas in Basic Sciences**	600.00	100.00	150.00	100.00
3.	**Mega-Science Projects**	-	-		-
4.	**Cross Disciplinary Technology Areas**	**2950.00**	**50.00**	-	**200.00**
5.	**Science & Technology for SMEs**		-	-	-
6.	**Effective Rural Technology Delivery (including partnership with Voluntary Organizations)**	**150.00**	-	-	-
	Total	**11160.00**	**650.00**		**300.00**

Table 3.17: Proposed Plan Allocation: Central S&T Departments/ Agencies

(Rs. in Crore)

Sr. No.	S&T Departments/ Agencies	Xth Plan Outlay	Xth Plan Actual	XIth Plan Proposed By the Dept	Additional budget recommended by Working Groups	XIth Plan Reco-mmended
1.	Department of Atomic Energy	1003.00	3200.00	11010.53	160.00	11170.50
2.	Department of Biotechnology	1450.00	1680.23	12000.00	650.00	12650.00
3.	Ministry of Earth Sciences	1540.25	1636.24*	12008.91		12009.00
4.	Department of Scientific & Industrial Research (including Council of Scientific & Industrial Research)	2574.00	3089.00	18733.00	200.00	18933.00
5.	Department of Space	13250.00	11502.00	36750.00		36750.00
6.	Department of Science & Technology	3400.00	4398.81	19300.00**	11160.00	30460.00**
	Total		25506.28			121972.50

* This figure includes allocations to IMD, NCMRWF and IITM when they were under DST

** This is due to several new programmes, particularly those related to attracting young people to careers in science, suggested by the Steering Committee to be piloted through DST and the NSERF. The factor of increase for DST without these additionalities is given in parenthesis in the last column.

4

Review and Assessment of the Tenth Five Year Plan Programmes of the Central S&T Departments/Agencies

The Xth Plan had for the first time made some recommendations that indicated a paradigm shift in terms of approach to use of science and technology as a means to national development. This was appropriate because of the change in the economic order both in terms of global opportunities in business and trade and also increased aspirations of the people of our country. Some of the generic fundamentals such as building and maintaining a strong science base; initiating mission mode programmes; development of clean technologies; intensification of science and technology activities in the states and union territories; etc., were mentioned both in the IXth and Xth Plans and the programmes were designed based on these issues. Additionally, the Xth Plan recommended initiatives towards academia- industry interaction, greater use and leveraging of the S&T infrastructure, application of S&T to rural areas and small scale industries, development of S&T manpower as dictated by the need of the country, restructuring of government ministries / departments and also R&D institutions and National Laboratories, etc. The funding for research and development in the S&T sector continued primarily through the scientific ministries / departments of the Central Government and the mission mode agencies.

A summary of some of the significant achievements of the Central S&T Departments Agencies during the Xth Five Year Plan is given below (more details may be found in the reports of the respective departments). The financial performance is reflected in **Table 4.1.**

Table 4.1 Allocations and Expenditure of the Scientific Departments during the Xth Plan

(Rs. in Crore)

Sr. No.	S&T Departments/ Agencies	Xth Plan Outlay	Xth Plan Actual
1.	Department of Atomic Energy	3443	3200
2.	Department of Biotechnology	1450	1680
3.	Ministry of Earth Sciences	1540	1636
4.	Department of Scientific & Industrial Research	2574	3089
5.	Department of Space	13250	11502
6.	Department of Science & Technology	3400	4399

4.1 Department of Atomic Energy (R&D Sector)

Department of Atomic Energy (DAE) has been pursuing its mandate of research in the use of atomic energy for power and non-power related uses. Being a multi-disciplinary and multi-functional organisation it has pursued research in basic science, development of technologies and transferring them to the industrial domain. Research in these fields are continued to maintain the cutting edge. It has participated and contributed in international mega-science projects and its contribution is recognized by the international scientific community. During the X^{th} Plan, the work of the Department was categorized into seven major programmes and their related sub-programmes. Programme-wise progress made by the plan projects during the X^{th} Plan are highlighted below:

4.1.1 Nuclear Power Programme – Stage – 1

- Work on development of PHWR-Fuels, Materials, Safety & Water chemistry progressed as per schedule
- Installation of equipment and systems of hot facility of P-4 Experimental facility completed
- On-line system for vibration diagnostics of steam turbine developed
- Methodology for evaluation of passive systems named Assessment of Passive System Reliability(APSRA) developed
- New technique based on ultrasonic sensor developed for generating axial creep data for PHWR pressure tubes
- Arial, reconnaissance, detailed and geochemical survey targets being met leading to augmentation of U3O8 resources
- Technology for production of identified metal extractants developed and transferred to Heavy Water Board for setting up full scale plants
- IERMON set up at 37 stations across the country. Intended to expand to 500 stations for getting on-line radiation data
- Mobile radiological survey laboratory developed and deployed

4.1.2 Nuclear Power Programme – Stage – 2

- Mark-I fuel reached burn-up of 154.3 GWd/t without any fuel pin failure in the core
- Post Irradiation Examination conducted on 100 GWd/t of FBTR fuel sub assembly
- CORAL, first facility in the world to reprocess high Pu content carbide fuel at high burn-up successfully commissioned. Fuel of 25, 50 and 100 GWd/t burn-up from FBTR successfully reprocessed
- Indigenous development of activated flux for autogenous TIG welding successfully carried out towards characterization of mechanical properties

- Sodium resistant concrete developed to protect structural concrete
- Steam Generator Test Facility commissioned
- Commissioning of ¼ scale model (SAMRAT) of reactor assembly and successful completion of experiments on it
- Experiments carried out for design validation of PFBR
- Major NDT Studies of reactor components carried out
- Production of Boric acid enriched in ^{10}B upto 65% achieved and technology transferred to Heavy Water Board for setting up a large scale plant
- R&D programmes for back end of FBR fuel cycle taken up
- Prototype Fluidic Pumps developed for the first time in the country
- Lab scale facility for developing remote fabrication of oxide fuel through sol-gel process is under commissioning
- Comprehensive programme on development of metallic fuels for FBRs launched
- Atmospheric dispersion models to predict radiological impact with on-line access commissioned
- Lab scale Supercritical Fluid Extraction Facility set up for recovery of actinides from waste materials. Recovery of U, Pu and Am from tissue paper waste has been demonstrated.

4.1.3 Nuclear Power Programme – Stage – 3 and Beyond

- Development of fuelling systems & control systems for refueling machine made good progress. AHWR fuelling machine (prototype) to be completed soon
- Development programmes for advanced nuclear reactors undertaken
- New process based on coated agglomerate particles for Th-U^{233} MOX fuels developed
- Pilot plant for production of pure beryllia and process development for fabrication of beryllia shapes were set up
- Laboratory development on vitreous matrices for HLW from AHWR/FBR carried out
- Hot cell facilities for processing of Th fuel for immediate requirement of U^{233} for AHWR programme are being set up at Trombay
- Design and development work for ADS system being undertaken
- India joins ITER as full partner

4.1.4 Advanced Technologies and Radiation Technologies and their Applications

4.1.4.1 Advanced Technologies and their Applications

- Refurbishing of CIRUS reactor completed

- Fundamental studies in physics, chemistry, biology, etc., and application of laser in medical, industrial, material processing, defence, etc., undertaken
- A set up using Nd:YAG laser (of up to 250 W average power) developed and deployed for in-situ cutting operation of en-masse coolant channel replacement at Narora power plant
- Facility for autogenous laser welding of automobile transmission gear assemblies using indigenously developed high power CO_2 laser set up at RRCAT
- RRCAT has set up a Metal Organic Vapor Phase Epitaxy (MOVPE) facility to grow multilayer structures for developing laser diodes
- Several critical cryogenic components for helium liquefiers have been developed indigenously
- Substantial progress has been made in the development of the processes for ceramic materials synthesis and thin film processes for tube geometry for the solid oxide fuel cell components.
- Eight types of ASICs, such as, singleplex, CODA, MICON, BLR, etc, and eleven types of Hybrid microcircuits were developed for DAE applications
- A host of high technology detector for HR Gamma Chambers, Boron and Tritium chambers, Beam Loss Monitor, SPND and He detectors have been made
- Technologies of the intelligent gauging instruments and advanced mass spectrometer have been demonstrated
- Development of Beam Technologies for Nuclear and Non Nuclear Applications taken up
- A 10 MeV RF Linac at Kharghar, Navi Mumbai has been installed and made operational at low power
- 3 MeV DC accelerator with RF oscillator to be commissioned in the 5^{th} year of this plan

4.1.4.2 Radiation Technologies and their Applications

- Seawater desalination unit for demonstration of low temperature vacuum evaporation process utilizing low-grade reactor waste heat integrated with CIRUS. Plant producing 30 Te/day desalinated water
- An 1800 m^3/day RO based desalination plant is under operation at Kalpakkam. Two smaller plants installed in Tamil Nadu and O&M transferred to local authorities
- Two varieties of Groundnut and one variety each of Soybean and Mung released and notified by Min. of Agriculture. Six varieties of oilseeds and pulses released by various Agriculture Universities are awaiting notification by Min. of Agriculture. So far 26 elite Trombay varieties released and notified for commercial cultivation
- Major developments undertaken in the field of biotechnology
- Food irradiators are now in public domain. MoU signed with 14 private parties out of which 4 plants are operational and the remaining are under various stages of construction

- Laser based land leveling system built for application in agricultural fields and technology transferred to M/s Osaw Udyog of Ambala Cantt
- First medical cyclotron in India and a Positron Emission Tomography (PET) facility installed at RMC Mumbai, for diagnosis of several diseases including cancer, epilepsy, inflammatory, neurological and cardio vascular diseases
- Tiny rice size radioactive seeds based on I-125 developed for brachytherapy applications and used in clinical trials for treatment of ocular cancers
- Medical facilities at BARC Hospital augmented
- ACTREC, the R&D centre of TMC was successfully commissioned in a new 60 acre campus in Kharghar, Navi Mumbai
- Bhabhatron, the indigenous telecobalt machine developed at BARC successfully commissioned at ACTREC. Technology transferred to a private entrepreneur
- Construction of a new eleven storied Tata Clinic with state-of-the-art radiotherapy and other therapeutic facilities started
- At TMH, facilities for film-less operations, including the necessary infrastructure for the capture, archival and distribution of radiological images, have been established
- A telemedicine network connecting all the Regional Cancer Centres with TMC has been commissioned. So far 19 cancer hospitals including seven in the North East and two from abroad have been connected with Tata Memorial Hospital
- In IGCAR, the feasibility study on application of thermal imaging for detecting early breast cancers has been initiated. Early results are promising. Clinical trials are underway
- India's first green laser photo-coagulator for treatment of diabetic retinopathy of the eye, developed and delivered to M/s Aurolab for clinical trials
- Extensive studies on the use of laser induced fluorescence technique for cancer diagnosis carried out

4.1.5 Basic Research

- Development, testing, fine tuning and commissioning of 512 node Xeon based Anupam-Ameya super computer has been completed giving a speed of 1.7 teraflop
- High Performing Computing facility including the Cray XD1 set up at S INP
- A National facility for High Field NMR studies with 500, 600 and 800 Mhz spectrometers has been commissioned and is being utilized by several institutions in the country
- The Indian National Gamma Array (INGA) was successfully set up and utilized by scientific community from BARC, TIFR, SINP, VECC and IUAC and universities
- GMRT has achieved significant international success

- Indian Lattice Gauge Theory Initiative was undertaken at TIFR, VECC, SINP, IMSc, HRI and IOP has made good progress
- Superconducting Cyclotron set up at VECC, Kolkata. Largest superconducting magnet has been built in the country for this Superconducting cyclotron
- Synchrotron Radiation Source Indus-2 set up at RRCAT, Indore. First synchrotron light out of Indus-2 was recorded on December 2, 2005 and the facility was dedicated to the Nation by Prime Minister on December 17, 2005.
- Superconducting Linac booster (joint BARC-TIFR effort) and several small accelerators for a variety of applications set up
- Notable progress made in low energy, ISOL-based Radioactive Ion Beam facility at VECC
- Contributed high quality components for the world's biggest particle accelerator, Large Hadron Collider
- Delivered Photon Multiplicity Detector for Relativistic Heavy Ion Collider at Brookhaven National Laboratory
- First beam line in the new beam hall of FOTIA has been installed and commissioned
- SST-1 fabricated and assembled. Commissioning test under progress
- Components of Neutron Beam Injector System fabricated. Assembly on test stand and commissioning to be completed in the X Plan
- Advanced New Systems for SST-1 Auxilliary Heating has progressed well
- A number of advanced diagnostics have been developed
- ADITYA diagnostics have been upgraded and RF system installed
- Development of nanomaterials and nanotechnology have been taken up
- Gas sensors for measuring ppm levels of hydrogen developed
- MEMS based silicon ultrasonic transducer for inspection of FBR components developed
- Basic research in material science carried out using 1.7 MV Tandetron accelerator commissioned during this plan
- SQUID based sensors developed
- Facility for growth of device quality single crystals established and crystals developed
- At IOP, several nanostructure semiconductors were synthesized
- Work on bio-molecule capping of nanostructures and activities on nanobiointerface initiated
- New MOVPE system for GaN based material established at TIFR
- High purity antimony prepared and methodology to prepare 7mm dia rods of desired density and uniform thickness developed at BARC

- SQUID magnetometer with 10-7 emu sensitivity commissioned using the indigenously developed SQUID sensor.
- High throughput technologies are being established at different DAE institutes for basic biological research
- Assessment of genetic and health effects of continuous high level natural radiation in Kerala continues. No deleterious affects have been noticed thus far
- DNA based analysis has been carried out on more than 250 families and health audit survey has been completed in 25000 houses in the Monazite belt of Kerala
- Drug-resistant mutants of HIV-1 protease enzyme have been produced in large quantities at BARC for crystallization trials
- Several proteins involved in leukemia, thalassemia and Huntington's disease have been cloned and their structures and interactions with other proteins investigated at SINP
- An optical imaging facility has been established with a laser scanning confocal microscope and two epifluorescence microscopes at TIFR
- At TIFR investigations were undertaken in a variety of areas and interesting results obtained in respect of cellular signaling, development of nervous system, motor-cargo interaction and proteins of malarial parasite
- At NCBS, TIFR, Bangalore, methods have been developed for detecting structural similarity of distantly related proteins
- That the pathways of cell death in plants and animals share critical mitochondrial components was demonstrated
- Mechanism of stress induced changes in neuronal architecture and behavior deciphered
- Optical coherence tomography (OCT) set up developed and used for various experiments

4.1.6 Research Education Linkage

- HBNI as a deemed to be University launched
- TIFR recognized as deemed to be University
- HBNI and TIFR to strengthen linkages between R&D and technology and generate scientific manpower
- TIFR is starting 5 yrs integrated M.Sc-PhD programme this year
- Centre of Advanced Research and Education (CARE) set up at SINP
- BRNS and NBHM continues to sponsor research in the field of nuclear science and Mathematics respectively
- HBCSE started National Initiative for Undergraduate Science

- Olympiad programmes of HBCSE have yielded impressive performance in international Olympiads

4.2 Department of Biotechnology

The Department of Biotechnology established in 1986, has completed two decades of existence. Human resource development, establishment of biotechnology facilities and capacity building for R&D in priority areas has been given thrust. Consistent with this, the Xth Plan had objectives of enhancing the knowledge base and generating highly skilled human resource; nurturing research leads of potential utility through adequate facilities and infrastructure; and bringing bio-products to the marketplace through innovative policies and partnerships.

- The area-wise achievements during Xth Plan period are:

4.2.1 Human Resource Development

- Sustained support at M.Sc./M.Tech level extended by starting 22 new courses in Xth Plan to increase the total to 63 courses for 1000 postgraduate students. These new courses include those in marine, agriculture, veterinary, medical, pharma, bio-chemical, biochemical engineering, etc.
- Seven universities and R&D institutions provided one time financial support under non-recurring grant for strengthening their ongoing PG teaching courses

4.2.2 Biotech Facilities

- 35 facilities during Xth Plan for production and supply of biologicals, reagents, culture collections and experimental animals set up
- International Depository Authority established at IMTECH, Chandigarh for patent deposits. It is the first such facility in India, 7th in Asia and 34th in the World.

4.2.3 Centres of Excellence

- A total of 9 centers of excellence supported in 2005-06 in diverse areas such as Cancer Biology and Therapeutics, industrially important non-conventional yeasts;
- Progammes supported for the development of drought tolerant crop varieties and characterization and validation of the mangrove genes in transgenic rice systems for abiotic stress tolerance undertaken.
- Coordinated Research on Tuberculosis for development of Alternate Strategies undertaken.

4.2.4 Bioinformatics

- Established an extensive Bioinformatics Network, covering 65 institutions, spread geographically all over the country. This network consists of Centre of Excellence (CoE), Distributed Information

Centres (DICs) and Sub-DICs. Scientists of this network have published more than 1200 bioinformatics research papers in peer reviewed journals in last five years and helped in publishing more than 3500 research papers in biology / biotechnology.

- Dedicated High Speed Network for the BTISnet – VPN and a Super Computer Facilities for Bioinformatics has been established. 12 major institutions have been inter-connected through high speed Network in the form of VPN (Biogrid India). Courses such as M.Sc. / M.Tech / Ph.D. in Bioinformatics has been introduced. Around 400 short-term training courses has been organized in different areas of Bioinformatics, training more than 4000 researchers & scientists.

4.2.5 Research & Development

4.2.5.1 Agriculture & Allied Areas

- **Crops Biotechnology:** Besides Plant Molecular Biology programmes, important programmes on rice genome sequencing, rice functional genomics, development of rice tolerant to drought and salinity, cotton resistant to bollworm, rice resistant to tungro virus, brinjal resistant to fruit and shoot borer, field trials of mustard lines with barnase / barstar genes, gene pyramiding for leaf and strip rust resistance in wheat, development of markers for wheat quality improvement, biotechnological interventions for improving important millet crops supported. Recently, projects on Crop biofortification have been initiated for enhanced Iron and Zinc contents and reduced phytates, in wheat, rice and maize through marker assisted breeding / transgenic approaches.

- **Plant Biotechnology:** Programmes supported on forest trees, horticulture and plantation crops. The thrust is on application of tissue culture for regeneration of high quality economically important plant species, demonstration of large-scale plantation and validation of proven technology; germplasm characterization, improvement of crops through molecular biology tools, basic research, genomics initiative; host pathogen interaction, resolving of taxonomic problems by molecular interventions, etc.

- **Biological agents:** Four mass production technologies for biocontrol agents / biopesticides developed and standardized. Mass production technology of *Trichoderma viride* (fermentation based) has been transferred. Six patents have been filed for the mass production technologies of various biocontrol agents.

- **Biofertilizers:** Information for transgenic biofertilisers generated with the objective of developing better nitrogen fixing microorganisms.

- **Animal Biotechnology:** Technology for the production of recombinant protective antigen (recombinant anthrax vaccine) developed and transferred, Leads in bioconversion of crop residues to animal feed and enhanced digestibility obtained, Embryo transfer techniques perfected, Molecular characterization studies of various livestock breeds carried out.

- **Animal Health:** A recombinant anthrax vaccine developed and its technology transferred to the industry. A diagnostics kit for Peste des petits ruminants (PPR) virus, based on antigen competition ELISA developed and found to be more sensitive than PCR based kit. A novel PCR based diagnostic kit for rapid diagnosis of Buffalopox virus (BPV) standardized.

4.2.6 Bioresources Development and Utilisation

- *An Indian Bio-resource Information Network (IBIN)* – a service and network system for all the digital databases on Bio-resources, developed under the National Bioresource Development Board (NBDB).
- Five Rural Bioresource Complexes set up at Bangalore; Hisar; Pant Nagar; Parbhani and Orissa for social empowerment and economic upliftment of the rural population. The complexes provide improved interventions for value addition to the existing technologies, with clear market linkages and buy-back arrangement. These would benefit approximately 10000 families.
- A Network of four national gene banks on medicinal and aromatic plants further strengthened. A total of about 8500 accessions of prioritized species are conserved in different forms such as in field bank, seed bank, *in vitro* repository, cryobank and DNA bank. Four technology transfer agreements finalized.

4.2.7 Basic Research and Nano-biotechnology

Several projects initiated in the area of protein engineering. 300 research articles published in National / International journals. Three technologies successfully commercialized.

4.2.8 Medical Biotechnology

- Development of newer technologies for affordable vaccines for Malaria, Tuberculosis, Cholera, HIV, Rabies and Japanese Encephalities, Helicobactor, Filariasis etc. undertaken. Efforts to develop a tetravalent dengue vaccine candidate are in progress.
- In Human Genetics, considerable progress made to carry out genetic research in SCA, schizophrenia & bipolar disorder and asthma. India is one of the first country to take up the project on Human Genome Diversity. A major consortium project implemented at Kolkata in a network manner with other 14 institutions.
- Stem cell research promoted for basic and translational research for more than 45 programmes.

4.2.9 Environmental Biotechnology

Laboratory for conservation of Endangered Animals set up. DBT-NTPC joint initiative on carbon sequestration launched. 10 technologies are ready for commercialization.

4.2.10 Food and Nutrition

Out of 19 technologies developed- 8 technologies transferred and 3 technologies commercialized.

4.2.11 International Cooperation

70 joint projects implemented in the areas of Plant, Animal, Human and Microbial Genomics, New Biology, Product and Process Oriented Research, Contraceptive and Reproductive Health Research, etc., involving more than 8 countries.

4.2.12 Biotechnology for Societal Development

- Use of biotechnological processes and tools for the benefit of entrepreneurs and also for creating a platform for employment generation among the target population, diffusion of proven and field-tested technologies through demonstration, training and extension activities supported for around 1,20,000 beneficiaries.
- Supported Biotechnology Park, Lucknow, and five Biotechnology Incubation Centres.
- Launched "Small Business Innovation Research Initiative (SBIRI)" to boost public-private-partnership effort in the country.

4.3 Ministry of Earth Sciences

Ever since the establishment of the Department of Ocean Development in 1981, the Ocean Science and Technology in the country has witnessed a significant progress primarily guided by the principles enunciated in the Ocean Policy Statement. During the last year of the Xth Plan, Department of Ocean Development, the India Metrological Department (IMD), National Centre for Medium Range Weather Forecasting (NCMRWF) and the Indian Institute of Tropical Meteorology were brought under a new Ministry named Ministry of Earth Sciences. The major responsibilities of the Ministry are formulation and implementation of programmes relating to long term economic and technological development.

4.3.1 Department of Ocean Development

- Strengthened infrastructure facilities in its three autonomous bodies (National Institute of Ocean Technology (NIOT), Chennai, Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, National Centre for Antarctic and Ocean Research (NCAOR), Goa, and 2 attached offices (Centre for Marine Living Resources and Ecology (CMLRE), Kochi, Integrated Coastal Marine Area Management (ICMAM), Chennai)
- Development and demonstration of desalination technology to cater to the needs of freshwater in coastal states and island territories of India
- Providing of Potential Fishing Advisories to fisherman, and Ocean State forecast for various stake holders
- Setting up an interim early tsunami & storm surge warning system
- Strengthening of ocean observing network by deployment of state-of-the-art technology data buoys and Argo floats, to operational weather forecast and climate variability studies

- Indigenous development of buoys, tide gauges to meet the requirement of ocean observations
- Development and transfer of technology of lobster and crab fattening for the benefit of smaller fisherman community
- Networking of institutions for conducting polar research
- Completion of geophysical surveys for delineation of Continental Shelf
- Close grid surveys in the allotted area in the Central Indian Ocean Basin under polymetallic nodule programme
- Establishment of Extractive metallurgical pilot plant to obtain Copper, nickel and cobalt from the nodules found at the seabed
- Design development and demonstration of Remotely Operable Vehicle of 6000m depth
- Development and testing of deep sea crawler at 500m depth
- Construction of Dyke at Haldia port leading to reduced cost of dredging, consultancy services to Sethusamudram & Kalpasar projects
- Launch of clinical trials two potential drugs (antidiabetic and antihyperlipedemic) from the marine organisms
- Demonstration of leadership in the Indian Ocean region to address common issues of the countries in the region
- Conducting multi-disciplinary studies to assess the Marine Living Resources in the Indian seas, and to understand a large scale variation of fishery resources.
- Development of shoreline management plans in selected coastal sensitive areas and establishment of marine ecotoxicology
- Continued systematic monitoring of coastal pollution to assess the health of the coastal seas of India and
- Strengthened basic research through setting up of a network of Ocean Science and Technology Cells.

4.3.2 Atmospheric Sciences

4.3.2.1 India Meteorological Department

- Doppler Weather Radars installed at Chennai, Kolkata, Machhilipatnam, Vishakhapatnam and Sriharikota for more accurate weather forecasting
- Installation of 100 Digital Cyclone Warning Dissemination systems along the Andhra coast
- Upgradation of meteorological capability at 4 International airports
- A Mountain Meteorology Centre was established at Delhi meteorological for inputs to prediction of landslides, avalanches and flash floods

- Capabilities in numerical weather prediction were improved by the induction of high resolution models
- Short range prediction lead time was extended from 2 days to 3 days with an additional 2 day outlook by adopting a new forecasting approach
- A new Long Range Prediction model was introduced giving more lead time and also July rainfall as an additional forecast product for helping Kharif crop sowing
- Detection and response times were considerably lowered by upgrading the seismic monitoring system
- An Earthquake Risk Evaluation Centre was established at Delhi for seismic microzonation. Seismic hazard microzonations were carried out for the city of Delhi at a scale of 1: 50,000

4.3.2.2 National Centre for Medium Range Weather Forecasting

- An end-to-end NWP system was developed.
- Continuous effort to increase reliability and scope of the forecasts was made
- For improving the location specific Medium Range Forecasts(MRF) Dynamical / statistical downscaling techniques were implemented. The Meso-scale modelling systems were implemented on specific demands from Ministry of Defence, Department of Atomic Energy and ISRO.
- On demand from Agriculture Sector and planners, challenging task of dynamical extended / seasonal prediction of monsoon was undertaken. As part of this effort, work on ocean state forecast and development of coupled model was initiated.
- To reduce the uncertainty in prediction and providing MRF in probabilistic terms, an ensemble prediction system was developed.
- A project to assess economic impact of agro-advisories based on Centre's MRF was undertaken. Preliminary results indicate a positive impact of 10-20% by way of saving the inputs and enhancing the yield levels.
- Crop-weather models for varieties of cops were validated, calibrated and transferred to AAS units for implementing weather based decision support system for farming operations.
- Customized forecasts for various other important applications(e.g. power distribution, water resources, defence, emergency response, adventure sports, special events etc.) in different sectors of economy were delivered to user agencies.
- NCMRWF is hosting a regional Centre for weather and Climate to support technological support for Economic Advancement in BIMSTEC countries. Forecasts were also provided to some other countries on their request.
- The high-end computer infrastructure was upgraded. At present the combined resource provides 1.5 TFlop peak performance.

4.3.2.3 Indian Institute of Tropical Meteorology

4.3.2.3.1 Monsoon Prediction, Climate Dynamics and Modelling

- Discovered a coupled feedback between the tropical Indian Ocean circulation and the southwest monsoon winds, on sub-seasonal / intra-seasonal time-scales.
- Demonstrated the role of Indian Ocean SST boundary forcing in influencing the monsoon intra-seasonal variability and the seasonal monsoon rainfall over India through atmospheric GCM simulation experiments.
- Improved understanding of the ENSO-monsoon teleconnection through convection changes over Northwest Pacific has been obtained that has major implications on predicting the seasonal mean monsoon.
- Experimental Long-Range Forecasts of seasonal mean monsoon rainfall based on various statistical and dynamical techniques were sent, every year, to the India Meteorological Department (IMD).
- Typical analysis of pixel-by-pixel OLR data, performed through digitized Kalpana-1 IR observations showed unique characteristic feature highlighting the persistence of very deep convection (OLR ~ 85 W / m) at Santacruz and surrounding area for a period 09 UTC of 26 July to 03 UTC of 27 July 2005. This analysis, gave the signature of occurrence of excessive rainfall over Santacruz.
- An integrated effect of NAO and ENSO has been found to give a signal 3 to 4 months in advance for the prediction of excess / deficient monsoon rainfall over the Indian region.
- A method to predict the onset date of Indian monsoon over Kerala, about six weeks in advance, has been developed.
- East Indian Ocean SST over the region 5ºS - 5º N, 85º - 95º E has been identified as a new predictor for both all India summer monsoon rainfall and annual rainfall.
- POM model simulated subsurface circulation indicated that reversal in the direction of Somali current is present only in the shallow upper layer up to 50 to 70 meter depth. Subsurface Somali current is found to be northward through out the year.
- IITM has taken a national lead in generating high resolution regional climate change scenarios for two time slices, one corresponding to the present (1961-90) and the other for the future (2071-2100), using Hadley Center Regional Climate Model (PRECIS).
- A set of four Atlases depicting the Spatial and Temporal Variations in rainfall during 1813-2003 over India have been prepared.
- For the first time, tree ring chronologies spanning more than 5 centuries of Tectona grandis based on extensive sample collections from Narange Forest, Kerala have shown to be useful in the reconstruction of monsoon climate over the Peninsular India.

- Tailor-made Hydrometeorological products generated at the Institute based on hourly and daily rainfall data from a dense network of stations in India have extensively been used by several central and state agencies dealing with water resources management, flood control and hydropower generation.

4.3.2.3.2 Environmental Meteorology

- Argon-ion lidar derived aerosol loading in the ABL over Pune showed a significant increasing trend in the last 14 years due to urbanization and a well defined seasonal variation. Multi-site aerosol optical characterization has been made using multiwavelength radiometers, and aerosol radiative forcing estimates at the surface and at the top of the atmosphere have been made for an urban location using sun / sky radiometer.
- Precipitation chemistry studies in different environments in India showed that rain is alkaline in nature at most of the locations except at some industrial and forest locations.
- State of the art atmospheric chemistry model to study the long-term trends in the atmosphere from surface to 100 km and a tropospheric ion chemistry model have been developed and also an Environmental Information Center (ENVIS Centre) for creating database and inventories of acid rain and atmospheric pollutants over the Indian region has been established at the Institute.
- A rotating drum automatic UV-visible spectrometer for monitoring stratospheric / tropospheric NO2, O3, H2O and O4 has been developed indigenously.
- An automatic twilight photometer has been utilized to obtain vertical profiles of aerosols up to 120 km altitude and observations during meteor shower periods.
- Sustained observations from an instrumented tower set up at the NCAOR campus during ARMEX experiment.
- Unusual changes in surface ozone and NOX concentrations (day time minima and night time maxima) have been observed during 3 January to 20 February 2005, a week after the giant Tsunami wave struck Tranquebar, Tamilnadu on 26 December 2004.
- Measurements on surface ozone along and across the Coromandal coast of Tamilnadu, in December (2000 and 2002) and in April (2001 and 2003) have shown higher ozone concentration along the coastline than 20 km inland possibly due to oxidation of hydrocarbon by chlorine radicals from sea.

4.3.2.3.3 Cloud Physics and Atmospheric Electricity

- Assistance to various State Governments in their respective rain enhancement programmes has been provided and extensive Radar data collected during these programmes are being analyzed to study the cloud microphysical characteristics.
- Isolated thunderstorms occurring over Pune region have been observed to have an extensive Lower Positive Charge Centre (LPCC), which can last for more than 75% of the lifetime of the storm.

- Thunderstorms occurring over Pune region frequently exhibit 'End-of-Storm-Oscillation (EOSO)' in surface electric field. A novel case of an inverted EOSO is reported in a thundercloud of inverted polarity in our observations.

4.3.2.3.4 Scientific Computing for Atmospheric Research

- Augmented the computational facilities at the Institute by acquiring workstations, PCs, printers, scanners, data storage devices, intranet and internet, and necessary softwares.

4.3.2.3.6 Number of Research Publications in peer reviewed journals during X Five Year Plan

- Total 250 papers published during the 10th Five Year Period (4 years i.e. 2002-03 to 2005-06) out of which 135 papers have been published in journals with Impact Factor. Cumulative Impact Factor of 135 Papers is 216.11717

4.4 Department of Scientific and Industrial Research (DSIR)

The Department of Scientific and Industrial Research (DSIR) is a part of the Ministry of Science and Technology and has a mandate to carry out the activities relating to indigenous technology promotion, development, utilization and transfer. The primary endeavour of DSIR is to promote R&D by the industries, support a larger cross section of small and medium industrial units to develop state-of-the art globally competitive technologies of high commercial potential, catalyze faster commercialization of lab-scale R&D, enhance the share of technology intensive exports in overall exports, strengthen industrial consultancy & technology management capabilities and establish user friendly information network to facilitate scientific and industrial research in the country. It also provides a link between scientific laboratories and industrial establishments for transfer of technologies through National Research Development Corporation (NRDC) and facilitates investment in R&D through Central Electronics Limited (CEL).

DSIR operated a departmental scheme called the Technology Promotion Development and Utilization Programmes in the Xth Plan with an outlay of Rs. 99 crore. As the name suggests, the scheme aimed at promoting technology development and industrial research in the country and encouraging its utilization by various sections of economy, be it industry or the academic and scientific institutions or the society at large. The scheme had eight components viz., Industrial R&D Promotion Programme, Technology Development and Demonstration Programme (TDDP), Technopreneur Promotion Programme (TePP), International Technology Transfer Programme, Consultancy Promotion Programme, Technology Management Programme, Technology Information Facilitation Programme and Technology Development and Utilization Programme for Women. The activities / achievements of the scheme during the Xth Plan included: giving away of DSIR National R&D Awards for outstanding in-house R&D Achievements; allowing weighted tax deduction to around 200 companies; completing more than 35 technology development and demonstration projects involving a royalty payment of around Rs. 5 crore; supporting 100 individual innovators to convert their innovative ideas into models / prototypes; compilation of exportable technology / project profiles of more than 500 SMEs; supporting consultancy clinics and design engineering centers; compilation of foreign collaboration approvals annually;

curriculum development for technology management; digital content development and initiation of sectoral portals and empowering women through entrepreneurship development. The expenditure of TPDU Programmes in the Xth Plan is expected to be Rs. 70 crore.

Besides the departmental programme, DSIR provided support to PSUs under its administrative control viz. CEL and NRDC. CEL, with an outlay of Rs. 25 crores expects to achieve a solar photovoltaic production of 10 MWp per annum and increase the capacity of production of digital axle counter to around 2000 per year by the end of Xth Plan. NRDC with an outlay of Rs. 20 crore expects to achieve a turn over of more than Rs. 5 crore and a profit of around Rs. 40 lakh by the end of Xth Plan.

4.4.1 Council of Scientific and Industrial Research (CSIR)

4.4.2 Overview of performance during the Xth Five Year Plan

CSIR has made significant contributions during the first four years of the Xth Plan in a wide spectrum of activities, which span from creation of public goods, private goods, social goods and strategic goods. While maiden flight of SARAS was a landmark in CSIR's contributions to herald the civil aviation industry in the country, the discovery of a new molecule, as a potential drug for cure of deadly disease of tuberculosis, CSIR's instant response to alleviation of hardships of Tsunami's victims were a few of the major contributions in other spheres.

CSIR lead the Team India initiative for setting up the first ever Traditional Knowledge Digital Library (TKDL) to provide a search interface to retrieval of traditional knowledge information on international patent classification (IPC) and keywords in multiple languages. Database has been created on traditional medicinal formulations comprising 13 million A4 size pages of data on transcribed 62000 formulations in Ayurveda, 60000 formulations in Unani, and 1300 formulations in Siddha. TKDL has been receiving wide international coverage.

During the plan, it promoted employment generation on one hand and developed diverse technologies to add to the quality of life on the other hand. These technologies include: ceramic membrane based removal of arsenic and iron from contaminated ground water; pesticide removal unit for producing potable water, free from organic pollutants; setting up of Reverse Osmosis (RO) based desalination plants in villages; hand operated microfiltration units (with 3 litre / minutes discharge rate) capable of providing bacteria & virus free water; Ultra Filteration (UF) membrane based technology requiring no electricity and chemicals to remove germs, cysts, spores, parasites, bacteria, Cryptosporidium, endotoxin etc.; low sodium salt from bitterns in place of pure sodium chloride; which is being recommended to patients suffering from hypertension; etc. CSIR response to Tsunami victims had shown its scientific and technical skills to mitigate the hardship of those survived. The initiatives taken by various CSIR laboratories could provide food, drinking water & shelter to the survivors.

Other notable S&T achievements are as under:

- The two seater all composite trainer aircraft ***HANSA*** designed and built by NAL has been certified by DGCA for day and night flying.

- ***SARAS***, India's first indigenously developed, multi-role civilian aircraft took its inaugural test flight to skies at 8.20 am on Sunday, 22nd August, 2004. Till September 2006, the prototype-1 has made 60 test flights.
- ***Head up display (HUD)***, which provides the pilot with essential flight information, navigational and target / weapon release cues etc., has been integrated successfully in LCA-TD2 and flights have taken place with CSIO developed HUD on board.
- CEERI designed different components of the ***high efficiency space TWTs*** for the satellite communication systems using in-house developed software packages.
- CSIR has established its first ***glass manufacturing*** unit at CGCRI and has developed more than four hundred different types of special glasses for use in mirrors in telescopes, reflectors in satellites, tracking robot movement, radiation shielding glasses to provide protection from harmful radiations
- NCL has developed an alternative novel route for synthesis of 1, 1', 1'' – Tris 4'-hydroxyphenyl ethane (***THPE***), a branching agent used in the synthesis of polycarbonates, a high performance-engineering polymer.
- An ***optical amplifier*** for light wave telecommunication network has been developed by CGCRI using erbium-doped optical fibre (EDF) and power semiconductor pump laser source.
- NCL has successfully developed the process for two specialty monomers (2-Methlyallyl sulfonic acid sodium salt and 2-acrylamido-2-methyl-1-propane sulfonic acid) for applications in the acrylic fiber industry. The plant setup has more than 80% of its production being exported.
- CEERI has developed ISFET based ***glucose biosensor***. This biosensor in smaller in size, is more robust, has easy cleaning, minimal need for maintenance, and fast response.
- MERADO / CMERI has developed design know-how of 35 hp ***Tractor*** with the novelty of deep cultivation capacity, efficient soil gripping, increased carrying capacity while climbing, maintaining very good speed while running in roads and this is marketed as Sonalika Tractor. CMERI has also developed a low HP tractor having a new finger tip single lever automatic depth-cum-position control hydraulic system for better working on mounted implements.
- MERADO / CMERI has developed 1-TPD ***Oil Expeller***, to replace the traditional ghanis to produce pungent mustard oil for employment generation in semi-urban and rural areas. A complete range of modern oil expellers, capacities ranging from 6 to 20 tonnes / day suitable for the efficient extraction of oil from mustard, groundnut, cotton seed and other oilseeds have been developed.
- CDRI has identified a synthetic ***antimalarial*** trioxane compound 97 / 78 as a substitute to the naturally occurring artemisinin. Another promising anti-malarial trioxane compound 99 / 411 is under pre-clinical evaluation.
- NIO has prepared the crude extract by the enzyme-acid hydrolyzing process from a marine organism (mussel), which shows potent ***anti-malarial*** activity.

- IICB has discovered and isolated a compound from the leaf of the betel plant (piper betel), which induces death of ***cancer*** cells in chronic myeloid leukemia (CML).
- RRL-Jammu has isolated a natural compound from Boswellia species, as well as alternatively prepared its semi-synthetic compounds for cancer of colon, prostrate, liver, breast, central nervous system (CNS), leukemia and malignancy of other tissues, including ascites and solid tumors. The pharmaceutical preparation has shown lower toxicity.
- RRL-Jammu has identified the cytotoxicity and anti-cancer activity of an essential oil, alone and also in combination with pharmaceutically acceptable or other carriers, of a new chemotype from Cymbopogon flexuosus (Nees ex Steud.) Wats [RRL(J)CF HP] for prostrate, lung, colon, cervix, ovary, breast, leukemia, liver, neuroblastoma, oral cavity cancer, and ascites and solid tumors. The oil regressed ascites and solid tumors in mouse tumor models.
- RRL-Jammu has developed an herbal formulation from the plant extract of Cedrus deodar for the treatment of cancer.
- For ***cardiovascular disorders***, IMTECH has developed a process for production of recombinant Staphylokinase. Patents for this technology have been filed in several countries to protect the IPR. The technology is currently being scaled-up.
- IMTECH has standardized a laboratory-scale process for the preparation of clot-specific streptokinase. The technology for preparation of clot specific streptokinase has been transferred.
- IGIB has commercialized two important formulations: one as a brand name Regen-DTM -60 for skin graft and burn injuries, while the other, Regen-DTM -150, meant for ***diabetic foot ulcer***. This work has been recognized by a national award (Technology award, 2006).
- RRL, Jammu developed a single plant based standardized Hepatoprotective agent useful for the treatment of ***liver disorder*** such as alcoholic & viral cirrhosis. The technology has been transferred and being released in the market named as LIV-1.
- CDRI has developed the compound 99/373 that has shown better ***anti-osteoporosis*** activity than raloxifene, during pre-treatment studies on rat.
- RRL, Jammu has developed a process for the extraction of an enriched extract of calcitriol from a plant found in South India. Calicitriol is physiologically active form of Vitamin D3.
- CDRI has developed an herbal medicament, which has shown promising ***anti-stroke*** activity along with antioxidant and anti-inflammatory properties on pretreatment in rat.
- CDRI in collaboration with Department of Biotechnology has developed and evaluated PCR based Tuberculosis Diagnostic Kit for its sensitivity and specificity in clinical samples.
- IICT has developed technology for ***oral delivery of insulin*** and Hepatitis B vaccine.
- IGIB has developed world-class facilities and software, Geno-cluster, for use in healthcare field.
- CSMCRI has successfully developed Thin Film Composite (TFC) ***reverse osmosis (RO) high***

flux membrane in-house for treatment of tertiary treated sewage water. One million liters / day capacity plant has been commissioned at Chennai Petroleum Corporation Ltd (CPCL), Chennai.

- NCL has developed, demonstrated and transferred an ***Ultra Filtration (UF) membrane*** based water purification technology. The filtration unit requires no electricity and chemicals to filter water. The unit has been granted US patent and the technology has been transferred.
- CSMCRI has successfully cultivated elite varieties of ***Jatropha curcus*** on marginal land to assess practically realizable seed yields. Further, the lab has developed a simplified process for production of biodiesel confirming Euro 3 specifications for free fatty acid methyl ester.
- A computer-aided microscopic inspection system HERBAS (Herbs Authentication System), which avoids some of the shortcomings of the conventional microscopic inspection methods, has been developed.
- CFTRI has developed weaning ***food for infants*** by incorporating amylase rich flour particularly from finger millet.
- CFTRI has developed a simple device and a method for direct measurement of ***cookability of grains*** based on the measurement of 'spread area' of cooked grains.
- CFTRI has developed the process of decortications of the Finger millet, wherein the texture of the endosperm of the millet is hardened by hydrothermal treatment and the grains are decorticated in a cereal milling machinery.
- RRL, Trivandrum has developed technology package for processing 2.5 tonnes of Fresh Fruit Bunches (FFB) / hr of Oil Palm for extraction of palm oil.
- RRL, Trivandrum has developed the Swing technology as a novel approach in the global context to process fresh spices to produce premium quality essential oils, oleoresin and active principles with 20-30% higher yield as compared to that of dry processing. One commercial unit for processing fresh ginger based upon this technology has been established in Meghalaya.
- IICT, has developed technology package for enzymatic degumming which catalyses conversion of even non-hydratable phospholipids into water soluble lysophospholipids which are removed by centrifugation yielding degummed oil with very low phosphorous. The technology has been transferred to 18 rice bran oil refineries and also licensed to 8 project engineering companies spread over 9 states.
- CSMCRI has developed a new technology for ***low sodium vegetable salt***, named as Saloni K.
- CCMB has studied small non-coding RNA commonly known as micro RNA and anti-sense RNA derived from genes and transgenes, which regulate gene expression in organisms ranging from nematode to human.
- NCL has isolated first biologically derived molecule ATB 1 that inhibits ***HIV-1 protease***. The isolated inhibitor has an amino acid sequence that shows no similarity to existing inhibitors.

- CCMB has carried out studies on a large cross section of Indian population to understand their origin, evolution and migration.

- IGIB has carried out studies for Synaptogyrin 1 gene and MLC 1 gene. Chromosome 22q is one of the important regions repeatedly being implicated in schizophrenia.

- IICT has developed synthetic peptide based nanotubes that could have uses for delivering DNA material for gene therapy and also making biochemical sensors. IICT has also developed modified peptide that show helicity using as few as three residues.

- CIMAP, has developed a novel, distinct, high herb and artemisinin yielding genotype of Artemisia annua through systematic marker assisted breeding followed by selection of uniform population. The plant Artemisia annua produces a sesquiterpenoid lactone endoperoxide named artemisinin, which is a promising antimalarial drug effective against Plasmodium falciparum and Plasmodium vivax at nanomolar concentration.

- **Scientific & Industrial Research Outputs**

During the period the, CSIR has emerged amongst the top three entities from the developing world in terms of PCT filing. CSIR was granted 543 US patents during 2002-06. 62% share in the total US Patents granted to Indians excluding NRIs and foreign assignees belongs to CSIR. Over 6885 basic research papers have been published in internationally peer reviewed journals with an average impact factor per paper of nearly 2.01 during 2005. For the period 2002-2006 (as on March 2006) the ECF generated was Rs 1178 crores and cumulative ECF is expected to touch over Rs.1550 crore at the end of the plan period i.e by 2006-07.

4.5 Department of Space

Over the last four decades, India has achieved a notable progress in the design, development and operation of space systems, as well as, using them for vital services like telecommunication, television broadcasting, meteorology, disaster warning as well as natural resources survey and management. The space programme has become largely self-reliant with capability to design and build satellites for providing space services and to launch them using indigenously designed and developed launch vehicles.

4.5.1 Highlights of Achievements during Xth Five Year Plan

The overall thrust of the space programme during 2002-07, the Xth five year plan period, have been to continue and strengthen the space based services towards socio-economic development of the country. The focus of the programme has been the large scale application of space technology in priority areas of national development. Highlights of the achievements are:

- Operationalisation of GSLV with 2T capability – three successful flights.

- Successful qualification of Indigenous Cryo engine – Stage qualification in advanced stages.

- Enhanced payload capability of PSLV – from 1200 kgs to 1500 kgs through qualification of extended stapon PSOXL.
- Establishment of state-of-art Second Launch Pad at Sriharikota.
- Significant Progress in GSLV Mk III – establishment of test and fabrication facilities, subsystems development and testing and initiation of hardware realisation.
- Advanced Technology initiatives – SRE, Air breathing Propulsion and RLV-TD.
- INSAT system augmented with FIVE satellites (GSAT-2,3, INSAT-3A, 3E and 4A) – ~ 100 Transponders added to the INSAT system from these satellites. Current INSAT capacity : 175. INSAT 4B (24 Tx) in advanced stages.
- EDUSAT launch – an important achievement of X^{th} Plan for spreading education in the country.
- HAMSAT – India's contribution to international community of Amateur Radio operators – more than 1000 users from 50 countries.
- IRS system augmented with TWO state-of-art satellites viz., Resourcesat-1 and Cartosat-1. Cartosat-2 in advanced stages.
- Kalpana (METSAT-1) Operationalised. Currently, two Met satellites in service viz., Kalpana and INSAT-3A.
- Disaster Management Support – a key area of space applications developed in X^{th} Plan – Decision Support Centre, Virtual Private Network, Mapping Support, Emergency Communication Support and Data base support.
- Initiatives in large scale application of Space Technology – Tele-education, Tele-medicine and Village Resource Centres.
- Host of Natural Resource Management Applications developed and operationalised – National Drinking Water Mission, Waste Land Mapping, PFZ estimation, Land use / Land Cover mapping, Bio-diversity characterization and many more.
- Innovative Space Science initiatives – Chandrayaan, ASTROSAT, Megha-Tropiques, Life science experiments using balloon flights, aerosol measurement campaign and Middle atmospheric studies using Sounding rocket flights.

4.6 Department of Science and Technology

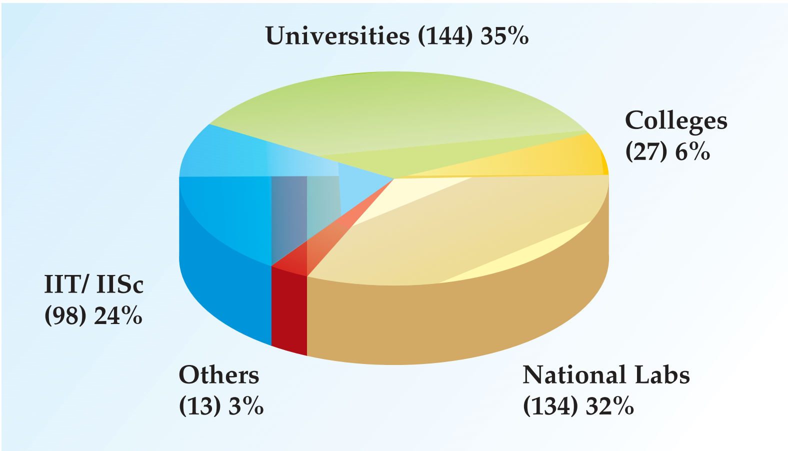
Department of Science and Technology, Government of India has been the major agency supporting basic research and technology development in the public funded institutions in the country. DST has also been overseeing two subordinate departments namely, Indian Meteorological Department and Survey of India. Some of the highlights of achievements during the X^{th} Plan are mentioned below:

4.6.1 Science and Engineering Research Council Programmes

- Science and Engineering Research Council of The Department of Science and Technology has emerged the major support system of Extra Mural Research funding in the country. SERC support for EMR funding during the Xth Plan period has averaged around Rs 13-15 lakhs per scientist per year. Impact Factors of publications emanating from SERC supported projects in various institutions have been consistently ranged 2.2+ 0.1 per paper.

- **Infrastructural Strengthening of University System in Research**. Data presented in the accompanying figure illustrate the important part played by FIST in strengthening S&T support structure in universities. Nearly 40% of funds of SERC have been deployed in strengthening of S&T infrastructure in universities and colleges during the Xth Plan period.

SERC Support - Institution Wise
2005-06



4.6.2 Autonomous Institutions supported by DST

The average output indicators per scientist per year have been worked out for the years 2002-06. Publication per scientist is generally in the range of about 2-6 for various institutions. The Aggregated Average impact factors per paper for all institutions have been in the range of 2.3, while some institutions have shown values of the order of 3.3 with an average output of 6 papers per scientist. DST is examining as to whether there is a correlation between budget support and average outputs per scientist on a nation wide basis.

4.6.3 Support to Pharmaceutical Research and Development

The Department of Science and Technology has been entrusted with the responsibility of promoting and supporting Drug and Pharmaceutical Research in the country through a special drive during the X[th] Plan period. This objective has been fulfilled by creating National Facilities in the field of Regulatory toxicology, Proteomics, Pharmacokinetic Evaluation, Bio-safety Facility both at level 3 and level 4 at various national academic institutions etc.

Collaborative research and development work was supported in institutions like NCL, CDRI, IICT, and University of Hyderabad etc with the participation of leading industries like Lupin, Bharat Serum, BE Ltd, Natural Remedies, Sudershan Biotech etc. In all 82 projects were supported under the X[th] Plan which include national facilities and research projects (collaborative as well as for Loan applications) on diseases like AIDS, TB, Diabetes, Leucoderma etc.

The important feature of the scheme included initiation of research work in Siddha and Ayurvedic medicines both for human and veterinary purposes. R&D efforts have resulted in 6 product patents – filed both in India and abroad, 13 process patents and synthesis of over 250 New Chemical Entities (NCEs) resulting in around 25 lead molecules. Around 7000 molecules already existing in various national Laboratories were screened for their efficacy for various diseases under various projects.

4.6.4 Technology Development Board

Total of 132 projects have so far been supported under TDB. More than 54% of the projects enrolling for support under TDB have been drawn from mostly health and engineering sectors. Some notable examples of projects succeeding for the country are a) vaccines from Shantha Biotech, b) health care products from Bharath Biotech, c) Rewa Battery operated car and d) Indica car from Tata motors. Some successful technology ventures supported under TDB mechanism have also won the National Technology Day Awards during the last five years.

4.6.5 Science communications

The Department of Science and Technology has been actively spreading the excitement of careers with science among younger population of India with a view to attract talents for career with science. The include the organization of various events including a) National Children’s Science Congress, b) National Teacher’s Science Conference, c) Steer the Big Idea – DST – CII collaborative program, d) Year of Physics, planet earth etc, e) scientific awareness programs in 579 districts and f) Management of Vigyan Rail.

4.6.6 International cooperation

Several new programs have been launched during the X[th] Plan period. The ongoing cooperation with France overseen by Indo-French Centre for Promotion of Advanced Research has been further strengthened. The ongoing partnership with USA has been enabled under Indo-US S&T forum. Under international cooperation program DST has supported a) 100 Fellowships / Training Opportunities (ICTP, Lindau, ILTP, JSPS, IRTC (Germany) etc.), b) Technology Exhibitions with Canada and c) Global Conference on “India R&D 2005 – The World’s Knowledge Hub of the Future”.

4.6.7 Technology and Entrepreneurship Development

Some important initiatives of DST during the Xth Plan period have been a) Technology Business Incubators (TBIs) promoted at IITs, IIMs, NITs, NID, ICRISAT, in the areas of ICT, BT, Design, etc, b) Over 150 tenants incubating various technologies / products, c) Collaborative programmes launched with EU & World Bank, d) 2000 Micro enterprises promoted at 40 locations in the country, e) Skill development programme for 7000 persons leading to self / wage employment and f) Three centres launched in PPP mode under SKILLS project of UNDP for skill training at Chennai and Bangalore.

4.6.8 New Intergovernmental Agreements Signed/concluded

During Xth Five Year Plan period, inter governmental Agreements for Cooperation in S&T were signed with 16 countries which included Canada, China, Colombia, European Union, Islamic Republic of Iran, Republic of Iceland, Italy, Laos, Mozambique, Republic of Korea, Serbia and Montenegro, Sudan, Sweden, Switzerland, Thailand, and USA. Further, the detailed protocols on IPR were also signed with Canada, Israel, USA and Switzerland. It may be added that the agreement with USA which could not be signed in last 15 years due to non agreement between the two sides on IPR protocol, was signed in October, 2005 with a detailed IPR protocol. In addition, MOUs were signed with many agencies including Maryland State, DST-SAFEA; DST-NSFC; DST-CAS; INSA-SFI etc. At present, India has signed / concluded Inter Governmental Agreements with 66 countries.

4.6.9 Renewal of Programmes of Cooperation (POCs)

During the Xth Plan, under bilateral programmes, suitable mechanisms were established with conclusion and implementation of Programmes of Cooperation (POCs) with Argentina, ASEAN, Australia, Bangladesh, Belarus, Brazil, Bulgaria, China, Cuba, European Union, France, Germany, Hungary, Indonesia, Islamic Republic of Iran, Israel, Italy, Japan, Kazakhstan, Malaysia, Mexico, Myanmar, Nepal, Poland, Republic of Korea, Romania, Russian Federation, Singapore, Sri Lanka, South Africa, Syria, Thailand, Tunisia, Ukraine, UK, USA, Uzbekistan and Vietnam.

4.6.10 New Joint R&D Centers Established

While the existing joint R&D centers were continued to be supported, 8 new Joint Centers were set up with active cooperation with some of the bilateral partner countries. Each of these centers is located at an Indian or foreign institution around existing capabilities and infrastructure for optimal utilization of resources both financial and physical. These centers are basically meant for facilitating focused and integrated interaction / collaboration between Indian and partner country institutions in identified fields of mutual interest. The new joint centers established during the Xth Plan are as follows:-

- Indo-French Center on Organic Synthesis, IISc, Bangalore
- Indo-French Laboratory for Solid State Chemistry (Flask), IISc, Bangalore
- Indo-Russian Centre for Ayurvedic Research, Moscow

- Indo-Russian Centre for Gas Hydrate Studies, NIOT, Chennai
- Indo-Russian Centre for Earthquake Research, IMD, Delhi
- Indo–French Institute of Mathematics, Mumbai
- Indo-Russian Centre for Biotechnology, Allahabad
- BIMSTEC Centre for Weather and Climate, NOIDA (virtual)

4.6.11 Access/Utilization of Major International Research Facilities

Indian scientists were assisted and supported in accessing / utilizing the following international research facilities for conducting experiments in the fields of crystallography, condensed matter physics, high energy scattering, solid x-ray spectroscopy, nuclear resonance scattering, magnetic Compton studies, etc, and received advanced training at international research facilities such as:

- CERN (Geneva)
- ELETTRA (Italy)
- Sp Ring-8 (Japan)
- KEK Accelerator (Japan)
- National Laboratory for High Energy Physics (Japan)
- Synchrotron Radiation Sources Beam line facility Novosibirsk, (Russia)
- FAIR (Germany)
- Fermi lab (United States)
- Synchrotron Light Source (Singapore)

4.6.12 Fellowships / Training / International exposures to young scientists

The young scientists from India were assisted by providing Doctoral, postdoctoral and other research fellowships instituted jointly with some of the partner countries / agencies Similarly, Russian young scientists were provided fellowships to work in Indian Institutions. The following fellowships were made available:-

- Japan Society for the Promotion of Science (JSPS)
- Science & Technology Agency (STA), Japan
- International Centre of Theoretical Physics, Trieste (ICTP)
- ILTP Fellowships for Russian Scientists

4.6.13 Science and Society programs

There have been several science demonstration projects working with NGOs. These projects have been varied in nature. Primarily the focus of the projects undertaken under Science and Society programmes has been referencing of technologies to the social contexts in which the technologies need to perform.

Active collaboration with State S&T councils has been built by DST. Annual National consultation processes with State S&T councils ahs been arranged for the last fifteen years. During the Xth Plan, the state S&T councils met also the SAC-PM Chairman and have been able to provide direct inputs to the planning process.

The State S&T Programme has contributed significantly towards replication of technologies developed in various national institutions such as the water purification technologies in the States of Rajasthan, Andhra Pradesh, Gujarat, West Bengal and all the eight North Eastern States; plastic and hospital waste handling technologies of Plasma incineration developed at Institute of Plasma Research, Gandhinagar demonstrated in Andaman and Nicobar Islands, Goa, Himachal Pradesh and Sikkim. Similar examples included energy generation based on micro-hydel, bio-diesel, etc. at various locations.

4.6.14 National Mission on Bamboo Applications

The Department of Science and Technology has been implementing a National Mission on Bamboo Applications since Xth Plan period. There have been several important technology leads under the mission. These include a) composites, b) construction materials c) gasifier feed stock materials.

National Mission on Bamboo Applications

- Composites / Flooring Boards unit entered production
- Clustered 48 house rehabilitation project completed at Wardha
- Packages of practices developed for biotic shelter belts
- Nagaland Foods commenced commercial production of processed bamboo shoots
- Cones, chunks, slivers and shreds prodn. commenced at Luit Valley Food Products, Jorhat
- Establishment of 2x1 Mw thermal gasifier is on schedule
- Mobile gasifiers developed.
- Development and documentation carried out for bamboo based orthotic and prosthetic application
- Bamboo Network Programme launched

5

Attracting Young People to Careers in Science and Retaining them there

5.1 The problem of attracting and retaining young people to careers in science and technology and the concomitant issue of improving undergraduate science education have been widely discussed in recent years and documented in several reports (e.g. “Attracting Young People to Careers in Science” report PSA / 2005 / 3 of the Office of the Principal Scientific Adviser to the Government of India; “Higher Education in Science and Research & Development: The Challenges and the Road Ahead” August, 2006 by Indian National Science Academy (INSA), New Delhi & Indian Academy of Sciences, Bangalore). Some key recommendations are summarized below from the Working Group’s report:

5.2 Massive Revitalisation of Science Education in Universities

- At least ten universities in the country need to be brought at par with the best universities in the world. The identified universities must provide education at the undergraduate and postgraduate levels and conduct research of high standard. A financial assistance of Rs.200 crore for each identified university will be required for upgrading infrastructure, laboratories, instrumentation and for their repairs and maintenance in the science departments. Adequate recurring grants must be ensured for basic infrastructure and services.

- Select about 20 other universities in the country (other than those included above) and provide them with major support (Rs.75 crore each) to upgrade their science departments and launch new integrated M.Sc courses after Class XII.

- It is well established that the best students all over the world are attracted to those universities that have ambience for high quality research. Setting up centers of excellence by National Laboratories in universities situated in close proximity to them will be an important step in this direction. An example is the forthcoming DAE-Mumbai University Centre for Nuclear Physics research. More such initiatives are required in the XIth Plan

5.3 Creation of more Central Universities

The central universities, by and large, are better funded and attract good faculty and students. It is essential to have at least one central university in every State of the country. Larger States may have two or more such universities. These are also likely to catalyze improvement in the other State universities in their neighbourhood. It would be more cost effective to convert an existing good State university into a central university. In the XIth Plan, to start with, ten promising State universities may be converted into central universities.

5.4 Inter-University facilities

The establishment of the three Inter-University facilities (IUCAA at Pune, IUAC, New Delhi and UGC-DAE Consortium for Scientific Research at Indore) is one of the most successful UGC initiatives in the past decade or two to upgrade science education and research in the universities. A substantial block grant to each of these Centres will strengthen their programmes further, resulting in direct benefit to many active and motivated teachers and research students.

5.5 Competitive research grants to universities and colleges

The overheads component should be increased to 25% of the grant with no ceiling, so that project related expenditure on infrastructure does not cut into the resources of the university / college. Further, efficient mechanisms need to be introduced to evaluate and monitor research projects, so that the time between submission of a project and release of funds for the (accepted) project does not exceed 6 months.

5.6 Strengthening of INFONET in the university system

There needs to be a massive strengthening of INFONET in the university system. Availability of online research journals and other resource material can bridge the large gap that exists today between metropolitan and non-metropolitan universities / colleges. Besides, it will also bring course ware / lectures by leading scientists from institutes across the world within the reach of remote colleges.

5.7 Creation of New Institutes

The Government has already approved the creation of three new institutes, named the Indian Institutes of Science Education and Research (IISER) at Pune, Kolkata and Chandigarh. (The first two begin their teaching terms from August, 2006). The Prime Minister has also announced the setting up of a National Institute of Science and Research (NISER) at Bhubaneshwar to be operated by DAE. These institutes are intended to be world-class institutions offering integrated M.Sc. courses, wherein students will be exposed to the best of teaching and research ambience in the country. It is suggested that the country may set up more such institutes during the XIth Plan.

5.8 Talent Search and Nurture Schemes

- It is recommended that the total number of National Talent Scholarships be increased manifold to say 10,000 every year. The quantum of scholarship must also be enhanced to Rs.1000 / - p.m.

after Class VIII (which may be upgraded further after Class XII) to enable talented students, particularly those without adequate means, to progress in their education without financial hurdles.

- At the senior secondary level, there are currently two major talent search and nurture schemes: Olympiads operated by Homi Bhabha Science Centre, Mumbai and Kishore Vaigyanik Protsahan Yojana (KVPY) after (10+2) run by DST.The total number of KVPY Fellowships awarded per year is currently about 150. Considering the total student strength at the senior secondary level in India, this number need to be tripled. The top Olympiad students who represent the country at different International Olympiads automatically qualify for the KVPY Fellowship. The top twenty Olympiad students in each subject identified by Homi Bhabha Centre for Science Education after the summer training camps may automatically qualify for KVPY Fellowships. Horizontal entry to KVPY scheme after B.Sc. should also be allowed.

5.9 15 years Career Support Programme

Under this proposed scheme attractive scholarships and nurture programmes from post Class XII to M.Sc. / Ph.D.; and, assured employment after Ph.D. for at least 5 years should be offered to selected meritorious students for careers in research and development, university/ college teaching, etc., in basic sciences. This will have three phases of five years each.

- **Phase I**

Support to KVPY scholars, Medal Winners in Science Olympiads, top rankers in IITJEE examination etc. who opt for science stream undergraduate and graduate education after 10+2 (~ 1500 nos.)

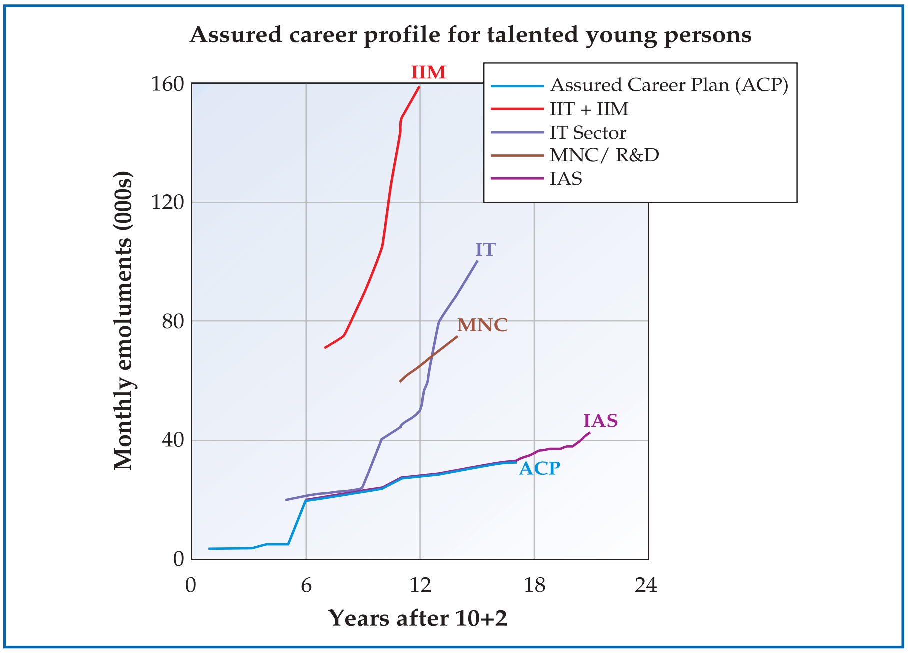
- **Phase II**

Fellowships after graduation for pursuing doctoral research (~500 nos.), the emoluments, which towards the end of the Ph.D. programme should match the salary including allowances of the first job.

- **Phase III**

Appointment for 5 year after Ph.D. grade Rs. 10,000-325-15200 + DA & HRA (~200 nos.)

This will make the emolument structure of the best in this programme at least comparable to that of the IAS cadre. (***see fig. overleaf***)



5.10 Science Education in IITs

The IITs and the leading post-graduate universities have excellent departments offering M.Sc. programmes and also have good research ambience. It should be possible for them to start undergraduate programmes in sciences. About 20 such institutions may be identified. This, at present, seems to be a relatively straight-forward measure that, however, will need adequate financial and manpower support for implementation.

5.11 Encouragement of B.Tech. holders to join Science Ph.D programmes

Another important reform that can be readily implemented is to permit B.Tech degree holders direct admission to Ph.D. Science Programme. Experience bears out that several of the best engineering degree holders in IITs, etc. have strong inclination to pursue science research, and a rigid insistence on M.Sc. may unreasonably close this vital input channel for Ph.D. Science.

5.12 B.Tech./M.Tech. for talented B.Sc. holders

To enhance the utility of conventional B.Sc. degrees holders from universities initiate post - B.Sc. 2-year B.Tech programmes, followed by the usual M.Tech programmes in interdisciplinary areas such as Optical Engineering, Materials Engineering, Nanotechnology, Space Engineering, Nuclear Engineering, Robotics, Biotechnology and Bio-engineering, Bio-informatics, Environmental Engineering, Agricultural Engineering, etc. To implement this idea, about 20 universities having potential for excellence with strengths in relevant terms of qualified faculty and infrastructure may launch this programme. It is expected that graduates with this composite training in Science and Engineering, would be a good material for pursuing engineering research and employment in science based industries, which are bound to come up in very near future in India.

5.13 Support to Science and Engineering Colleges

- To support the large number of colleges in non-metropolitan areas who mostly cater to students from rural/semi-urban parts of the country, about 400 science and engineering colleges should be identified for support to the tune of Rs.1.00 crore each for improvement of their libraries and laboratories for practical experiments, particularly for undergraduate students.
- College teachers should be encouraged to do research and those who are pursuing worthwhile research should be offered financial support in terms of laboratory equipment, books, etc. Pedagogic research aimed at improvement of theoretical and experimental teaching should be included for this support.

5.14 Satellite/ EDUSAT based programmes

While hardware and technical facilities for this are seeing rapid expansion in India, the corresponding effort on software/content development is sub-critical. To overcome this, a few co-ordinating centres would need to be identified and given required financial support to ensure that quality programmes in sufficient number are produced for the satellite channels.

5.15 Support to National Level Science and Engineering Academies

- The national level Academies have been taking notable initiatives to improve science and technical education in colleges/universities. These educational initiatives like summer programmes/ refresher courses etc. need to be strongly supported.
- The Academies may be funded to float a scheme of National Professorships (about 100 in number) for outstanding academics/researchers in universities/ institutes. A National Professor may get compensation and incentive package, at the same level as say the INSA Professorships. The compensation may also include award of a suitable research grant.

5.16 Employment and Service matters pertaining to Scientists

- Scientists need to be treated differently from other Government employees in service and salary matters. Their peer reviewed good performance needs to be given due recognition through a suitable scheme of incentives. The incentives may include additional pay (besides normal salary), salary raise, enhanced research grants, travel support, sabbaticals, and so on.
- Appointment of outstanding scientists as National Professors, to Endowment Chairs, Fellowships etc. be liberalized.
- As is well known, mobility is essential for modern scientific research, which is presently conspicuously absent among college teachers in India. A strong and vibrant Visiting Teacher scheme should be launched and sustained in colleges across the country. Good active college

teachers should be able to go on say six-month sabbaticals every five years or so at reputed research institutions / university departments. The same kind of mobility is equally needed for Ph.D. / PG / UG students working on their projects. The contingency grant for research for teachers and students should adequately take care of such visits. Funding occasional international travel of teachers and research students for presentation of papers / talks at conferences abroad should also be made possible. The current quantum of support under these schemes should be enhanced and the same should be made available through a single source.

- It is known that many scientists in national institutes and universities continue to be active in research and education after superannuation. The educational system could greatly gain from their academic and research expertise, by encouraging such scientists to teach at colleges / universities. For this purpose, a suitable support scheme for retired scientists should be implemented.

6

Basic Research

6.1 Keeping in mind the strong commitment of the Government of India to promote science and technology, the Working Group on this subject suggested that the XIth Five Year Plan provide a special thrust to basic science research in our academic and research institutions. It also suggested creation of a New Funding Mechanism / Inter Institutional Linkages / New Infrastructure and Manpower Development.

6.2 Specific Thrust Areas

6.2.1 Biological/Medical Sciences

● Integrative and Systems Biology ● Genetics & Genomics ● Infectious and metabolic disease: basic biology, biochemistry and drug design ● Immunology and Vaccine Research ● Structural Biology, Proteomics, Chemical Biology ● Ecology, Biodiversity and Conservation ● Plant molecular Biology and Basic Research in Agriculture ● Nanobiology ● Science Initiative in Ayurveda (*see Box 6.1*) ● Biotechnology and nano-technology based on biological systems ● Basic research support to facilitate replacement of energy intensive steps in chemical engineering by engineered enzymes ● Tissue engineering, stem cell research biocompatible materials and machine vision for biotechnology and bioengineering.

Box 6.1

Science in Ayrveda

Even though Ayurveda means science of life, research in Ayurveda has placed too much emphasis so far on herbal drugs and too little on science. It has become identified with the screening of herbs and herbal products for new chemical entities. As a consequence much else of importance in theory and practice of Ayurveda has not received the attention it deserved. Due to advances in modern methodology, science today offers an excellent opportunity to test many of the basic concepts, procedures and products in Ayurveda. With this background the office of PSA to GoI, involving experts from related fields, organized a brainstorming session on 13th February, 2006. Prof. M.S. Valiathan was the main resource person for this initiative termed "A Science Initiative in Ayurveda". Clinical research and drug formulation were not part of this discussion.The brainstorming session concluded with a decision to prepare position papers relating to Doshaprakriti, Genomics of anti-dosha plants, Panchakarma, Rasayana and Bhasmas. These papers were discussed in a National Seminar held at IISc, Bangalore on 30th May, 2006 in which experts and practitioners of Ayurveda participated along with scientists and other domain experts. At the seminar it was decided that detailed project proposals would be formulated in the areas mentioned and the investigators and institutions were also identified. The proposals have been received and peer reviewed. A Project Review and Monitoring Committee has been set up under the Chairmanship of Dr. Valiathan and the proposals would be considered for approval on 18th December, 2006. A budget of Rs 50.00 crores is proposed for this initiative in XIth Plan.

6.2.2. Physical Sciences

● Nano and Meso-scale physics ● Optical Physics (Photonics (*see Box 6.2*); Physics and technology of ultra-intense lasers; Physics and technology of ultra-cold atoms; New generation of compact ultra-short pulses; Quantum computers and quantum information processing) ● Low temperature physics ● Soft condensed matter including biologically inspired physics ● Development of plasma and laser based accelerators (High energy particle beams or Lasers for creating extremely large pressures and electric fields; development of Plasma Wakefield Accelerators (PWA), Beat Wave Accelerators (BWA), Laser Wakefield Accelerator (LWA), Self modulated Laser Wakefield Accelerators (sm LWA)) ● Research related to Fusion Program: in particular the technology of superconducting magnets and plasma heating system (RF, beams) ● Astronomy and Astrophysics (first, consolidation and continuous modernization of existing facilities, and second, focus on development of appropriate manpower).

Box 6.2

Photonics

Photonics – the science and application of light has become a key technology for applications in information technology, data storage, flat panel displays, material processing, medical applications etc. There is a feeling among scientific community that the effort on Photonics in India is sub optimal. A Brain Storming session was held on this topic in the Principal Scientific Adviser's Office on 27th September, 2006. Leading experts in India attended this meeting. The issues which were discussed at this meeting included (i) frontier topics in this area (ii) which of those topics would be beneficial to the Indian industry from a technology point-of-view, and (iii) what are the topics in which we could probably promote **directed basic research in Photonics**. Prof. Deepak Mathur of TIFR and Dr. D.D. Bhawalkar, former Director, Centre for Advance Technology were requested to prepare a position paper on photonics in India. This is now available. In this, the authors have given the current status of photonics related work in India and identified the thrust areas ,which should be pursued in the next five years. In order to promote focused, multi disciplinary, inter-institutional research in photonics, it is proposed that a National Photonics Initiative or National Photonics Programme be launched. Further, an *enabling* body should be constituted to oversee this Initiative. An initial core allocation of Rs.100 crore is requested for this.

6.2.3. Chemical Sciences

● Synthetic Chemistry (New methodologies; Conversion of natural products into small building blocks and vice versa; Reactions, which avoid protection-deprotection methodologies; Solventless and "green" conversions) ● Supramolecular and Materials Chemistry (Structure and dynamics of intermolecular interactions; Control of molecular assembly into solids and supramolecular aggregates; Development of advanced functional materials and their utilization in new technologies; Polymorphism of pharmaceuticals and industrially significant materials; Chemistry of energy conversion processes and harvesting of different forms of natural energies) ● Chemical Biology (Biomimetic synthesis; Diversity oriented synthesis; Molecular mechanism of drug action; Chemical Ecology / Natural Products; Interface areas of chemistry with biology and materials science) ● Catalysis (Rational catalyst design; Chemistry at interfaces; Gateways between chemistry and chemical engineering) ● Fundamentals and frontiers (Chemistry of single molecules; Mesoscale species; Complexity in chemistry).

6.2.4 Engineering Sciences

● Multiscale modelling for the relation between molecular/mesoscale structure and the macroscopic (thermodynamics and transport) properties of complex and structured materials ● Quantum theory and experiments related to optics, computation, chemical reactions nano systems ● Fundamental studies of turbulence, multiphase flows, computational fluid mechanics

● Tools for analysis of complex systems such as networks, etc. Image analysis, soft computing ● Systems analysis, optimization and control with applications in process industries, robotics, automobiles, aircraft, supply chains, biological systems ● Algorithms for VLSI design, parallel computing, data structures, data mining. Bioinformatics, Signal processing and communication networks, Wireless communication ● Fundamentals of microelectro-mechanical devices, microfuridic systems, colloidal systems and interfacial engineering. Applications as sensors, actuators, lab-on-achip for medical and engineering devices, biosensors ● Structural Mechanics, Health Monitoring, Earthquake Engineering, Dynamics. Prediction of natural disasters including earthquakes, cyclones, tsunamis etc., early warning systems, structural engineering for resistance to natural disasters and loss mitigation technologies ● Energy engineering, including energy generation (renewable / non-renewable), energy storage, efficient utilization and pollution control technologies.

6.2.5 Cyber Security

● Denial-of-Service (DOS) related (Thresholding studies; Behaviour Modelling; Studies relating to distribution of resources; Analysis of velocity of attack; Artefact Analysis) ● Non-cryptographic analysis (Cache attacks; Side-channel attacks; Remote Monitoring and social engineering) ● Cryptographic primitives (Analysis of new and existing algorithms; Design of new algorithms; PKI and other interfaces; Other primitives like hashes, signatures) ● Development of e-infrastructure (Concepts, architecture and design; Sensors for Wide-Area Networks; Monitoring and analysis tools; Test beds; Bayesian and other learning techniques) ● Security policy (Development of standards and templates for security policies; Study of social, legal and ethical issues; Mechansim for security auditing; Mechanism for revision; Technological implementation of security policy).

6.3 New Funding Mechanism

The Working Group has strongly endorsed the need for setting up the proposed National Science and Engineering Research Foundation at the earliest (NSERF). The NSERF may then be charged with the responsibility of formulating and implementing the new schemes for enhancing research infrastructure and for attracting a new generation of students and faculty into our research institutions and universities. The NSERF should function as an autonomous body in addition to the existing ministerial mechanisms for funding, which are being administered by the various arms of the Government. An allocation of Rs. 1000 crores per year during the XIth Five Year Plan period would be necessary to inject fresh vigour into our basic research system. Specific schemes, which may be taken up by the NSERF, are listed below:

- ***Schemes for funding new infrastructure in the University system and in National institutions:*** Flexible mechanisms need to be evolved where funding is effected rapidly and installation and operation of equipment follows quickly. The NSERF should act both as a creator of facilities and also as a watchdog to ensure efficient operation.

- ***Special schemes to upgrade selected University departments in carefully chosen frontier areas of science:*** This scheme would draw upon the experiences of the COSIST programme of the UGC, DSA / CAS programmes of the UGC and the FIST programme of the DST. It is clear that the quantum of grant support to major departments needs to be increased by at least an order of magnitude if our institutions are to remain internationally competitive.

- ***Initiative for recruitment of faculty/scientists:*** At present, the most pressing problem in our institutions is the growing shortage of newly recruited faculty members. As a consequence, most institutions have aged collectively with a consequent decline of their research profile. Vigorous and attractive recruitment policies need to be introduced without any further delay within the Indian S&T system. It is absolutely essential that the ground rules for recruitment, which are in force for administrative positions in Government, should not be applied to the S&T departments. New recruits to positions of scientists / faculty usually enter several years later than their compatriots in the civil service. This is consequence of the need to obtain Ph.D. degrees and several years of post-doctoral experience before entering to our academic institutions. Flexibility in the salary support and start-up grant is necessary in order to attract the best scientists to work in India. The NSERF, armed with autonomy, should be free to develop new schemes in which new recruits to the academic S&T system can be centrally funded and placed in institutions under programmes, which are designed to provide suitable incentives for growth and development.

- ***Inter-institutional Linkages:*** India's scientific research output is largely determined by the activities carried out in centrally funded academic research institutions and national laboratories. The vast university system no longer contributes to scientific research output in a major way. This is largely because of the decline of research activities in the science departments of State universities. In order to quickly enhance the scientific activity within the university system, a new programme to promote inter-institutional linkages is proposed in the XIth Five Year Plan. This programme should seek to provide grants support for creating common infrastructure, research facilities and collaborative projects between national institutions and State universities.

  - A programme be initiated to promote the establishment of technology business incubators in Universities. The incubators will provide support to scientists to start businesses based on technology developed in the lab.

  - Industries with active R&D divisions should be encouraged to recruit research students working in basic science areas related to new technology areas by some incentives. New techniques and methods are most easily transferred to practice in this way.

  - National Laboratories may consider setting up basic research laboratories in different Universities. A Senior Scientist may be deputed to the laboratory along with one or two additional scientists. A few faculty members and research students may be associated with the laboratory. The deputed scientists should be adjunct faculty of the University and should have some teaching load. The laboratory should be engaged in fundamental research related to the parent Department/Laboratory, and should be liberally funded. Each laboratory should exist for a fixed duration.

6.4 New Infrastructure

- Physical Sciences:
  - Nano-fabrication facilities
  - Synchrotron and Accelerator Facilities- In case the DPR is ready early; additional funds could be requested for initiating the construction of the Second Synchrotron facility during the XIth Plan itself. - (*see Box 6.3*)
  - Ultra high magnetic field facilities
  - Lasers and photonics facilities
- Biological/Medical Sciences:
  - Molecular and Medical Imaging Centres
  - Institutions to bridge the gap between basic biological research and clinical research
  - Nanobiology laboratories
- Chemical / Pharmaceutical Sciences
  - Analytical Instrumentation Centres
- Mathematical Sciences:
  - Centre of Cryptology
- Engineering Sciences:
  - Computer Clusters for large scale modelling
- Directed Basic Research:
  - Technology Utilization Centres

Box 6.3

New Synchrotron Light Source in XIth Plan

The Working Group on Basic Research has suggested that two complementary efforts need to be simultaneously pursued during the XIth Plan period regarding the synchrotron sources in India. These are:

(a) Strengthening of activities around Indus - 2 operated by DAE and

(b) Setting up of a new facility

On this the Working Group on Basic Research made the following observations "in strategic terms as well as in terms of an appreciation of the probable level of usage, India needs at least two high energy light sources. Once synchrotron sources become available in the country, they are expected to be heavily used. As has happened with other facilities, they would also become indispensable for day-to-day functioning. In such a scenario, exclusive dependence on a single facility would be extremely unwise. Further, considering the gestation period in setting up of light sources, enough work to effectively use at least two facilities is expected to develop by the time the second source is ready. What is required is a 3GeV source with features complementary to those of Indus-2. That is expected to cost around Rs. 600 crores. The new facility should be set up primarily by an appropriate segment of the user community. Detailed discussions among concerned experts confirm that this is a perfectly feasible undertaking. In addition to providing a much needed facility, this undertaking is expected to raise the level of scientific and technological competence of the community to a higher level".

The proposal for a second intense photon source was also discussed in detail by the Working Group on Mega –Science Group, and it was felt by them that "the INDUS-2 facility being set up by the Raja Ramanna Centre for Advanced Technology, (RRCAT) would meet most of the requirements. Of the thirty two beam lines which INDUS-2 can support, it would be possible to set apart ten to twelve beam line positions for setting up such dedicated facilities. Interested research groups could be funded by the DST, and RRCAT should provide exclusive space and services for these experiments".

These conflicting views were discussed on 31st October, 2006, in the Steering Committee on S&T for the XIth Plan. In this also the opinion of the members was divided. Based on these discussions, Chairman suggested that the Users Committee of INDUS-2 could discuss these issues at length at a special meeting. Dr. Anil Kakodkar, Secretary, Department of Atomic Energy, Dr. S.K. Sikka, Scientific Secretary, Office of the Principal Scientific Adviser to the Government of India, Dr. T.V. Ramakrishnan, President, Indian Academy of Sciences, Bangalore and Dr. T. Ramasami, Secretary, DST should be special invitees for this meeting.

Dr. T.V. Ramakrishnan (also a Co-Chair of the Working Group on Basic Research) was requested to ensure a detailed presentation at this meeting on the background for the requirement of the second synchrotron source, detailed cost estimates the contemplated mechanism for construction, operation & maintenance and for the building of the beam lines.

This meeting was held on 30th November 2006. Three major recommendations from this meeting have emerged. These are:

1. All efforts and resource inputs for expediting the completion of the development of INDUS -2 to its fullest designed specification complete with injector, insertion devices and at least additional 10 beam lines by an year ahead of the currently planned target of early 2009 will need to be reflected in the XIth Plan provisions of DST and DAE subscribing to the overarching principle of equal partnership. For the beam line construction, proposals may be invited from the users on competitive basis. Provisions existing in the frame work of International S&T cooperation may be employed for bench marking the performance parameters of the device. In order that the user base of the facility is increased and enabled among the various university departments in the country, it is necessary to build also a budgetary provision complete with implementation mechanism for training and the user-facilitation within the XIth Plan program. Overall for the new beamlines and enhancing the user base of INDUS-2 a provision of Rs. 65 crores in the DST budget is recommended

2. In order that Indian users are able to gain access to global facilities on Synchrotron, DST may explore possibilities and provide resource inputs for constructing Indian beam line on instruments such as Spring-8 of RIKEN under bilateral cooperation. Budget provisions may also be made under bilateral cooperation for Indian researchers to travel and undertake experiments using such Indian beam lines in other countries. A budgetary provision of Rs. 35 crores is envisaged

3. India would need to plan the installation of a next generation device over the best and final specification of the INDUS 2. Therefore, a budgetary provision of Rs. 50 crores may be made in the XIth plan budget of DST for preparation of Detailed Project Report for the construction, operation and maintenance and management of next generation Synchrotron Indian facility. In case the DPR is ready early, additional funds could be requested for initiating the construction of the Second Synchrotron facility during the XIth Plan itself.

7

Mega Science Projects

7.1 These are defined as:

(a) Mega-Science projects should appeal to **the scientific curiosity of the researchers** in search of answers to some of the important questions facing the world of science, and should be of interest to a large scientific community from various research groups within the country and outside.

(b) Mega-Science projects would be very large in terms of outlays or the complexity involved. Thus a user group, institution or even individual countries would need to join hands with other similarly interested groups. Implementation of such projects would involve **multi-institutional teams, including possible international collaboration.**

7.2 General

- In cases where India's participation in international programmes is being sought, it is desirable that there should be a corresponding pre-existing Indian research or development programme, which has considerable overlap and maturity. This will ensure that there is sufficient 'feedback' into our programmes and also enable the possibility of scientists from other countries to participate in such programmes in India, thereby creating greater opportunity for larger number of young Indian scientists to be exposed to their peers.
- Similarly, when a major research facility is being built in India, it should be with some distinctive features with potential to meet the research interests of the larger scientific community, the world over.
- Since the typical project outlays would be very large, leading to higher per-capita expenditure, the decision of the projects should be preferably made by national consensus.
- These projects lead to direct technological gains for the country in terms of advanced technologies and equipment building, as well as development of expertise to take on similar projects in future that push the frontiers of technology.
- There would also be opportunities for Indian scientists to set up their experimental stations around some of the major research facilities abroad. Setting up such experimental stations enables

greater access to our researchers and should be promoted wherever such proposals are cost effective.

- The large projects like the induction of LCA, ALH into the Services, 10 Ton Airship, High speed trains, nano - and micro-technologies, Hydrogen economy etc. are important for the country and should be supported. These should be considered 'mega science' from the national development perspective. These projects should be taken up by the concerned Ministries and Departments.

- The proposal for a second intense photon source was discussed in detail, and it was felt that the INDUS-2 facility being set up by the Raja Ramanna Centre for Advanced Technology, (RRCAT) would meet most of the requirements. Of the thirty two beam lines which INDUS-2 can support, it would be possible to set apart ten to twelve beam line positions for setting up such dedicated facilities. Interested research groups could be funded by the DST, and RRCAT should provide exclusive space and services for these experiments.

7.3 Some Recommended Mega-Science Projects

7.3.1 High Energy and Nuclear Physics

7.3.1.1 International Linear Collider and related programs

- Particle physicists the world over have established the physics case for a TeV, Linear electron-positron collider as a machine that would be complementary to the Large Hadron Collider (LHC), and which offers the possibilities of studying directly the 'dark matter' which makes up most of the mass of the universe, as well as answer fundamental questions about the fabric of space-time.

- The Indian High Energy Physics Community is interested in the physics studies at this International Linear Collider, (the ILC) which, as said above, is the next frontier of research in the subject. Indeed, the community is in a position to do so meaningfully in view of its important contributions to the subject of collider physics till date.

- The HEP community, in its road-map for the next 20-25 years, has identified the ILC and the INO as the two activities which the community is keen on pursuing. The ILC technology has commonality with that of the X-ray Free Electron Laser (XFEL), the High Intensity Proton Accelerator (HIPA) as well as the Facility for Antiproton and Ion Research (FAIR). (See *Annex 3a*) The accelerator Physics Community is keen on participating in the design and construction of the advanced accelerator projects such as the ILC, XFEL, High Intensity Proton Accelerator (HIPA) and FAIR. The Nuclear Physics Community is interested in doing physics with the Radioactive Ion Beam (RIB) and FAIR. It may also be noted that the condensed matter and material science community is keen on participation in the physics studies that are possible with an XFEL. The participation in the design and construction and in the R&D of facilities such as the ILC, XFEL, HIPA and FAIR will enable our accelerator community to take part in highly advanced technologies in the important accelerator field.

All of these programs have a major component of international collaboration and participation in them will allow the Indian scientific community to take its rightful place in the world scene. Even more importantly, participation, as mentioned above will also feed back to the domestic programs in a major way.

While participating in the ILC, the Advanced Accelerator Projects such as XFEL, HIPA and the accelerator aspects of other programs such as the FAIR, one would like to emulate the highly successful model, of the participation by Indian Scientists in the LHC project which is soon to be commissioned at the European Organization for Nuclear Research (CERN). India's participation in and the 'in kind' contribution to the LHC-machine, generated some funds towards India's further participation in the R&D for the detectors, as well as building them. Our participation in all these has showcased the ability of Indian scientists and the Indian Industry to undertake challenging tasks and deliver on the tight international schedule. It has brought recognition to the country such as the 'Observer status' in the CERN Council. This can only increase, with India's continued contribution in the Physics analysis and studies at the LHC. This has also given Indian Industry the opportunity to meet globally competitive technological demands. Hence it is essential to continue India's participation in these International projects.

An ILC and Advanced Accelerator Technologies Forum, has been initiated to discuss various aspects of participation in the above activities by the Indian scientists, maintaining a synergy with existing and planned programs in related areas in the country. The various activities towards R&D in generic technologies related to the ILC and other high power accelerators: XFEL, High Intensity Proton Accelerator (HIPA) as well as the accelerator component of FAIR are to be taken up in different institutions.

7.3.1.2 India-based Neutrino Observatory (INO)

An India-based Neutrino Observatory (INO) has been proposed by a large community of scientists from various institutes and universities in India for doing front ranking experiments in the field of neutrino physics. With this objective, a neutrino collaboration group was established in 2002. This collaboration was assigned the task of carrying out the feasibility studies for setting up such a facility for which funds were made available by DAE during the Xth Plan. The INO collaboration has already completed the feasibility study and submitted a detailed report to DAE and other funding agencies. The Collaboration has also identified the Pykara Ultimate Stage Hydro Electric Project (PUSHEP) at Masinagudi in Tamil Nadu state as the preferred site for locating the underground laboratory.

The proposed goal of this project is to:

- Build an underground laboratory and surface lab for doing front ranking experiments in the area of neutrino physics in India.

- Construction of a 50 kton magnetised iron calorimeter to study atmospheric neutrinos, which may be augmented to 100 ktons later.
- Creation of an INO centre with all modern facilities like workshop, electronics lab, detector fabrication and testing bay, offices, hostel and guesthouse.

Apart from being a premier experimental facility in the country, the INO centre is expected to become a nodal centre for initiating collaborations and educational outreach programs with leading HEP and nuclear physics laboratories in the world. An immediate impact of this centre will be in the field of training experimental physicists. In particular the contribution to the culture of doing experiments, small or big, will be enormous. The particle detectors developed by the high energy and nuclear physicists over the years have found wide application in areas such as medical imaging, material science, and industrial control and in geological survey. Detector development for such purposes is also expected to be a major part of the over-all activities of this centre. It is therefore going to play a major role in the development of detector technology and in the transfer of this technology to industry for its potential large-scale utilization.

7.3.1.3 National Radioactive Ion Beam Facility

The nuclear physics community in the country in various universities and research organizations is engaged in carrying out front-line research and has been making internationally reputed contributions. During the deliberations at the recent DAE-DST vision meetings, all the leading nuclear physicists have very strongly and collectively recommended setting up of a world class, National Radioactive Ion Beam (RIB) facility, in the country, for contemporary and front-line nuclear physics experiments. The research areas include the study of explosive stellar events, nucleo-synthesis, structure of exotic nuclei, limits of particle stability, synthesis of super-heavy nuclei etc. Highly advanced materials science experiments will also be carried out with such a facility. A low energy, highly sophisticated RIB facility is under development at VECC, Kolkatta. Several complex technologies relevant to a front-line RIB facility have been developed. It is now proposed to initiate the development and construction of a large and high energy RIB facility in the country, as mentioned above, which will compare with the best in the world in the field of nuclear physics research. The accelerator facility and related experimental facilities will be set up with the participation of several research organizations and universities of the country. International participation in this endeavour is also expected. In fact, VECC has already been collaborating very actively with two leading international laboratories, namely RIKEN at Japan and TRIUMF at Canada, both for accelerator design and development and for the nuclear physics experiments in the field of RIB.

7.3.1.4 Facility for Antiproton and Ion Research (FAIR)

This facility will be built around 2011 at GSI, Germany. With this facility, research can be performed in a broad range of areas, namely (a) high-energy nucleus-nucleus collisions to study compressed baryonic matter, (b) nuclear structure and nuclear astrophysics studies utilizing rare isotope beams, (c) plasma physics utilizing short pulse heavy ion beams, (d) studies in atomic physics and applied research including radiobiology using antiprotons and highly charged heavy ion beams and (e) researches in hadron physics including hypernuclei with antiproton beams. There is enormous interest among Indian researchers to perform experiments at this facility. The areas include nuclear structure physics, high-energy heavy Ion collisions, plasma physics, radiobiology, medical research etc.

FAIR will have innovations in the field of accelerator science and technology as well. Some of the highlights in the field of accelerator are, (a) fast cycling superconducting magnets, (b) large aperture super-ferric magnets (c) fast stochastic cooling for radioactive ions and antiprotons (d) generation of short (~50ns) and intense (10^{12}) ion pulses with terawatt beam power and (e), operation at very high intensity RIBs.

Some scientific and technological advantages out of participation in FAIR are:

(i) Opportunity to take part in and contribute to the large variety of highly advanced experimental facilities for nuclear physics and other areas.

(ii) Working for the development of fast and radiation-hard detectors and electronics, which is a unique activity.

(iii) Experience in parallel beam operation of a large accelerator complex

(iv) To learn about high intensity target preparation - useful for our ADSS and RIB programs.

(v) Working in the areas of plasma science and technology complements magnetically confined plasmas and our participation in ITER.

(vi) FAIR will deal with highly intense beams. Building of any device in this high current environment needs innovative technology. Two areas where we will have direct access and will be useful in our own programs like the ADSS are:

- Building complex superconducting dipole, quadruple and sextuple magnets from design to installation.
- Building components for high current proton-LINAC at FAIR.

7.4 Astronomy based Research

The country at present has several major new telescopes: Currently, the GMRT (Giant Metre-wave Radio Telescope, operated by NCRA-TIFR) represents a major international, competitive, facility for radio astronomy at metre wavelengths, functioning for the last five years. At optical and infrared wavelengths, a very promising beginning has been made by the Indian Institute of Astrophysics (IIA) with its recently commissioned 2m telescope at Hanle in the Himalayas, one of the highest sites worldwide for optical and ground based infrared astronomy. The IUCAA telescope is poised to create and serve a strong university community in astronomy. The ASTROSAT X-ray observatory due for launch in 2008 will give a major boost to X-ray astronomy and related areas in the country. With this background, the astronomy community in the country is considering several new initiatives where the planning and build up will be in the XIth Plan and the actual execution is likely towards the end of the XIIth Plan. These are:

a) The Square Kilometre Array - an international radio observatory, costing about USD 1 billion, due for construction 2012-2020, NCRA-TIFR is already formally involved in the international discussions and planning.

b) A 10-m class optical / near-IR telescope in the Himalayas, under serious discussion by IIA, ARIES, IUCAA, TIFR.

c) New satellites for space astronomy, particularly X-ray and far -infrared work. ISRO is the nodal agency with significant TIFR and RRI involvement.

While the initial small funding can be met from the existing Plan of TIFR, major funding can be made available in subsequent Plan periods. Some general observations are:

i. There is a need for a broad roadmap and consensus in the astronomy community, which is best, achieved by working papers from individual groups followed by an intensive representative workshop of stakeholders in the various projects

ii. One strong common thread is user community development, particularly in the universities - clearly IUCAA has a key role here.

iii. All these areas require very significant technology development. This should utilize the existing agencies as well as engineering institutions plus industry, as appropriate. A consortium approach would give the needed co ordination combined with flexibility.

7.5 National Hetero-structure Facility

During the last two decades, nitride semiconductors have emerged as strong candidates for high frequency as well as light emission applications. Indeed it is possible to replace household lighting systems with these light-emitting diodes (LED) to conserve the power and achieve long life usage. Further, dilute nitrides have emerged from conventional III-V semiconductors such as GaAs or InP by the insertion of nitrogen into the group V sub-lattice, which has profound influence on the electronic properties of these materials and allows widely extended band structure engineering. This is expected to lead to novel devices, e.g. for optical data transmission, solar cells, biophotonics or gas sensing, some of which are already making their way into the market.

In view of the importance of this area, a proposal to set up a National facility to carry out research in the area of semiconductor heterostructures and related devices and materials was received. The Centre for Semiconductor Heterostructure Research (CSHR) is intended to provide facilities initially for carrying out advanced research, which are important for the national energy, and security needs.

DST has discussed in the its Programme Advisory Committee on Condensed Matter Physics and Materials Science. It was further discussed in the Science and Engineering Research Council and also by an Expert Committee constituted by the DST to discuss its XIth Plan proposals. Accordingly, DST has 'flagged' this facility in their documents containing the XIth Plan Proposals.

7.6 The ITER Project

ITER INDIA is a developmental Mega Project, a project of the type where a department undertakes a major R&D effort in a mission mode in an area of national need. ITER INDIA project is connected with the development of nuclear power programs in the country and seamlessly connects to the strategies related to the Third Stage and beyond. These strategies aim at nuclear technologies of importance in the latter half of 21st century and include new technologies like nuclear fusion.

ITER INDIA project, being large in size, is also being used to promote a national program of research and development in fusion energy and plasma physics. Some funds have been earmarked for smaller related R&D programs in Universities, IIT's and other research institutions, which will be simultaneously promoted. This will lead to cross fertilization of ideas by networking of institutions and research programs and will assist in the task of human resource development.

India's contributions to ITER are largely based on the indigenous experience and the expertise available in Indian industry. India will be fabricating the 28 m dia, 26 m tall SS cryostat, which forms the outer vacuum envelope for ITER. It will also take up the design and fabrication of eight 2.5 Mwatt ion cyclotron heating sources, complete with power systems and controls. It will also take up the fabrication of a diagnostic neutral beam system, which will give crucial information about the physics of burning plasmas in ITER. India will also be responsible for a number of other diagnostic subsystems. Finally, India will contribute to cryo-distribution and water-cooling subsystems. All this equipment will have to be built with ITER quality standards and in a time frame (approximately ten years) as determined by the International Team at the host site in Cadarache , France. This is the challenge.

The opportunity that participation in ITER offers us is also enormous. This is the first time we will be full partners in a prestigious international experiment. We will have to come to international standards of quality, safety, time schedule maintenance etc immediately. Our scientists and engineers will get direct hands on experience in design, fabrication and operation etc of the latest fusion technologies. We will get access to a number of fusion technologies on the scale relevant to fusion reactors for the first time. If we backup the ITER INDIA effort with an aggressive well focused national programme, it will allow us to leapfrog by at least a couple of decades.

7.7 Indigenous Passenger Aircraft Development

Being a large country with growing economy and having a large and capable Science & Technology expertise, it would be appropriate for India to have its own civil aviation aircraft design and manufacturing capability. It is projected that upto 2025 India will need about 350 passenger aircrafts. The current proposal envisages development of passenger aircraft during the next 10 years. The estimated cost of this will be around Rs. 2035 crore spread over two five year plan periods. CSIR has already budgeted Rs. 635 crore in their eleventh plan proposal.

7.8 Modalities of Implementation and Benefits

The modalities of implementation and the benefits that accrue by taking up and participating in such projects are:

(i) Apart from the scientific facilities, there would be a need to bring together a large group of researchers who come from different institutions situated within the country and from different parts of the globe. This would entail the creation of an appropriate environment and infrastructure at the sites of mega - projects.

(ii) Even though it is recognized that these projects would be implemented with multi-institutional collaboration and management, it would be appropriate that the funding should be channelised through a mutually agreed host institution.

(iii) While the actual implementation of these projects would involve multi-institutional involvement, linking the projects to a broader academic framework would help sustain the research activities around these large facilities.

(iv) These kinds of projects have the advantage that they network a wide range of expertise from a range of different disciplines. This offers a new paradigm for exposing our young researchers to a more holistic training in research involving state-of-the-art techniques.

(v) One of the major benefits of implementing mega science projects is that it creates an exciting opportunity for our young scientists to participate in cutting edge research and attract them to science by offering meaningful post graduate or doctoral programmes, and at a larger level, it enhances the scientific culture in the country. Specifically, this could include organizing summer / winter schools, summer projects for B.Tech, projects for M.Tech students, and research programmes for students pursuing a Ph. D in science or engineering. Wherever necessary, funding for these activities can be provided by creating appropriate mechanisms under BRNS and DST.

(vi) Finally, these projects lead to direct technological gains for the country in terms of advanced technologies and equipment building, as well as development of expertise to take on similar projects in future that push the frontiers of technology.

8

Cross-Disciplinary Technology Areas

8.1 Under the umbrella of *"Cross-disciplinary technologies"* we identify those S&T areas, cutting across the traditional divides of sciences, engineering and medicine, where investments can pay rich dividends. The R&D being pursued in S&T departments and mission programs, which have followed a multidisciplinary approach, have contributed to our self-reliance in strategic sectors. In addition, there exists a strong scientific and technological base, spread over various academic institutions, R&D laboratories and industries that can be leveraged for the economic prosperity of the nation.

Working in cross-disciplinary technology areas is about inculcating the culture of translating the scientific knowledge to practical gains. Towards this, there is a need for building the interfaces amongst Academia, R&D laboratories and industries to create an environment for innovation and invention. This calls for adequate infrastructure for focused R&D, as also establishment of methodologies for financing innovation in the early stage of technology development.

The following cross-disciplinary areas need to be supported during the XIth Plan.

- Desalination and water purification technologies
- Nutrition
- Health care (Medical diagnostics, Medical devices, Vaccines)
- Advanced Computing
- Advanced Manufacturing
- Robotics and Automation
- Combustion Research
- Sensors & Integrated Systems
- Distributed Sensors and Networks
- Security Technologies
- Advanced Functional Materials

The above list is certainly not comprehensive, it represents a common denominator of cross disciplinary areas, where building the core expertise and competence will have far reaching consequences in the development of science based technologies for societal benefits, economic competitiveness and national security. The above cross-disciplinary areas transcend more than one domain both in terms of expertise that is called for and the useful technology that is developed. The Working group also noted that while some of the topics indicated above are already being pursued by S&T ministries, their identification under cross-disciplinary technology areas is an endorsement of their importance and the need for focused support.

8.2 Desalination and Water Purification Technologies

Water security is a fundamental requirement for a sustainable development. Increase in population and in the per capita demand are imposing tremendous strains on our water resources. Given this, a comprehensive R&D programme on various desalination and water purification technologies should be pursued. These include:

- R&D on thermal desalination plant optimised for Indian conditions with focused research efforts on energy reduction, cost optimisation, scale control, improved heat transfer coefficients, materials and minimising thermodynamic losses etc.
- Offshore desalination using Ocean Thermal Energy Conversion- Low Pressure Distillation.
- Waste heat based seawater desalination plants
- Water recovery and recycle from industrial effluents and sewage
- Development of solar energy / other renewable energy driven desalination plants,
- Advanced pretreatment & post treatment systems for desalination
- Work on Indigenous membrane development, in particular on the development of biodegradable membranes

It is estimated that a comprehensive R&D in the above areas will entail an investment of Rs.200 crores. It was also felt that apart from R&D in the above areas, there is also a need for suitable governmental policy measures that should encourage and promote (a) setting up of dual-purpose plants for power and desalinated water production along the coastal areas, (b) incentives / subsidies for the industries to retrofit desalination units using the waste heat, wherever possible, (c) appropriate technologies to recover water from spent streams and effluents for reuse. Further, environmental norms with respect to desalination and water recycle plant location and discharges need to be established and notified.

In suggesting the above recommendations, we have drawn heavily upon the position paper and technical report on Desalination and water purification technologies, prepared based on a brain storming session convened by PSA, GOI. This involved a meeting on 23rd August, 2005, with the representatives of R&D organizations and academic institutions, such as BARC, Mumbai, CSMCRI, Bhavnagar, RRL, Bhuvaneshwar, NIOT, Chennai, IITs etc, as also the concerned industries such as BHEL, Ion Exchange

(India) Ltd., ROCHEM Separations etc., and a subsequent national level discussion meet, organized by BARC at Anushaktinagar, Mumbai on February 27, 2006.

8.3 Nutrition

Nutrition for all age groups, from pediatrics to geriatrics, is a necessity for the well being of the country. Anemia, malnutrition, low birth weight, unhygienic living conditions etc., are areas that need technological as well as social intervention. It is imperative that during the first formative years of the child, in particular the girl child, a high class nutrition be provided that can make a huge difference later. This preventive approach to good health, through nutrition, can obviate the need for expensive damage control at later times. The success of implementation of the programme on Nutrition calls for the participation of various governmental organizations and NGO's.

A comprehensive R&D programme on Nutrition needs to look into several aspects such as (1) the important role of micro-nutrients (Fe, Zn, I.) and their fortification, (2) Genes and diet (3) Neutraceuticals and functional foods, (4) To exploit the value of traditional Indian foods – perhaps for future markets etc. Further, the power of food processing and value addition must be carefully and strategically used for production, protection and extension of shelf life.

There is a need to establish a referral centre for nutrition analysis. This high-tech analysis centre would carry out a variety of important analysis such as Macro and Micro Nutrients, Calorific value, Food allergens, Food pathogens and pesticide residue.The estimated cost of establishing the referral nodal center for nutritional analysis is Rs.25 crores

8.4 Health Care Technology – Medical Devices & Vaccines

Healthcare technology is probably one of the most important cross-disciplinary areas. Today, healthcare delivery is dependent on three major product groups, namely: (1) Drugs, (2) Biologicals - vaccines, blood components, etc and (3) Medical Devices. While the Indian drug industry is well established, biologicals, especially vaccines require technological improvements and refinements. But most importantly, the bulk of MEDICAL DEVICES, that include Life saving implants, High tech diagnostic equipments and instrumentation, Diagnostics test kits, Surgical instruments and accessories etc., continue to be imported (estimated at over 80% of the country's market). Further there is very little control over their safety and quality before being placed on the market.

Given that medical devices form one major cost-component of healthcare, ignoring this sector and depending on imports will continue to make it difficult - if not impossible for a majority of our people to have reasonable access to safe and adequate healthcare. Hence, the Working group calls for a Mission Mode Development of Medical Devices and Vaccines. The major recommendations are:

1. A MAJOR THRUST for development & delivery in selected high impact segments (a) Medical Instrumentation (b) Orthopaedics (c) Diabetes treatment. The programme on Medical

instrumentation will take into cognizance the report on Instrumentation published by INSA, under the chairmanship of Dr. S.K. Sikka.

2. A MAJOR THRUST for development of Vaccines under Good Manufacturing Practice conditions with an integrated approach; a major initiative in Tissue engineering, - an emerging frontier area.

3. Set-up an INDEPENDENT Medical Devices Regulatory framework; develop infrastructure for safety testing and evaluation to support this.

4. Promote the growth and formation of:

   - Strong interdisciplinary R&D centres / groups / consortia
   - Infrastructure for the training of the much needed Clinical and Biomedical Engineers.

The above programme will entail an expenditure of Rs.350 crores and call for a cross disciplinary approach involving Medicine and Engineering.

8.5 Advanced Computing

Advances in computational technology continue to transform Science and Technology research, practice, and allied education. Computing has become the third pillar of Science and Technology, complementing the traditional activities of theory and experimentation. There has been a tremendous increase in the volume of data that scientists working in physics, chemistry, biology and many areas of engineering need to analyze in real time. Scientists in many disciplines have begun revolutionizing their fields by using IT information, computers, digital data, and networks to replace and extend their traditional efforts. For example, High Energy Physics community is able to carryout today calibration, reconstruction, simulation, analysis in collaboration with their partners located any where across the world. The processing, mining and visualization of large volume of data in areas spanning medical, nano sciences, material sciences and space sciences would be one of the major cross disciplinary areas of the future.

Box 8.1

Petaflop Supercomputer

India has been denied many high technologies under various dual technology controlled regimes and sanctions. High speed computers have been one of them. However, this has spurred different agencies (CDAC, DRDO, BARC, etc.) to develop supercomputers for high level computing applications in science and technology. During the Xth Plan, because of these efforts, the computing power has gone up from gigaflops to teraflops. The next frontier is petaflop computing. India cannot afford to absent itself from this strategic area.

On 29th of June, 2005, a meeting was held in the Principal Scientific Adviser's Office to discuss a proposal by Dr. N.K. Karmarkar (then the Head, Computational Mathematics Laboratory (CML), TFIR, Pune) on a new strategic national initiative for developing a physical design for petaflop (10^{15} floating point operations per second) supercomputer.

The concept of Dr. Karmarkar to develop the design of petaflop supercomputer appear to be feasible. Tata Consultancy Services (TCS) agreed to join this initiative as an Industrial Partner. The indicative cost of this initiative would be approximately Rs. 500 crores. It was decided that a detailed project report will be made jointly by Dr. Karmarkar and TCS.

Currently, there is a shift in the philosophy of computations and the trend is to share the computing power rather than own it. This has become possible due to a new & upcoming technology called "Computing Grid", which is being developed using the Internet and the World Wide Web technology. By integrating this distributed environment using low cost Internet, very high speed technology, now it has become possible to provide supercomputing power in the hands of individual users that until now could only dream of affording such power without having to make an exorbitant capital investment. Furthermore, information processing activities, such as data base indexing and financial modeling, emails, data mining via search engines through Internet etc., are becoming more computationally and I/O intensive and require high performance computing facilities.

The working group on cross disciplinary technology strongly endorses the setting up of a Indian Grid for Science & Technology (IGST), a Nation-wide "Hierarchical networks of High Speed Computing & Communication systems" based on an open platform. It will be very high bandwidth multi 10Gpbs backbone primarily to cater to the Science & Technology applications, such as weather forecasting, bio-informatics, high energy & condensed matter physics, sharing of digital libraries, information on education, Video meeting etc.

This proposal for establishing IGST is based on the meeting of cross disciplinary technologies held at IIT-Madras on 17-6-06, followed by a brain storming session held at PSA's office on July 20, 2006. Dr. Chidambaram chaired this meeting, that was attended by specialists like Dr. B.K. Gairola of NIC, Dr. S.V. Raghavan of IIT, Madras, Dr. R.K., Shyamsunder of TIFR, Shri. P.S. Dhekne of BARC, Shri.

S.Ramkrishanan of C-DAC, Dr. A. Kembhavi of IUCA, Dr. Baldev Raj of IGCAR, Dr. S.K. Dash of IIT, Delhi and Shri. Neeraj Sinha of PSA office. The Brain storming meeting suggested that the proposal on setting up of IGST is to be overlaid with another proposal for the creation of a nationwide high-speed e-infrastructure that is being submitted separately.

Setting up of IGST will take India into the next century of research and education by supporting advance research in S&T by developing state-of-the-art technologies in information technology, computing and advanced computational modeling. It is planned to explore new modes of computing by extending the concept of clusters to that of wide-area grids of supercomputers allocated dynamically to a common problem over both wide distance and multiple organizations. Establishing Indian Computing Grid for S&T (IGST) would require funds to the tune of Rs. 500 Crores.

8.6 Advanced Manufacturing

The XIth Plan approach paper highlights the importance of increasing the growth rate in the manufacturing sector to achieve economic prosperity. The deliberations at the Working group, with inputs from earlier brain storming sessions suggested that there is an urgent need for

- Providing a sound scientific and technological support to the Indian manufacturing industry from conceptual design to prototyping of components in general engineering as well as strategic sector.
- Developing innovative materials, processes, products and practices that can help the manufacturing industry to be a leader in the global market.

Some of the specific areas where emphasis need to be placed include: (1) Manufacturing Technologies for Multi Material Microsystems, (2) Capability Building of Advanced Materials Processing for value added engineering / smart components, (3) Optimization of Process Parameter for Net-Shape Manufacturing through Rheo-casting, and (4) Rapid Manufacturing of Customized Biomedical implants and precision engineering components from functionally graded materials (FGMS), and (5) Development of magnesium components for automobile applications, that includes Pressure Die Casting, Twin Roll Casting, Sheet Making, Hydroforming etc.

In order to meet the above mission, a three layer approach involving Universities, R&D laboratories and industry is to be followed. This calls for an investment of Rs.160 crores.

8.7 Robotics & Automation

Robotics and automation play a crucial role in a wide variety of areas ranging from manufacturing, inspection and repair to medical and bio-engineering technologies. So far, in India, R&D on robotics has been pursued by strategic sectors like Atomic Energy, Space and Defence. These technologies also have important roles in advanced manufacturing, disaster management, rescue and surveillance in addition to extensive applications in strategic sectors.

Robotics and Automation calls for inputs from a number of areas like mechanical, electrical, electronics, instrumentation and software engineering, and parallel developments in the field of sensors like micro-vision, MEMS, touch-sensitive skins, etc. To meet the objectives of indigenous technological and scientific growth, and to facilitate strong interaction of experts in various domains of interest, it will be beneficial to establish a national centre devoted to work on Robotics and Automation. The prime objectives of this Centre will be in the development of Robotics in manufacturing, Robotics for extreme environments and Autonomous miniature robots, which can be customized for a variety of applications.

The proposed Centre, apart from having in-house R & D, will encourage collaboration with academic institutes, with small and medium scale industries for proto-type building, manufacturing, integration, testing and validation and offer customized solution for industry / institutes. It is estimated that a comprehensive R&D center on Robotics and Automation will entail an expenditure or Rs.150 crores.

8.8 Combustion Research

The technologists and researchers working in the area of automobiles are confronted with the challenges of the requirements of fast combustion processes and intricate system geometries mainly driven by emission legislations, fuel economy and the need for alternative fuels. The need for focused research and accurate measurements in these areas is fast growing. For example, the use of laser diagnostics facilitate improved understanding of a wide variety of combustion phenomena in modern engines from efficiency and emissions standpoint. These techniques provide remote, non-intrusive, in-situ and spatially and temporally precise measurements. The non-intrusive laser based measurements are becoming essential for validation of the in-cylinder computational results produced through CFD analysis of the engine combustion system. Besides improving the competitiveness of our engine technology in terms of fuel economy, emission compliance, these scientific research input would benefit the nation in its urge to achieve energy security and cleaner environment.

Currently, there is a very limited activity in combustion research, diagnostics and modeling leading to indigenous development of modern automotive engines and enhanced fossil energy systems. In view of this, the working group strongly feels that there is a need to establish a state of art research centre for combustion technology with a view of ensuring energy and environment security, and global competitiveness. This Centre, housed in an academic institution, will work in the public-private partnership mode, and will help to build upstream and downstream interfaces, with R&D institutions engaged in fuel research and manufacturers of energy system. This calls for an investment of Rs.100crores.

8.9 Sensors & Integrated Systems

Ultrasensitive and miniaturized sensors and actuators are crucial to a host of domains from advanced science and technology to the security of the nation. Conversion of physical, chemical and biological parameters to measurable electrical signals and their integration with electronic measurement system is at the heart of modern science and technology. These have impact on every segment of human endeavour that includes agriculture, environmental monitoring, industrial processing, medical diagnostics, strategic sectors and so on. Constant innovation with respect to the development of new sensing materials and devices, multifunctional sensors, array sensors for imaging, sensors integrated with actuators etc., are being pursued worldwide as they contribute to the critical technologies. Advanced sensors that can detect ppb levels of chemicals, in atmosphere, remote sensing of weak electrical, magnetic and vibrational signals buried in a noise are major challenges that push the frontiers of science and technology. Competence in the development of sensors and integrated systems is one of the core technologies that will pay rich dividends in a variety of sectors from agriculture, manufacturing to healthcare, help build national economy and contribute to the security. For example, ultra sensitive sensors have become very important in the context of terrorism of various forms that calls for remote detection of explosives such as TNT, RDX etc, and dirty bombs wherein a conventional explosive material is packaged with radioactive material etc.

In India, a vast amount of research is being pursued on novel sensor materials that include solid-state materials, polymeric materials, biomaterials, nano materials etc. These have shown the potential for sensing and measurement of physical parameters such as pressure, temperature, humidity, magnetic field etc. Extensive research is being pursued in advanced sensors and methodologies based on piezoelectric effect, MEMS devices, magnetoresistance, SQUIDs etc. However, a major lacuna seems to be translating the gains of this R&D, being carried out in Universities and Mission departments, into devices and systems that can be used in various sectors. This calls for efforts at tailoring these materials in desired configurations (thin films etc), integration with suitable electronics, packaging, interfacing with measurement systems etc.

It is recommended that a focused R&D on advanced sensors be pursued. To facilitate this, a Center for Advanced Sensor Technology be established that will enable the translation of the R&D that is being pursued in the universities and institutions into final sensors and systems of required configuration. This center may also be entrusted with the mandate of testing, calibrating and certifying the sensors that are developed.

8.10 Terahertz Technology

All molecules, biological, organic and inorganic, have their characteristic vibrational and rotational spectra that lie in the terahertz (0.1 to 10 THz) range. These wavelengths are short enough to enable millimeter imaging whilst long enough to penetrate many materials, allowing hidden objects to be imaged. The front line area of Terahertz technology finds a variety of applications in areas such as remote sensing, medical diagnostics, and recognition of hidden objects for national security and to combat terrorism. Given the wide range of applications including the strategic sector, India should enter into this nascent technology. There is a need for establishing a developmental synergy across the academic institutions and industries towards a common goal of terahertz technology. This will carry out indigenous development of semiconducting heterostructures for microwave and Terahertz devices, Terahertz radiation sources based on photo-mixing devices, Superconducting nanostructures for Terahertz detection, Integrated circuits for Terahertz radiation etc.

8.11 Thin Film Transistor Technology

In the world of information and communication technologies, large area electronics based on Thin Film Transistor (TFT) is going to play a crucial role in information collection, transfer and interface with societies. TFT based sensors, images, electronic papers and displays are expected to become a part of our lifestyle in the years to come. Information is critical in military engagement and national security. While commercial requirements would be met by globalised economy, the strategic needs still require to be home grown in which Indian industry need to take up the challenge.

In contrast to microelectronics industry, large area electronics is still an emerging technology in which India has the capability to get in the race. The recommendation is for setting up a flat panel display facility- that will work in conjunction with high-technology industries.

8.12 Development of a National Facility for VLSI Testing and Failure Analysis

Having established itself in the Software field, India is looking towards the engineering of electronic products as the next milestone. This typically involves three stages, namely, i) Design, ii) Fabrication and iii) Testing. While the country has already become the preferred destination of major multinationals for the Design stage, there are relatively few manufacturing facilities and virtually no testing or failure analysis facility. Fabrication of electronic products requires major investments, which can be justified only by commercial consideration, and is therefore better left to the private sector. Further, in the overall South-east Asian region, there are a number of manufacturing units, many of which are running far below their installed capacity. In contrast, there are just a few test facilities, which are accessible to them. Even when such a facility exists, the needs of the defence, space and atomic energy sectors cannot always be outsourced due to strategic reasons. Organisations like SITAR, SCL and GAETEC do fabricate ASICS for these sectors in India and require testing and Failure Analysis (FA) facilities. It can therefore be seen that there is an urgent need for such facilities to be established within the country, which will cater to the existing and upcoming manufacturing facilities not only in the country, but also be able to take up contracted jobs from abroad in order to become self-supporting in the long run.

8.13 Distributed Sensors & Networks

Distributed sensor network is an emerging cross disciplinary technology bridging materials research, electrical engineering, computer science etc. An integrated system comprising of sensing, computing and communication, geographically distributed on a network can be used for a plethora of applications such as monitoring, surveillance, disaster management, health care etc. There are challenging technological issues related to miniaturization, power consumption, ruggedisation, networking etc., and India should enter into this technology domain of far reaching ramifications.

The area of Intelligence and security informatics spans areas such as Wireless sensor and actuator networks, data mining and knowledge discovery from unstructured data. This area is also prompted by the fusion of computing, communicating and sensing elements all into one single electronic device.

8.14 Security Technologies

Transportation systems, viz., Road, Maritime and Air, is a vital backbone of any nation's economy and its security must be of great concern. In the recent times this sector has become a potential soft target. Emergence of new threats from organized terrorism has made this task very challenging and recourse is taken to technology-based solutions. Further, protecting industrial infrastructure, critical to nation's economy, and strategic system's protection are vital requirements.

The modern security technologies encompass a gamut of advanced technologies related to sensors, signals, image processing, mobile system security, Network and information security, crypto analysis etc. While it is necessary to work with other countries to develop these technologies in order to save time and money, it is also essential to develop our own solutions unique to our own requirements.

The proposal under cross disciplinary technologies is for establishing basic technologies that is common to, and serve most of the security and strategic system's needs, that is vital to national security. In addition to Sensors and Distributed systems, which already are emphasized in the report, there is a need for investment for R&D in Basic surveillance systems, Distributed and Mobile systems security, Network and information security which includes cryptology and crypto analysis and fast searching of massive remote distributed data bases. This calls for an investment of 200 crores.

8.15 Transportation -Wireless Technologies

One of the focus areas related to this technology is the Skybus Telematics System. Research and development in this area has included implementation of telematics technologies that would enable multimedia-rich communication between vehicles and stations in a metropolitan-area rapid transit network. This involves developing a new system of Intelligent and Interactive Telematics for Transport Systems using WiFi-based wireless mesh networks and embedded in-vehicle information appliances. The key attributes of this system will be security, safety, reliability, performance, multimedia user interface, viable revenue model, and relatively low cost. Advanced research is focused on Vehicular Ad hoc Networks and Vehicular Sensor Networks.

R&D on the front line area of Wireless and distributed networks calls for establishing facilities for Electronic Design and Automation Tools, Production of custom built chips at Fabs, both in India and abroad, and integration with front-end electronics. It is estimated that this enterprise would call for an investment of 200 crores.

8.16 Advanced Functional Materials

Here under the category of Advanced Functional Materials, we consider those new materials that have interesting electronic, optical or magnetic properties with considerable potential for application in a variety of technologies that include energy, health care, communications and security. Silicon exemplifies the classical functional material, that has heralded the modern electronics and communications technology.

Materials science, one of the most active areas of research, has thrown open a variety of new materials, that hold considerable promise for performance in a variety of technological domains. These include:

1. Solid-state materials that include superconducting materials, magnetic oxides exhibiting giant magnetoresistance, ferromagnetic semiconductors for spintronics, piezoelectric, pyroelectric and ferroelectric materials.
2. Functionalised nano materials for sensors and Biomedical applications
3. Organic semiconductors for electronic devices.
4. Membranes and strategically important Elastomers
5. Complex fluids with interesting rheological properties including ferro fluids and nanofluids

One of the promising approaches is to combine in one material different physical properties to achieve rich functionality. For example, attempts at combining ferromagnetism and ferroelectricity – the multiferroics, optics and electronics the photonic materials etc. All the above areas are at the forefront of research today, and India has a strong scientific presence in many of these areas.

The recommendation is for focused R&D that aims to explore and exploit the potential of Advanced Functional Materials. The focus will be on Design and synthesis of novel materials including computer based design, materials processing for performance, and materials integration for devices. This recommendation is for an investment of 200 crores for R&D in various functional materials, with further investments for the development of devices and products to come through active industry participation.

R&D on functional materials has an enormous potential for wealth creation. It is a vital investment that can interface academia and industry at the cutting edge to enhance nation's industrial and economic competitiveness.

8.17 Mechanisms

Success in cross-disciplinary technology areas is about inculcating the culture of translating the scientific knowledge to practical gains. This calls for several mechanisms to be in place to ensure the success of "cross-disciplinary technology areas". The major recommendations of the Working group include:

- Establishment of research parks to facilitate cross disciplinary research. These science parks will act as the hub for interfacing of universities, R&D centres and industries.
- Empowered panel of experts, with financial control, that can suggest and implement mid-course corrections to the programme, to facilitate and exploit breakthroughs in R&D.
- For the success of these interdisciplinary areas, such as robotics, medical devices etc, there is a need to have an education system that integrates Science, Engineering and Medicine.
- For areas such as Desalination and Nutrition, Public-Private Partnerships must be encouraged
- Need for adequate legislations to ensure progress in some of the cross-disciplinary technology areas, such as Desalination.
- Need for an autonomous regulatory authority in the area of Medical instruments.
- India is on the threshold as a hub for clinical trial, especially for vaccines. This must be exploited.
- It was also felt that in several of the cross-disciplinary technology areas, collaborative venture with Scientists and Technologists of Indian origin Abroad, and foreign institutions of repute should be actively encouraged. This will pave the way for crucial inputs both by way of science and technology and work practices that will help us to leap frog in the development of science based technologies. The identification of the collaborating scientists and institutions will be carried out when the detailed proposals are submitted.

9

Leveraging International Collaborative Inputs

9.1 International collaboration inputs have so far been used by various Departments/agencies for providing facilities to individual scientists in the form of joint R&D projects involving exchange visits, sharing of scientific data & information and knowledge through joint workshops and seminars, providing access to sophisticated and international facilities. International Collaborations have also been used successfully for developing joint centers and joint mechanisms. In addition, some initiatives have also been taken during the end of Xth Five Year Plan for supporting pre-commercial R&D.

During the XIth Five Year Plan, the International Collaboration Inputs and activities should be leveraged primarily aiming at complementing and supplementing ongoing national efforts in selected areas of basic research. New initiatives aiming at developing and implementing mega S&T projects both in areas of basic sciences and other areas of need including societal needs also should be given due importance and priority. International collaboration inputs should also be effectively used in developing world class facilities in selected areas in the country as well as for India's participation in major International S&T mega projects/initiatives.

Following are the specific recommendations:

- **Continuation of bottom-up approach**

The initiatives taken by various departments and organizations during Xth Plan period for developing collaborative activities between individual scientists and groups (bottom up approach) need to be continued during XIth Five Year Plan. **About 40% of the total available budget should be devoted for such initiatives.**

- **Synergy Between national programmes and international collaboration inputs**

National priorities/ national strength and national needs should be kept in mind/view while negotiating/concluding S&T Cooperation Thus, international collaboration inputs should be used in linking up the research groups working on nationally important and relevant projects with the counterpart researchers abroad.

- **Effective Coordination between Implementing Agencies**

A National Coordination Committee on International Collaboration Inputs may be constituted preferably under the chairmanship of Secretary, DST with adequate representation of subject experts both from academia and R&D, industry representatives and representatives of various S&T Departments and agencies to avoid overlapping of interests and duplication

- **Developing Strategic Relationship with select countries**

Strategic relationship needs to be developed with those countries, which have gained experience in developing strong programmes / mechanisms on Industry-academic and R&D collaborations. Thus, international cooperation inputs should also be leveraged for India's technology led economic growth in select industrial sectors.s / alliances be developed with appropriate countries for mutual benefits and gains.

- **Gaining leadership through Technology-led Diplomacy**

India needs to leverage from technology-led diplomacy in international cooperation in S&T. For several developing countries, India is a role model for Science and Technology based growth. India can play an enabling role for many nations. This should be used for geo political advantage of the country.

- **International Cooperation in areas of need including Societal needs**

India need to develop strategic partnership in some key areas of economy with those developed countries that have standardized technology packages. Energy, water, environment, disaster management / preparedness, health and nutritional security of India would call for such large models of S&T Cooperation. Wherever India could assist other developing or less developed nations, it should develop cooperation in S&T with those countries for gaining geo political advantages.

- **Retaining Indian Talent and attracting talent from abroad including Indian diaspora**

The initiative taken by DST during the Xth Five Year Plan for providing fellowships to STIOs needs to be strengthened both in quality and quantity in the XIth Five Year Plan. Also, attractive fellowships both at pre PhD and Post Doctoral level should be offered to attract foreign researchers to work in Indian Institutions. Similarly, other modes such as guest lectures, planning visits, short duration fellowships, joint research projects from industry etc should be encouraged to attract foreign researchers to work with Indian researchers.

- **Participation in mega science projects**

There is a need for Indian's active participation in International Science projects which are multi nation projects or large collaborative projects such as International Partnership on Hydrogen Economy (IPHE), Facility for Antiproton and Ion Research (FAIR), ILC, International Thermo nuclear Experiment Reactor (ITER), Relative Heavy Ion Collider (RHIC) etc. Similarly, India should also leverage international collaboration inputs for developing mega science projects and developing sophisticated facilities in India in areas where it has edge such as Synchrotron facility, HANLE Telescope, INO, Coordinated Research Project on Spintronics, Congnitive Sciences, National Large Solar Telescope, Space Cornograph aboard INSAT, large optical / infrared telescope etc. Such facilities should be provided access to scientists both from developed countries as well as developing countries.

- **Access to advanced facilities**

More avenues should be provided to Indian scientists to gain access and usage of advanced international facilities such as CERN (Geneva), ELETTRA (Italy), Sp Ring -8 (Japan), KEK Accelerator (Japan), National Laboratory for High Energy Physics (Japan), Synchrotron Radiation Source Beam line Facilities at Novosibirsk, Russia and Brazil, FAIR (Germany), Fermi Lab (USA)), Synchrotron Light Source (Singapore), HLC, RIB, ITER, etc.

- **Support to pre-commercial R&D**

International S&T Collaboration inputs should be leveraged effectively for national gain in undertaking joint R&D projects of industrial interest / commercial value at pre-commercial stage involving academic and R&D groups as well as industrial groups at both the ends. To begin with, such cooperation could be concluded for pre-commercial R&D or up scaling of technologies, which have been developed and tested at laboratory scales.

- **International Collaboration for developing negotiating capabilities**

International collaboration inputs should be used for providing appropriate inputs / capabilities on technology negotiations, technology sourcing, etc. Appropriate training programmes need to be designed for developing indigenous capabilities in these areas.

- **Commercial Technology Transfer**

In a few cases, transfer of commercially proven technologies developed abroad, could also be supported provided such technologies are of social relevance and useful for large masses or help in bringing down the cost or indigenous development of such technologies may require not only huge resources but also considerable time.

10

Academia Industry Interaction

Relationship between the academia and industry is not just one of technology donor-recipient, but is of interactive, collaborative, participative nature spanning respect for each other's role and contributions to bring about research production integration - the true purpose of such interactions. Here, academia-industry interactions are viewed as a system where active participation of all players is important.

In the S&T system, there are four important aspects - basic education, advanced education, basic R&D and applied R&D. For each of these aspects, academic-industry interaction may be important for achieving the desired goals and level of activity. In order to strengthen academia-industry interface it is imperative to work on critical priorities relevant to these four aspects.

Focussed on tapping the public-private partnership effectively, the priorities identified are creation of enabling environments, facilitating right skilling, creation of new interface structures and enhancing mobility of S&T professionals. New structured mechanisms which lead towards these identified priorities have also been suggested. There would be a substantial increase in the academia-industry interaction if the suggested new mechanisms targeting these priorities in the 11th Five Year Plan are implemented.

10.1 Need for Academia-Industry Interaction

There is a tremendous need for academia industry interaction. All the Stakeholders, namely: Institutions, Industry, Students and Society stand to gain, as it can be a 'win-win' partnership. Industries could gain by using the academia's knowledge base to improve the industry's cost, quality and global competitive dimensions, reducing dependence on foreign know-how and expenditure on internal R&D. Industries also get benefited by updating and upgrading the knowledge base of the industry's professionals through management development programmes designed by the academia.

Academics benefit by having the satisfaction of seeing its knowledge and expertise being used for socially useful and productive purposes, widening and deepening of the curricula and the perspectives of teachers and researchers and thereby improving their morale as well as that of students, secure training and final placements more easily for their students based on the respect earned from, and the relationship established with industry. Academia also gets benefit of improved financial sustainability and security.

The faculty's exposure to industry leading to improved curricula and widened and deepened teaching perspectives resulting in professional graduates of improved caliber emerging from the academia to man industry. Students stand to gain by way of hands-on training, reduction of learning curve in industrial practices; and, society stands to gain by way of improved quality of goods and services.

Overall, Effective Academia Industry Interaction leads to strengthening competitiveness, promoting innovation and new technology development and ensuring quality and quantity of the human resource base.

10.2 Inhibition Factors

Although the concept of '*Academia -Industry'* interface has been taken up by concerned agencies in the past decade or more, its full potential is far from being realized owing to the basic 'attitudinal differences' and perception of technology development between the two sides.

From industry's side: Insensitivity to, and / or lack of awareness of, the resource potential of the academia, easy availability of foreign know-how, obsession with expensive, high profile professional consultants, compulsions of existing technical collaboration agreements, bad experience of interactions with the academia in the past, anxiety to keep problems and breakthrough confidential for fear of losing the competitive edge.

From academia's side: Apathy towards applied research and extension and reluctance to leave the comfort zone of pure teaching, inadequate marketing of its strengths to industry, lack of a critical mass of experts and specialised technical infrastructure, restrictive internal policies and procedures discouraging academician's attempts to collaborate with industry. Largely ignorant about the real industrial and national needs, inadequate recognition for practicing faculty as compared with pure academics performers.

Academia-Industry Interaction cannot be legislated or forced on either academia or industry- the academics should feel confident and motivated about this interaction and industry should see it as something profitable to itself vis-a-vis other options. Our industry, used to short-term and sometimes questionable measures to stay in business, also lacks a tradition of seeing knowledge as a sustainable competitive resource. A change in perspective is therefore required on both the sides.

10.3 Areas of Academia-Industry Interaction

In the S&T system, there are four important aspects - basic education, advanced education, basic R&D and applied R&D. For each of these aspects, academic-industry interaction may be important for achieving the desired goals and level of activity.

In Basic education, the current level of education and exposure to students is inadequate; students do not get the opportunity to work on actual equipments and thereby their confidence level is apparently low. Similarly in advanced education, quality and depth in research carried out by students at Doctoral level is inadequate and therefore, tailoring of curriculum is very crucial, so that the research scholars become more industry relevant.

Public-private partnership and industry involvement is particularly important with regard to applied R&D, where there has to be a focus on reaching the outputs and technologies developed to the marketplace. These marketplace linkages and a demand-driven approach need to be promoted. This requires that industry increasingly needs to be both the source of support as well as the performer of applied R&D.

While basic research is likely to continue to be largely supported through public funds and carried out in public institutions such as academia and the national laboratories, even in this, public-private partnership may be essential for creating and maintaining the level of research infrastructure that enables cutting-edge science.

Therefore, enhanced academia-industry interaction and the modality of public-private partnership is likely to be very important for achieving the desired outcomes in all of the four major aspects of the S&T system.

10.4 Priorities for 11th Plan

i) Creation of enabling environments

ii) Facilitating right skilling

iii) Creation of new interface structures such as consortia, partnership research institutions, etc., for basic and applied R&D.

iv) Enhancing mobility of S&T professionals

v) Promote movement of technology from laboratory to marketplace through technology transfer and new venture creation

10.5 New Mechanisms

10.5.1 Creation of an Enabling Environment

- **Flexible compensation based on pooling of resources:** Institutions could create corpus funds received from more than one industry / organizations and to enhance the salaries for faculty in respect of “Chairs” created in academic institutions.

- **Incentives:** Provision for tax exemption to the tune of 125% for all expenditure on R&D where industry and academia work together could be given, Provision of Nil service tax for any royalty coming out of technology transferred by an academic / research institutions to an industry.

10.5.2 Facilitating Right Skilling

- **Centres of Relevance and Excellence:** There is lack of qualified skilled manpower catering to the industry requirements- one way of addressing this issue would be through creation of centers of excellence in identified areas. The TIFAC COREs under Mission REACH programme could be taken up as a model, wherein Centres of Relevance and Excellence (COREs) are set up in institutions in select areas of S&T, which are of direct relevance to industries, who in turn are major stakeholders in the CORE. The Government and the industries share the infrastructure costs and the host institution bears the recurring expenses (salary of staff, maintenance of equipments and other organizational cost) for the centre. The involvement of industry in the TIFAC CORE is right from the inception of evaluation process, in the Monitoring Committee, for customizing the curricula according to recent trends in technology and also for placement of students.

- **Student internships:** Internships for students expose them to industrial practices. The student internships should be made more meaningful and long term so that it benefits both students and industry. This would enable the industry also to plan and structure the internship program.

10.5.3 Creation of Interface Structures

- Create research and interface institutions within the academic institution that function with a degree of autonomy, with significant industrial partnership and government support. There are already some success stories of such centers in India, which include Society for Innovation and Development (SID), IISC, Bangalore. SID aims to bring leading intellectuals of IISC and their R&D development efforts closer to industries and business establishments in a cordial atmosphere. Like SID, there are many institutions having dedicated interface structures like SINE (IIT Bombay), FITT (IIT Delhi), etc.

- **Consortia projects for applied R&D and technology development:** Academia-Industry-R&D lab consortia could be an effective mechanism for industry-oriented applied R&D and also to tackle ambitious scientific and technological targets. Refinement of the original mission mode concept, but now focusing in creating new innovative solution for targets that will have significant economic and social developmental value. The following would be some example areas of targets:

  i) Distributed power for rural housing at Rs.2 / unit

  ii) Real time speech recognition for Indian languages

  iii) Automated sensing and action (enforcement on traffic violation)

  iv) Indigenous diagnostic equipments at an affordable price

  v) Environmentally clean technologies

Such approaches have also been used to establish and enhance global competitiveness of industry in technology intensive areas. For example, the Core Group on Automotive R&D (CAR) could be adopted as a model. This consortium focuses on pre-competitive partnerships involving academia to help Indian companies develop advanced technologies and upgrade their manufacturing competitiveness. Government funding will involve grant in aid to academia and / or conditional grant to innovative small companies. The industry members of the consortium will provide inputs like domain knowledge, facilities, testing equipments, subassemblies, etc., and help to test and validate the prototypes. OEMs and component manufacturers further work on the generic technologies and develop products that they will commercialize, to gain competitive advantage.

Similar consortia could be formed for formulating Roadmaps for identified sectors. These could become the next generation of innovation missions that could be taken up in the XIth Plan.

- **Shared and co-located R&D facilities:** Government funding can be provided to create major national facilities to be co-shared by a number of firms on a demand-driven basis. This public-private partnership can assume two forms namely (i) co-locating an industrial R&D Centre, in early stages to start up, within the premises of National Laboratory or academic institution and ii) co-sharing some of the laboratory's select facilities with industry, e.g. the Technology Centre for Genomics Applications (TCGA).

10.5.4 Enhancing Mobility of S&T Professionals

- **From academia to industries:** Internship programme for young faculty - The young faculty could be given an internship programme at advanced level so that they could spend time from two months one year, full time in industry. This would enable them to impart more practical knowledge to students, relevant to industry.

- **From industry to academia:** Active programmes should be established for regular visits of experts from industry to address students, academic and scientific staff and to spend a few days at campuses for participating in teaching or research. A professional from Industry, with several years of work experience should be treated equivalent to a Professor. He could be called as a Professor of Industrial Practices, so that the individual also gets due recognition. This programme could be adopted on the lines of AICTE-INAE Distinguished Visiting Professorship scheme.

- **Tapping into global talent pool:** Developing an effective network through a structured mechanism for Indian diasporas would be the first step. Apart from providing support for Indian enterprises in business like targeted identification of overseas opportunities, access to business contacts, etc., this new initiative could involve Indian Diaspora with industry experience to target specifically on these two important areas in academia:

  i) **Raising aspirations:** Enterprise mentoring support for schools and colleges, preferably, the member could select an institution in his / her own birthplace, so that an emotional bond is maintained. The mentor could provide guidance on improving employability skills, provision of placements and employment for Indian students, delivering lectures in Indian universities

ii) **Leveraging contacts and expertise:** Advice on economic development opportunities and strategies, intelligence on new global trends, technologies, products and practices

The existing programmes and initiatives by the alunmi associations of IITs, IISc and other universities, STIO programme launched by Department of Science and Technology, etc. are the steps which have been already initiated towards encouraging more involvement of Indian Diaspora. Similar schemes and initiatives need to be replicated throughout the country in large numbers.

10.5.5 Improve Flow of Technology to Marketplace

- **Scaling up beyond incubation- transition to support growth of enterprises:** Recent economic literatures have pointed out the importance of clustering. Further, the *spatial dynamics of innovation* suggest that there are locational advantages of having incubators proximate to sources of high quality R&D and manpower. Therefore, it is necessary to increase the number of Research parks within or in proximity (cycling distance) to academic institutions, where industry would find it attractive to set up its R&D. Government should make the land available adjacent to these institutions and provide highest possible concessions like all benefits of SEZ, concessions in electricity tariffs, duty exemptions for imported equipments, etc. Successful examples in India include *Science and Technology Parks of IIT, Kharagpur and NIT, Tiruchirappalli.*

- **Supporting ecosystem:** Accelerating the creation of high technology start-ups requires funds for providing seed capital to these start-ups and an ecosystem that connects technologists with risk-taking entrepreneurs and investment managers.

- **New venture funds:** One of the key weaknesses in proliferation of knowledge-based entrepreneurship in India is absence of seed and early stage funding for such ventures. Therefore, Venture funds for seed funding and first stage funding should be set up. Sizeable and predictable flow of funds for venture finance should be ensured and a minimum percentage of investment in a particular asset class to be fixed.

- **Developing a cadre of Technopreneurs (from academia to start-ups):** Hundreds of academics in the western world have become technopreneurs catalyzing knowledge driven industrial development. The prevailing provisions do not give freedom to scientists to set up commercial entities while in professional employment with universities/institutions. Government may evolve facilitating provisions for faculty entrepreneurship, in the service rules.

- Public support for R&D in small and medium enterprises is now an accepted part of the public policy worldwide and in India. Partnership with large companies is generally restricted in India to strategic sectors like Defence, Space and Atomic Energy. In the remaining knowledge sector that contributes a bulk of new intellectual property a coherent policy framework is lacking although there are examples where different departments of the Science Ministries have partnered with large companies. We propose that policy guidelines for public sector partnership and co-investment in R&D with large enterprise be provided for the XIth Plan.

Several areas have been identified where these partnerships are justified and indeed important to pursue. These include:

- **Frontier Technologies:** In many areas where there are new opportunities such as Nano Science, Advance Materials, Stem Cell Biology, there is a concern that public sector effort by itself is not sufficient to both accelerate science and at the same time lead to commercialized technology and products. To maximize benefit from public investment in new areas, it is important that R&D in the public sector as well as R&D in private sector grow concurrently.

- **Fulfillment of National emergencies / requirements in Health and Agriculture:** In the health sector a very apt example is rapid development of vaccines and diagnostics against infectious disease that occur as large outbreaks or epidemics, threatening security to life as well as tourism and economy. Illustrations are vaccines against Dengue, Influenza, HIV, Tuberculosis, etc. It needs to be recognized that often private sector is not willing to invest in these areas because of the risk involved and as there are alternate investment opportunities with faster returns and less uncertainty. Drug discovery against viral infections that cause health crisis such as AIDS, Avian influenza or Tuberculosis is another example. In the agriculture sector appropriate examples are new crops / seeds against drought, salinity or major disease and orphan crops of regional interest where private interest is usually low.

- **Shared major facilities as core facilities:** It is our experience that national facilities, established with good intent lack user friendliness and are underutilized. Public-private partnership is justified for core facilities. An appropriate model is management in the private hands, access to private sector at commercial rates and to the SME sector and public sector at preferred rates. This type of collaboration is already approved by the government for the infrastructure sector. A good example of such facilities would include large animal facilities, Genomic technology centres, proteomic centres and drug discovery related technology centres and several others. Similar partnership can be extended to centres for education and training where science, innovation and enterprise marriage is desired.

- **Joint Cluster building:** Knowledge based enterprise creation has been most successful in countries where cluster building approach has been promoted. Often this requires strategic co-location and funding of institutions, parks, innovation centres, business facilities, technology transfer units in single place with joint oversight of the whole cluster. Some of the components are best publicly funded, others by private sector, but the union has to be common.

- **Administrative mechanism for fastening such collaboration:** The areas for collaboration outlined above are different in purpose and as such several different models for investment by science department are required.

In one model, both sides contribute equally to the R&D programmes and the company has the first right to a licence to commercialize, government gets some royalty and has a right to give atleast one more licence to another company. This approach also promotes competition and benefits consumers. For joint facilities, public investment be limited to 26% equity and management be in the hands of industry with differential pricing system for private and public use. For national emergencies, public funding be given on a contract basis by the government. The company concerned would have the first right to a licence and the government should give licence to atleast 2 other companies, again with a view to promoting competition and greater accessibility of the products to the public.

11

Science & Technology for Small & Medium Enterprises

11.1 Small- and medium-scale enterprises (SMEs) occupy an important and strategic place in economic growth and equitable development in all countries. Constituting as high as 90% of enterprises in most countries worldwide, SMEs are the driving force behind a large number of innovations and contribute to the growth of the national economy through employment creation, investments and exports. Their contribution to poverty reduction and wider distribution of wealth in developing economies cannot be underrated.

11.2 Recommendations

- **Technology Business Incubators (TBIs) and Technology Innovation Centres (TICs)**

  A total of 170 Technology Business Incubators and 50 Technology Innovation Centres, should be set up during the XIth Five Year Plan

- Creating a climate for Entrepreneurship

  Entrepreneurship should be promoted as a preferred career and not as an alternate career. Entrepreneurship / incubation should be a part of the engineering curriculum. Towards this, the training of teachers / trainers is necessary and special steps should be taken in this direction. ***An enhancement in budget in all schemes promoting innovation and entrepreneurship is recommended.***

- **Role of Polytechnics and ITIs for Rural /small town areas**

  It is understood that there are plans to launch schemes for revamping and modernizing polytechnics and ITIs in XIth Plan. It is recommended that Polytechnics and Industrial Training Institutes should be encouraged to organize short-term programs for vocational training of school dropouts in a variety of multi-skilled job positions that would be available in SMEs. In evolving these training programs, Industry involvement should be mandatory and employer-based training programs should be encouraged.

- **SME Cluster Development**

  Some of the sectors like Casting, Sports Goods, Scientific Instruments, Surgical Instruments, Diesel Pump & Engineering Industry, Agricultural Implements Industry and Pottery are already identified by TIFAC & Ministry of SSI for a Mission Mode approach for technology intervention in the XIth Plan to help increase their productivity and exports significantly. An outlay of Rs. 50 Crore is recommended for this mission mode programme for the seven selected SME clusters.

- **New Schemes/ Programmes**

- A strong need for preparing sectoral technology profiles of the SMEs has been felt. These Technology profiles will help in critically examining and addressing technology needs in line with the business requirements of the respective sectors. To begin with, at least 10 SME sectors can be taken up for technology profiling. A financial outlay of Rs 50 Crore is recommended during the XIth Plan for this activity.

- **Information & Communication Technology (ICT) for SMEs**

  It is understood that Ministry of SSI is working out a programme for helping SMEs to identify their ICT needs and providing resources for its implementation. Some initial work has been taken-up jointly by Ministry and the CII with a view to enhancing competitiveness of Indian SMEs. A total budgetary outlay of Rs.160 Crore with another Rs. 140 Crore from private partnership is envisaged for this endeavour.

  Special Purpose Machines (SPM)

  It is felt that the productivity of SMEs can be improved significantly by making available to them Special Purpose Machines (SPM). A national level committee / Group should be assigned the task of identifying such machines and also suggesting if they should be developed indigenously or imported for these SMEs. TIFAC & INAE can be entrusted the task of identification of such machines. Institutions like IITs, CMERI, NITs, etc. can take up development of machines. An outlay of Rs. 50 Crore is recommended towards implementation of this scheme.

- **Promoting Academia-SME interaction for Innovation**

  Engineering College should be encouraged to interact with as many SMEs in its neighbourhood as possible. It may be stipulated that minimum 20 of this should be micro and small enterprises to be taken up by each College. DST/TIFAC may launch a pilot programme to be coordinated by the Indian National Academy of Engineering (INAE) *for two years aimed at colleges, community polytechnics, ITIs and professional Societies* with an outlay of Rs 120 Crore.

12

Rural Technology Delivery

12.1 It is felt that the emphasis should be on rural industries as it is extremely important in the context of the current rural development scenario and socio-economic development of the country as a whole, particularly as regards unemployment / under-employment and poverty. It has been widely noted that employment in the rural non-farm sector, i.e. in rural industries and a variety of related and other services, is vital for the creation of employment in rural areas at a juncture when agricultural employment has little scope for expansion and employment in urban areas is also not likely to expand so greatly as to absorb people from rural areas, more so when newer more modern industries tend not to be employment-intensive. Around 70% of the rural population is engaged in agriculture (or allied-sector activities), which however contributes only around 28% of GDP. Rural industrialization offers a means by which to add value to rural produce within rural areas themselves, not only to generate rural employment and incomes, but also to redress the adverse terms of trade between (rural) agriculture and (mostly urban) industry and increase the contribution of rural areas to the GDP by increasing their share within the industrial sector. The Sub-Group therefore commended the focus on rural industrialisation within the broader ambit of technology transfer to rural areas, and decided to give it special emphasis in its recommendations.

Technologies relevant for rural industries in particular and rural development in general require to be competitive, have high productivity, produce quality products, reduce or eliminate drudgery, and yet generate maximum possible employment. These goals are not mutually incompatible at all, as several successful models have demonstrated, but represent the real challenge of R&D for rural application.

It is also felt that most contemporary science and technology should be brought to bear while developing Technologies for rural industrialisation. It is also important that Technologies introduced should be such as could be scaled up or down, upgraded without much difficulty, and should take into account technology-market scenarios 10-20 years later. Rural industries cannot be subject to obsolescence within a few years, leaving the target population to face the same situation they faced prior to the introduction of the technology, and cannot afford expensive refitment every few years. An understanding of the contemporary and future foreseeable scenarios in terms of the market and technologies should be an integral part of the process of R&D and generation of technologies which would then have in-built features enabling it to withstand market changes which are only going to get increasingly rapid in years to come.

Technologies offered for replication should be accompanied by all necessary support services such as assistance in sourcing and procurement of equipment and machinery, installation / commissioning and after-sales service and maintenance of the same, training of project personnel, transfer of know-how, trouble-shooting and hand-holding services. Many a technology transfer effort has floundered because all these aspects have not been tied-up with the technology and the local beneficiary group has been left to its own devices after some initial assistance. This is one reason why it is best not to speak simply of a technology to be transferred but a Technology Package, which should come bundled with all aspects and services necessary for its transfer.

The essential foundation for rural industrialization must be the natural resources available locally whether these are cultivated / husbanded or gathered from nature. These constitute the basic produce and raw material in the hands of the rural population, especially weaker sections, to which value is sought to be added. Such a strategy of local value-addition at / near the source of raw materials would also have enormous additional advantages to the national economy in reducing wastage, energy savings and obviating of unnecessary non-productive expenditures along the value chain, especially given the perishable nature of most of these commodities. It is well known that over 15% of cereals and other food grain as well as around 25% of horticultural produce are lost each year, resulting to losses running into thousands of crores, due to spoilage at different stages between harvest and retail sale. Lack of or poor storage facilities in rural areas, spoilage during prolonged and multiple stages of transportation and warehousing are major contributors to these losses. Much of this national loss could be mitigated, with enormous benefits to both rural producers, the national economy and consumers, if proper preservation and processing or semi-processing are undertaken in producing areas themselves. Rural industrialization based largely on value-addition to rural natural resources is clearly the way forward.

Many a well-meaning effort at rural technology transfer has become infructuous because it had been assumed that training and some occasional visits by the technology provider would suffice to ensure sustainability. Experience has clearly brought out, however, that most types of rural industries must have some in-house technical supervisory and managerial capabilities, such functions being an integral part of the production process itself. External technical back-up may still be required for trouble-shooting and specialist inputs, but on-line technical and managerial inputs are essential to ensure proper application of the new / improved technology, quality control, accord with legal / regulatory norms as well as management of marketing operations. In most rural industries, the requisite capabilities can be built from among the prime beneficiary group itself or from local educated youth. In many successful examples, personnel of the promoting NGO themselves perform such functions and become part of the Enterprise's supervisory / managerial staff earning their livelihoods from the increased productivity generated and thus acquiring a stake in the enterprise. Whatever the methodology of building and sustaining such capabilities, there is little question about their necessity for rural industries, not just for their regular operation but importantly also to oversee their future upgradation to keep up with changing market scenarios and to link up with S&T Institutions. Such linkages, in turn, should be utilized not only for specialist or R&D inputs into the enterprise in question but also for absorbing expertise so as to maximize in-house capabilities in the relevant technology sector and build capacities to act as Resource Centres during downstream dissemination endeavours.

It is often argued that small rural industries, especially if they are based on appropriate that is specially-evolved technology packages, are swimming against the current in which the contemporary large industries with economies of scale will always score over their poor rural counterparts. To the contrary, experience with many successful models of rural enterprises, not only in India but also in other countries, has shown that economies of scale can be achieved in small rural industries by adoption of appropriate technologies and production strategies. One of the ways this is achieved is through decentralised and networked production systems with division of production functions and inter-linkages between different levels. Such systems enable application of technologies and economies of scale appropriate to different levels / functions thus generating employment as close to source of raw materials as possible and generation of substantial production volumes while obviating large capital investments in centralised units. This also underlines the importance of *technology systems* rather than stand-alone machines or processes.

12.2 Recommendations

- It is felt that the emphasis should be on rural industries as it is vital for creation of employment in rural areas.
- It is also felt that most contemporary science and technology should be selected for rural industrialisation. Scaling up or down and upgradation should be possible without much difficulty.
- Voluntary organizations with in house S&T capability should be entrusted to provide technical, supervisory and managerial inputs and also be the interface with S&T institutions for R&D inputs.
- Technologies offered for replication should be accompanied by all necessary support services such as assistance in sourcing and procurement of equipment and machinery, installation / commissioning and after-sales service and maintenance of the same, training of project personnel, transfer of know-how, trouble-shooting and hand-holding services.
- The essential foundation for rural industrialization must be the natural resources These constitute the basic produce and raw materials in the hands of the rural population, especially weaker sections, to which value is to be added.
- An overarching area supported under the Programme will need to be all projects concerning innovative application of science and technology in the provision of water to rural communities.
- It is proposed to take up a programme **" S&T for Rural Industrialisation, Development & Employment (STRIDE)** bringing together DST and the Ministry of Rural Development (MoRD) for generating 1 lakh jobs through S&T-based Rural Enterprises **covering 100 Districts** during

the XI[th] Plan period. Based on mid-course reviews, this target can be further expanded and the work replicated more widely.

- The **STRIDE Programme** would focus on those sectors where proven innovative technology packages are available, and would only require minor upgradation or location-specific adaptation, for value-addition through processing / semi-processing of rural produce. Need-based, demand-driven, locale-specific and beneficiary owned enterprises would be set up and taken through to sustainability in each of such sectors.

- A Special Project Vehicle (SPV) is proposed to be set up and be monitored by PSA Office and DST. The SPV would in turn identify and network partner S&T-capable NGOs, all with impeccable credentials and track record in different States / Districts, as well as collaborating S&T Institutions in different sectors. These would provide the necessary technology transfer, technical back-up and hand-holding services for the need-based pro-poor enterprises of SHGs.

- The programme would be multi-disciplinary and involve multiple actors and stakeholders such as artisans, small farmers, agricultural labour, local traders etc besides NGOs, DRDAs, Panchayats, S&T Institutions including local Polytechnics etc.

- It is proposed to set up about **500 Enterprises** covering around **100 Districts**.

- Additionally, it is also proposed to set up **five Rural Technology Delivery Centres** to be operated by S&T Voluntary Organisations with technology back up and support from technology institutions and R&D laboratories.

13

S&T in States and Socio-Economic Ministries

13.1 Science & Technology Advisory Committees in Ministries/ Departments

In view of the importance of integration of S&T with economic development, during the VIIIth Plan, a proposal was made regarding the setting up of an apex Standing Science and Technology Advisory Committee (STAC) in each of the Ministries chaired by the Secretary of the concerned Ministry or by an eminent scientist, which would be serviced by the Cell under the respective Scientific Advisors in the concerned Ministry. The STACs have been constituted in 24 Ministries / Departments. Inter-sectoral Science & Technology Advisory Committee (IS-STAC) of DST has played a pro-active role in the constitution and revival of various STACs by giving them guidelines about terms of reference of committees, project funding and by contributing financially and technically in selected R&D projects. Under the scheme, IS-STAC has launched Joint Technology Projects (JTPs) to provide thrust to promotion of research in the areas concerning the Ministries / Departments. The IS-STAC also brings out a publication STAC-Scan Plus, a Newsletter of Science and Technology Advisory Committees (STACs) for wider dissemination of results of joint technology projects among the scientific community, especially those in academic institutions, universities and industry.

13.1.1 Some Achievements of STACs/IS-STAC

- A separate budget allocation for S&T in the budget of socio-economic Ministries has been made either through the Plan allocation or through a separate Industry Fund
- IS-STAC of DST has helped in pooling efforts in support of applied industrial research, a gap area in funding
- A number of RD&D Joint Technology Projects, undertaken with the participation of other Ministries of Government of India, have been demonstrated on the industrial scale
- DST has played pro-active role and from a few projects supported jointly during the IXth Five Year Plan, the number has grown to more than 50 projects with a total budgetary allocation of

100 crores. The DST's share in RD&D joint technology projects has been about 20-25% of the total expenditure and the rest of the funding was from Ministries.

13.1.2 Recommendations during the XIth Five Year Plan

- The STAC mechanism should continue. It should have an enlarged membership base consisting of eminent experts from public & private industry, besides academic institutions

- Committed funds (such as OIDB for STAC of Ministry of Petroleum & Natural Gas, SDF for STAC of Ministry of Steel) may be created with associated enabling mechanisms (such as Centre for High Technology (CHT) of Ministry of Petroleum & Natural Gas) to ensure critical support and assured implementation

- An eminent scientist / technologist should chair the STACs and not the secretaries of Govt. of India as is the case presently

- PAN-India programmes should be introduced in S&T through participation of STACs in select time bound top-down sectors of Techno and Socio-economic growth

- Adequate steps be taken for human resource development through joint support mechanisms by introducing Ph.D. scholarships shared between DST and concerned sectors

- S&T allocations for different Ministries should be anywhere upto 2% of the annual budget of the Ministry, depending upon the scale and scope for S&T intervention in the Ministry

- The PAN-INDIA programmes to be taken up in Key Sectors of Economy should be supported jointly with DST. Adequate provisions should accordingly be made in the Plan

- The Ministries should strengthen their Institutes to reduce the disparity with other S&T institutions. The Ministries that do not have adequate institutions should consider creation of virtual R&D Centres by networking with State / Central institutions

- Keeping in view the need to support large-scale projects, allocation for DST specifically should be enhanced for the XIth Plan to 5% of its total budget allocation to be earmarked exclusively for the STAC projects

13.2 Role of State S&T Councils

The S&T Councils should have a programme oriented approach in mission mode with an effective management system. The S&T Councils seem to be restrained by the lack of expertise and funds, as presently R&D funds are distributed mainly among Central R&D institutes. It is, therefore, important that some core funds are earmarked for the State Councils so that they would be free to take up R&D projects based on the needs of their State. Their focused activities shall include the following:

- Capacity building and human resource development
- Setting up of a network of community S&T Centres in the State for science popularization and dissemination of techno-economic information
- Technologies and innovations to promote industrial development utilizing the local resources and infrastructure
- Technology upgradation in small enterprises and their networking for enhancing growth potential with special emphasis on rural development
- Field demonstration and upgradation of new and innovative technologies to solve need based and local specific problems in the State
- Central R&D institutes must interact individually with each State Council. They could also assist the State Councils to identify and develop mega projects towards the development of the States. This interaction is missing at present
- The State Councils must meet twice a year to exchange ideas and share expertise. The Regional Meetings of the Councils should also be promoted to develop cross-boundary projects

13.2.1 The State Councils met on 18-19 September, 2006 in New Delhi. Four specific themes of technologies viz. (a) safe drinking water (b) decentralized power generation (c) decentralized solid waste management (d) remunerative utilization of regional and local natural and resources have been identified.

13.3 Recommended overall Budgetary Provisions for STACs and S&T Councils

Science Technology Advisory Committees (STACs)

Techno-Economic & Socio-Economics Ministries	2% of total allocation to the Ministries
Department of Science & Technology	5% of total allocation to DST

State S&T Councils

Total allocation recommended for various States to make planned S&T intervention	Rs. 5000 crores

14

Eleventh Five Year Plan Programme – Department of Atomic Energy (R&D Sector)

14.1 Nuclear Power Programme

14.1.1 Stage – 1

- Augmentation of R&D support to existing and next generation (700 MWe) PHWR programme for improved capacity utilization, safety, control instrumentation, ageing management, corrosion, materials etc.
- Intensification of Uranium exploration efforts including development of indigenous capability for locating concealed deposits having no surface manifestation
- Development of indigenous technologies related to fuel development for light water reactors
- Comprehensive and sustained R&D for back-end programmes of fuel reprocessing and waste management in the areas such as development of solvents, new separation methods, equipment and materials, remote handling & robotics and safety
- Several safety related research programmes in the areas of thermal hydraulics, life extension, accident behavior analysis using simulation and experimental setups
- Setting up more rigorous and comprehensive environmental monitoring systems around nuclear facilities

14.1.2 Stage – 2

- Intensification of R & D efforts to develop materials, equipment and processes on a comprehensive basis for FBRs
- Enhanced efforts towards development of process for fabrication of mixed oxide and metallic fuel for FBRs
- Demonstration of fabrication technology of helium bonded metallic fuel elements for fast reactors
- Generation of characterisation data for metallic fuels for fast reactors

- Initiation of fabrication of test fuel pins with metal alloys and irradiation in FBTR with the twin objectives of fuel cycle development as well as expanding the core of FBTR
- Life extension programme of FBTR by another 20 calendar years
- Studies on Sodium chemistry and related equipment development to continue
- R&D activities towards understanding reactor engineering aspects of FBR systems to continue
- Structural mechanics experiments will be continued to validate innovative design features of future FBRs in the field of high temperature, fatigue, buckling and seismic design
- Pre-service, in-service and post irradiation examination technology to be developed
- Repair and inspection service including quality assurance programme to be developed
- R&D on development of safe and economical reprocessing technology using mixed oxide fuel as well as envisaged use of metallic fuels to be intensified

14.1.3 Stage – 3 and Beyond

- To pursue full scale engineering validation of major innovative features of AHWR reactor and assessment of the associated design margins
- Setting up of major large size experimental facilities at Tarapur, supplemented by the programmes at Trombay to facilitate continued development of advanced technologies for next generation reactor systems
- Detailing of the design of AHWR, mainly for the non-nuclear systems and conventional structures will be continued
- Develop facilities to demonstrate Thorium material technologies
- To build a demonstration unit of a Compact High Temperature Reactor which would serve as a platform for development and demonstration of very high temperature heat removal capabilities and other challenges associated with the operation of high temperature components
- Setting up plant for special materials for High temperature reactors at Visakhapatnam
- Development of processes for generation and storage of hydrogen. Towards this a demonstration plant for hydrogen production by electrolysis route based on high surface area electrode developed in BARC is to be set up at BARC, Trombay.
- Participation in ITER project as full partner. Towards domestic infrastructure development and fabrication of components and diagnostic systems to be supplied to the project will be taken up with industry partners

14.1.4 Advanced Technologies and Radiation Technologies and their Applications

14.1.4.1 Advanced Technologies and their Applications

- A high flux Multipurpose Research Reactor is planned at Visakhapatnam with possibility of coupling external neutron supply to enhance facilities for basic research, material irradiations & production of radioisotopes of high specific activity
- Upgradation of APSARA reactor to ensure continued availability of reactor and enhancing the reactor power up to 2 MW planned
- Upgradation and replacement of systems / equipment for other research reactors is also to be taken up for improved availability and long term performance
- Efforts for indigenous development of manufacturing technologies and medical / scientific instruments

  Isotope processing facility is planned along with MPRR at Visakhapatnam
- Development of high power lasers for engineering applications in nuclear and industrial fields will be pursued at RRCAT
- Methodologies of laser material processing including laser refurbishing of engineering components, laser rapid manufacturing and hybrid laser processing will be established
- Technology developed at VECC during the Xth Plan is proposed to be utilized to construct a superconducting magnet energy storage system for a variety of applications
- A 10 MeV, 5 miliamperes proton cyclotron is proposed to be built, indigenously, as part of the ADS programme at Kolkata
- Technologies for development of ADSS to be taken up
- Fifth beam line, heavy density liquid metal target system at medical cyclotron, Kolkata will be set up
- Upgradation of injector and Indus-2 will lead to better beam quality and higher beam current in booster synchrotron & Indus-2 Synchrotron Radiation Source
- Enhancement of utilization of Indus-1 and Indus-2 planned
- Diagnostic beam lines for SR studies and improvement planned
- Setting up of High Current Proton Injector Linac for Spallation Neutron Source planned
- R&D towards major accelerator based scientific facilities, such as X-ray Free Electron Laser (XFEL) in Europe (spearheaded by DESY lab in Germany) and International Linear Collider (ILC) through transnational participation are currently being pursued vigorously through collaboration between countries across the globe. Participation in these programmes to develop in-house expertise to build critical subsystems for future accelerators

14.1.4.2 Radiation Technologies and their Applications

- To develop various desalination technologies and manufacturing processes for various types of membranes, set up a MED - RO based plant at BARC Trombay and also a RO based plant at Visakhapatnam to augment water supply at these places
- Projects in the areas of food preservation & hygienisation, nuclear agriculture, isotope hydrology & industrial tracers, production of radioisotopes & radiolabelled compounds and radiation processing of materials are planned
- Tata Memorial Centre (TMH & ACTREC) would expand the existing programmes and initiate new programmes of prevention, clinical management and basic, translational and clinical research in cancer
- A new 11 storey clinical facility (Tata Clinic) would be completed along with augmentation and replacement of several radiotherapy, radiology, nuclear medicine, surgical, telemedicine, teleradiology and hospital information equipment at TMC
- R&D in collaboration with DAE units and national laboratories for development of indigenous equipments and cost effective technology for cancer diagnosis, treatment, rehabilitation and research
- Further development work on telecobalt machine '*Bhabhatron*' to be undertaken for its accessories and treatment planning to make it versatile and cost effective
- Developement of Cancer Care facility at Shillong and Ranchi
- 30 MeV Medical Cyclotron will be available for medical isotope production as well as R&D experiments to a wide spectrum of Indian users
- A 250 MeV superconducting cyclotron for proton beam will be constructed at VECC and installed at ACTREC for cancer therapy, radiobiological and related research. This will be the first of its kind in the country
- Biocompatible materials for orthopedic and other implants to be developed to bring down their cost and make them widely available
- Facilities at BARC hospital, Anupuram dispensary (IGCAR) will be augmented

14.2 Basic Research

- Development of internationally competitive state of the art high performance computing platforms by BARC
- R & D in Information security, surveillance and access control systems, new computing paradigms to be taken up
- IT set up at various units of the Department to be upgraded to meet the present day requirements.

- A multi-institutional, multi-organisational Indian Neutrino Observatory to be set up. It will be open for international participation
- Using Accelerators like Pelletron, Superconducting cyclotron etc detailed studies of nuclei under extreme conditions will be undertaken
- To set up National Radioactive Ion Beam Facility at VECC, Kolkata
- Facility for Research in Experimental Nuclear Astrophysics (FRENA) will be set up at the new campus of SINP at Rajarhat, Kolkata
- A Centre for Astroparticle physics to be set up at new campus of SINP
- Improvement in the sensitivity of the TACTIC gamma ray telescope at Mt. Abu and the Low Energy Neutron pile at Gulmarg and setting up of an advanced neutron beam research facility are planned by BARC
- Development of energy conversion technologies to harness alternate sources and carriers of energy and its efficient utilization planned
- R&D work in materials will be carried out at RRCAT to indigenously grow large size non-linear optical crystals, ceramics and thin films for use in lasers, photonics and other devices
- India's participation in ITER project is to prepare for Indian demonstration fusion reactor DEMO and develop prototypes for future Fusion reactor grade Tokamaks using accessible ITER designs and thereby generate indigenous know how / technologies required for such machines
- Enhanced R&D efforts on development of nanotechnology under "Micro-Nano Initiative" of DAE at various units of Department
- Ongoing international experiments like DZERO, BELLE, PHENIX, STAR to get completed in the XIth Plan
- Participation in new international projects like ILC, XFEL and FAIR for strengthening domestic programme
- DAE core research programme on biological effects of radiation and other genotoxic stresses on microbes, animal and plant systems, human health and cancer would be expanded
- Identification and characterization of genes/proteins important in radioresistance and DNA repair will be carried out
- Development of miniaturized bio-analytical systems for separation of biological macromolecules will be initiated
- Studies on biological and health effects in the human population exposed to continuous high-level natural radiation will be continued to understand the nature of molecular DNA lesions and genes involved in congenital malformation

- Radiation exposed individuals will be monitored to generate information on their immune status and other markers
- Mechanistic aspects of intracellular transport, protein folding, cell death and development of nervous and other systems their regulation to be further investigated at TIFR, NCBS, BARC and SINP
- Basic and molecular epidemiological research is proposed for understanding the pathogenesis of malaria and the sex dependent control of host responses along with identification of novel drug targets and vaccine candidates
- In the area of cellular organization and signaling, studies will be carried out on the development of human cervical cancers, regulation of cell death by immune system, protein based regulation of DNA functions and molecular mechanism of endocytosis
- New facilities for solid state NMR of proteins will be added at the National Facility for High Field NMR for investigation of many new variants of HIV-1 protease, malarial proteins, metal binding proteins, proteins related to neurodegenerative diseases etc
- At ACTREC, existing and new leads on potential cancer biomarkers will be validated and these will be developed as diagnostic agents and therapeutic targets through basic, preclinical and clinical studies
- At RRCAT, Indore, studies on the use of lasers for biomedical imaging, diagnosis, manipulation and processing of biological samples will be continued

14.3 Research Education Linkage

- Training School as an affiliate of BARC Training School to be started at IGCAR for trained manpower required for second stage of our NPP
- Training School for AMD in lines with other training schools in the Department
- DAE Administrative Training Institute for personnel in support services
- HBNI to help increase intake of PhD students and development of scientific manpower for the Department
- DAE-Mumbai University Centre for Excellence will be set up in Mumbai to conduct five years integrated B.Sc.-M.Sc. programme in Sciences
- BRNS and NBHM to continue funding research in nuclear field and Mathematics
- To further expand the activities of HBCSE, new laboratories for educational purposes will be set up especially for training students for Olympiad programmes
- Prospective Research Fund introduced

14.4 Infrastructure & Housing

- New campus planned for BARC at Visakhapatnam, IPR at Gandhinagar, TIFR at Mumbai and VECC / SINP at Rajarhat, Kolkata
- Expansion of NCBS campus at Bangalore to be taken up
- Campus for HBNI at Visakhapatnam
- Training School building to be constructed for IGCAR at Kalpakkam, AMD at Hyderabad and DAE Administrative Institute at Mumbai
- Construction of convention centre at Mumbai and auditorium for HRI at Allahabad planned
- Hostels and family accommodation for large participation of research scholars in Departmental programmes at all our major R&D centers
- Strengthening of infrastructure development for security reasons
- Upgradation and maintenance of existing infrastructure
- Construction of new housing colony at various units including quarters for CISF personnel

14.5 Prospective Research

It is proposed to introduce a new element in the XIth Plan and it is creation of a 'Prospective Research Fund (PRF)'. It will be operated on lines similar to BRNS. Project proposals will be invited from units within the Department. This would primarily bring in some flexibility for pursuing basic research. While most of the plan projects of the Department are mission oriented and contribute to the overall goals of the Department, the proposals through this fund would facilitate research on new ideas that could arise during the plan period. The fund would also enable the Department to fill critical gap that might arise during the course of XIth Plan.

14.6 Atomic Energy Regulatory Board

(1) Significant expansion of the Indian Nuclear Power Programme and the related activities is envisaged during the XIth Plan. Atomic Energy Regulatory Board (AERB) will have to meet the challenge to cater to the regulatory needs of this large expansion in activities. This will require significant increase in the resources of AERB in terms of manpower, infrastructure and facilities. Safety review of new reactors of diverse and innovative designs would require substantial enhancement of regulatory capabilities. With the spread of nuclear and radiation facilities at several places across the country, it is now considered appropriate to establish some Regional Centres of AERB for speedy and more effective regulation. A budget of Rs. 13.00 crores has been proposed for AERB for the XIth Plan.

15

Eleventh Five Year Plan Programme – Department of Biotechnology

15.1 Promotion Of Innovation:

- **Establishment of Technology Management** – National and Local Centres : A technology management network that is locally linked to stronger central resources.
- **Centres of Excellence:** Expansion to establish more **C**entres of Excellence (CsoE) within existing universities and medical, agriculture and allied colleges, around innovative leaders with focus on basic biological science, engineering and technology and directed towards innovation in scale-up and manufacturing processes for biopharma, and bio-based industrial products in health, animal, agriculture, food and environment sectors.
- **Creating Regional Biotech Innovation Clusters:** Existing clusters will be examined for gaps, which can then be strengthened. New clusters could be considered in Punjab, Delhi, Haryana, West Bengal, Gujarat and Orissa.
- **Upgradation/reengineering of existing life science departments:** The focus will be on university departments and medical colleges.

15.2 Human Resource Development

- **National Council on Biotechnology Education & Training:** A National Biotechnology Council will be created to formulate model undergraduate and postgraduate curricula in life sciences and in translational science keeping in view, future needs.
- **Creation of leaders in Biotechnology:** Emphasis is required to be given to interdisciplinary education and training and creation of leaders in biotechnology through substantial expansion of Ph.D and Post Doctoral Fellowship programmes.
- **Quality Teachers:** At the master's level, emphasis will be on improving the quality of teachers through establishment of a Biotechnology staff college and regional training centres for mid career training programmes.
- To improve infrastructure in colleges and creating at least one or two 'Star' colleges in each state.

- **At the secondary level** to improve the interest in life sciences and biotechnology, it is suggested to (i) increase availability of scholarships on merit cum means basis (ii) summer schools to give exposure to experimentation and (iii) teachers training programmes.

15.3 Industry promotion

- Promotion of Small Business Innovation Research Initiative (SBIRI) for SME's.
- Setting up of Biotechnology Industry Research Assistance Programme (BIRAP) for monitoring, supporting and nurturing R&D in small and medium biotechnology companies.
- Enabling Public Institutions to work with Industry: Public funded successful R&D institutes may be allowed and supported to establish not for profit companies to facilitate collaborative work with industry. In these facilities, industry scientists can pursue innovative projects for defined periods on user charge basis providing access to centralized equipments and scientific consultation.
- Encouragement of Public Partnership with Large Industries**.** The industries would then have preferential access to the intellectual property generated in such jointly funded projects.

15.4 Infrastructure, Major Equipment and Facilities

- Creation of large animal house facilities with GMP for testing candidate vaccines and biotherapeutics, DNA and stem cell banking facilities, depositories of biological materials, testing facilities for GMO / LMO and validated laboratory facilities to support major clinical trials.
- Strengthening bioinformatics R&D and infrastructure in terms of more super computing facilities, expansion of biogrid, human resource development, linkages with industry, institutional mechanisms for software development and validation, development of an Indian portal site and bioinformatics parks and clusters through public private partnerships.
- **Biotech Parks and Incubators:** Promote establishment of Biotech parks and incubators as a part of biotech clusters, essentially through public private partnerships. Establishment of incubators by consortia of small and medium enterprises.

15.5 World class Regulatory Mechanism: A National Biotechnology Regulatory Authority is proposed to be created to provide effective single window clearance mechanism for all biotechnology products.

15.6 Mission mode programmes

Interdisciplinary mission mode projects are suggested in the areas of national importance where biotechnology interventions can bring about significant value addition, cost effectiveness and competitiveness in product and process diversity. The areas are:

- Food and nutrition security
- Molecular breeding of agricultural crops
- Molecular breeding of silk worm
- Microbial prospecting for industrial, agricultural, environmental, medical and therapeutic purposes.
- New generation vaccines and delivery systems
- Diagnostics for health care
- Integrated Tuberculosis
- Stem cell biology regenerative medicine
- Bioengineering

15.7 International collaboration: International collaborations and networks would be harmonized with National S&T programmes and development goals for leveraging external strength in national objectives.

15.8 Prioritization of sectoral R&D

The priorities identified are:

- ***Agriculture and Food Biotechnology*** – disease and pest resistant, drought and salinity tolerant seeds and plants; nutrition enhancement,
- ***Health care***, particularly mass public health - Vaccines, diagnostics and therapeutics; biomedical devices, implants and instruments; advanced materials for biological and medical use; clinical trial and contract research; nanobiotechnology; regenerative medicine and stem cell technology.
- ***Bioresource development and utilization*** – characterization and inventorization; bioprospecting of plants, microbes, marine organisms for novel products, improved processes for bioresource based product development.
- ***Forest Biotechnology*** – improved biomass productivity, new bioprocesses for paper and pulp, timber and other value added minor forest products.
- ***Animal biotechnology*** - with focus on vaccines, diagnostics and animal feed,
- ***Marine biotechnology*** – increased productivity and disease management
- ***Environment friendly*** technologies and schemes – bioremediation, pollution abatement; biofertilizer and biopesticides.
- ***Industrial biotechnology*** – biotransformation to make bioproducts cost effective; advanced manufacturing technologies for production of vaccines and other medical products; bioseparation

technologies for recombinant DNA products; reactor engineering; and development of bioprocesses for high quality textiles, silk and paper industry.

- ***Biofuel*** **–** New processes for cost effective bioethanol production from agro and cellulosic waste, improved biodiesel production.
- ***Advanced computational biology*** **–** bioinformatics, genomics, proteomics, pharmacogenomics, in-silico drug design.

15.9 New Institutions

A critical review has revealed that new Institutional structures are urgently required to be built up, especially in the areas, which have marginal strength and a critical mass of expertise. These include institutes for:

- Stem cell research
- Animal biotechnology
- Seri biotechnology Center at Bangalore to be taken over as requested by Silk Board.
- Translational centers especially designed for technology development in Health, Agriculture and Food sectors and strategically located within or in the vicinity of a University Campus with effective industry linkages.
- Molecular Medicine Centers in at least two medical colleges.
- Agri-food institute and central bioprocessing unit in Punjab
- Institute of plant health
- Plant Health Research Institute
- UNESCO centre for education and research

15.10 Expansion And Remodeling Of Autonomous Institutions

- *National Institute of Immunology, New Delhi* to establish four vertical translational research progrmmes in design of novel inhibitors for decimating pathogens, development of anti-HIV microbicides, anti-viral vaccines and Cancer diagnostics and therapeutics. An innovation foundation through public private partnerships for public goods may be supported for genetically defined MACAQUE primate animal strain facility.
- *National Centre for Cell Science, Pune* to initiate focused programmes on diabetes by use of human fetal pancreatic islet-derived progenitor / stem-cells for diabetes cure and identification of anti-viral compounds with potential for development of microbicides to prevent HIV infection and

transmission. Systems Biology of Global Regulatory Networks, unraveling Sequence Features in Promoters that Dictate Tissue-Specificity of Gene Expression, Inter-institutional Network program on HIV and Tuberculosis are to be initiated apart from establishing centres for cell and tissue engineering and immuno-thereupatics.

- *Centre for DNA Fingerprinting and Diagnostics, Hyderabad* to enhance the volume and scope of its existing activities as well as to undertake new activities such as National Facility for Training in DNA Profiling (NFTDP), Disaster Victim Identification Cell (DVIC), Secretariat for DNA Profiling Advisory Board and Creation of National DNA Database, Quality control and accreditation, and Other DNA profiling services.

- *National Brain Research Centre, Manesar* to take up Neural Stem Cell Research, application of insights from basic research to animal models, Clinical Research Centre for Brain Disorders and Brain Machine Interface, network programme on genetics and pathogenesis of neurological and psychiatric disorders and Development of neural prosthetics in addition to centralized facilities of Brain bank for neural tissue, CSF and DNA samples, Primate Facility and Biological containment facility.

- *Institute of Bioresource and Sustainable Development, Imphal* to establish a Genome Club for regular interaction between bio-entrepreneurs, graduate students and researchers on biodiversity conservation and bioresources management.

- *Institute of Life Sciences, Bhuneshwar* to undertake vertical translational activities such as Development of DNA chip based diagnostics, nanomedicine alongwith establishment of National Repository of C.elegans, a model genome for all fundamental biological studies.

16

Eleventh Five Year Plan Programme – Ministry of Earth Sciences

16.1 Department of Ocean Development

16.1.1 Front ranking research in Polar Science:

- Launch of research expeditions to Arctic preferably through international cooperation
- Construction of a new Antarctic Research Station to enhance research activities
- Establishment of a dedicated satellite based communication and data transmission system between the Antarctic and India
- Undertake southern Indian Oceanographic studies both in terms of assessment of living and non-living resources
- Collaborative projects during International Polar Year (2007-08)
- Establishment of a dedicated facility at CCMB to undertake studies related to microbial prospecting and biotechnological applications.
- In order to undertake the proposed activities, an ice-class research cum logistic vessel is an essential requirement and the same has been proposed for acquisition during the XIth Plan.

16.1.2 Consolidation of Desalination Technology: NIOT would take up a scheme to design, develop, and demonstrate the large-scale desalination plants (25-50 MLD). To realize such a large number of LTTD plants, NIOT will explore the industry partnership in a big way during XIth Plan. The ultimate goal of the endeavour will be to establish such desalination plants along the coast and island territories of India to alleviate drinking water problem of coastal region

16.1.3 Providing of reliable Coastal Ocean Services:

- INCOIS, Hyderabad, would provide all possible reliable services pertaining to ocean sector to meet the requirement of a wide range of user communities in India. The user-oriented data/

data products would be generated and disseminated using existing and upcoming satellite and in-situ data, on operational basis, such as Potential Fishing zone advisories, Coastal Ocean State Forecast, using a wide range of media for dissemination of information. These include setting up of electronic display boards, information kiosks in every coastal village covering the entire coast of India for providing information including storms, cyclones, weather, sea state, etc., INCOIS would focus on development & dissemination of effective early warnings of oceanogenic disasters such as Storm Surges and Tsunami. INCOIS would also develop a core group in ocean-atmospheric modeling with a support of mix of ocean observations.

- NIO, Goa will work on science aspects of ocean services particularly for development and improvement of these.

16.1.4 World Class – Ocean Technology: NIOT will be concentrating in XIth Plan mainly on:

(i) Design, development and demonstrate underwater technologies for deep sea mining

(ii) Development of underwater materials and sensors

(iii) Creation of sea front technology and other research infrastructure for testing of oceanographic equipment. (These include Deep sea technology, Deep sea mining system for 6000 m, In-situ soil testing in the Central Indian Ocean Basin, Marine vehicle Manned submersible, AUV (up to 3000 m), Hybrid ROV, Infrastructure Marine Sensors and Electronics to support Underwater electronic support facility and component development, offshore structures, offshore operations, development of SGS, XCTD, XSV, ultrasonic current etc.)

(iv) Coastal engineering, demonstration of coastal protection measures, Sediment transport atlas, Rates and Constants Measurements for Mathematical modeling, Geomorphologic studies for Siltation control in Hooghly, Monitoring and Modeling of Thermal and Oil Spill Modeling Resource Site, Deep water survey capability, Capacity Building for Marine Archaeology and Saltwater Intrusion, conduct marine corrosion and antifouling studies and other ocean and coastal engineering related projects.

16.1.5 Ocean Science and Technology for Islands (OSTI):

- OSTI would take up development of Fish Aggregating Devices, Continuation of lobster and crab farming activity, Island resource information & GIS mapping Materials for marine application, Open Ocean Aquaculture of marine organisms under controlled conditions to meet the increasing demand and dwindling capture fishery resources.

- Further, it is planned to take up development of technology for micro algal culture and value added products using deep ocean water along with the utilization of bioprocess engineering technology for commercial production of phycocolloids, chemicals and polysaccharides.

16.1.6 Integrated Coastal Marine Area Management (ICMAM) & Coastal Ocean Monitoring Area and Prediction Systems (COMAPS):

- In order to access the impact of these activities, it is necessary to develop inundation map for the entire coast of India and develop ICMAM plans for all the sensitive areas. During XIth Plan, ICMAM would concentrate on Demonstration of Ideal Coastal Protection Measures, Coastal circulation, Ecosystem modeling, Marine Ecotoxicology, Carbon cycling in coastal waters and Preparation of Coastal Risk Atlas. Although, the Ministry has been monitoring the coastal waters by making systematic observations at regular interval in selected locations, it is important to collect the additional parameters at more locations. COMAPS should bring out periodically bulletins indicating the levels of these pollutants in various regions particularly in the hotspot regions.

- Under COMAPS the work for XIth Plan will be continuation of existing monitoring, modelling and GIS data base programmes, undertaking of modelling of movement of oil spills along Western and Eastern EEZ of India, Microbial biodiversity of coastal waters. Acquisition of a new vessel for COMAPS programme as a replacement of one or two Coastal Research Vessel(s).

16.1.7 Resource Mapping and Technology Development for Gas Hydrate:

- NIOT would identify suitable technology devices for supporting offshore activities for harnessing the resources of gas hydrates.

- Develop the submersibles for various applications.

- Develop skill base and infrastructure to support and maintain the deep ocean systems. Conduct validation studies at selected locations particularly for demonstration of technology for exploration of these resources by enhancing the capability of coring system, storage, transportation and processing gas hydrates.

- Independent ship and up-gradation of support submersible: It is proposed to develop 6000m depth coring, Human Operated Vehicle (HOV), Autonomous Underwater Vehicle (AUV), and Hybrid Submersible (HYSUB). NIOT would also work on the associated civil works required including integration facility with handling and storing systems, facility for factory testing, facility for component level qualifications, infrastructure for working facilities, laboratories for electronics, etc.

16.1.8 Limits of Continental Shelf: NCAOR would initiate a comprehensive study of the geological and structural evolution of the Arabian Sea and the Bay of Bengal sectors. The major facets would include, study of the Gulf of Mannar – its origin, whether it is a simple pull-apart basin or a nascent ocean developing as Sri Lanka is drifting away, Delineation of the continental / oceanic crust boundary on the Indian plate, both off the Western and Eastern offshore, Structural evaluation of the 85° Ridge, Offshore extension of the Deccan Volcanics, Formation of Chagos-Laccadive Ridge as a consequence of

Reunion hotspot trail, Imprint and implications of hot spots on the Indian continental margin, Structural highs and gravity lows in the Bay of Bengal – the reasons for their association, Fan sediment development vis-à-vis Himalayan orogeny.

16.1.9 Topographic survey: The ministry would take up dedicated project on undertaking topographic survey of the Indian EEZ, considering the importance of the data generated from the survey in the context of exploitation of both living and non-living resources.

16.1.10 Drugs from the Sea:

- An Advanced Research Centre for Drugs from Ocean would be created at CDRI, Lucknow and a Taxonomic Centre to preserve the marine organism in an appropriate location.
- The MOD would continue clinical test of two compounds (antidiabetic, antidyslipidemic) derived from marine organisms are in the advanced stage of drug development. Besides, some lead compounds found to be having potential activities such as antibiotic, antiviral, antileukemic would be taken up for toxicity and clinical trials**.** The work includes continuation of clinical evaluation of existing compounds and taking up on new activities such as Bioevaluation for anticancer, anti-inflammatory, immunomodulatory, and if possible anti HIV compounds.

16.1.11 Polymetallic Nodule: The work initiated during the earlier plans and the X^{th} Plan will be continued and carried forward.

16.1.12 Marine Living Resources (MLR) & CMLRE:

- The Marine Living Centre at Kochi would be upgraded into a full-fledged centre equipped with state-of-the art laboratory facilities and research vessels to carry out sampling process and extraction of compounds.
- CMLRE would undertake projects such as (i) Semi-Commercial Exploitation of Myctophid Resources of Arabian Sea which has an estimate potential of 100 tons (ii) Resource assessment of demersal stocks (200-1500m depths), Refine Harvest technology for deep sea fishing, Squid jigging (iii) Monitoring & surveillance of Harmful Algal Bloom (HAB), Setting up HAB centre and R&D on HAB (iv) Marine Benthos in the Indian EEZ (v) Fishery Oceanography (vi) Biodiversity & census of marine life & (vii) Survey, assessment and semi-commercial exploitation of krill and fishery resources from Southern oceans, and related studies.

16.1.13 Sustained Ocean Observation Network: The major work during the plan would be (i) integration of all the existing and planned observations network Data Buoys, Tide gauges, Drifters, HF Radar, XBT, Current meters, automatic Weather Stations, Argo Floats under one umbrella for wider utility, (ii) upkeep of existing 40-buoy network & possibility of augmentation of the network using low cost buoys to meet the requirement of operational weather services, (iii) setting up of 4 maintenance centers, 2 each on west coast and east coast of India for logistical operation and maintenance of observation network in addition to the routine work elements.

16.1.14 Marine Research Technology Development (MRTD): During the Plan the focus would be on:

(i) Developing National Oceanarium

(ii) Increasing the number of OSTCs: 9 to 20

(iii) Upgrading another one / two cells into Centre of Excellence (CoE)

(iv) Augmentation of all the continuing programme including Coastal Ocean Monitoring and Pollution Control Non Marine Living Resources, Integrated Coastal and Marine Area Management.

(v) In addition, Deep-ocean drilling and core sampling would be taken up through the Integrated Ocean Drilling Programme for potential mineral deposits such as, sulfide deposits, cobalt crust, etc., in the mid oceanic ridge including the Andaman Areas. Further, it is also proposed to demonstrate the shore protection measures through pilot project to be implemented at selected locations. It is also proposed to take up soil testing in the central Indian Ocean basin

16.1.15 Human Resource Development: To cater manifold increase in the activities of Ocean Development, it is proposed to induct and train the requisite manpower with the help of concerned University, Departments, R&D centres and the participant institutions. The additional requirement of scientific and Technical manpower during XIth Plan is estimated as around 1100. The funds for manpower Development have been earmarked in the respective programmes / institutes scheme.

16.2 Atmospheric Sciences

16.2.1 India Meteorological Department

The new thrust areas are: 1) Observation and Met Telecom System, 2) Weather Forecasting System, 3) Specialized Meteorological services, 4) Seismology and Earthquake Risk Evaluation Centre, 5) Climate, Environment Monitoring and Research 6) Human Resource Development, 7) National & International Cooperation, 8) Infrastructure Development and 9) Capital Works.

The salient features of the XIth Plan for the Ministry pertaining to meteorology are summarized below:

1. Space Meteorology

- With the new INSAT 3D designed to carry several meteorological payloads, the vast data that would be generated would require enhancing capabilities of this data utilization for high-resolution model predictions.
- Capability will also be built to access data from High Resolution Picture Transmissions of foreign polar orbiting satellites to improve data quality by mixing.

- Space platforms shall also be utilized in a big way to disseminate early warnings and Met communications.

2. Met Telecom

Upgradation of the Telecom Hub at Delhi is being envisioned to go beyond the present scope of message routing to perform new functions *viz.* data base management, multi-technological connectivity, web interfacing, application support and IT activities. It is also planned to run a real time backup of these services in the event of a calamitous failure at the main center.

3. Observational System

- Rainfall being highly variable in space needs a 25km x 25km density for adequate representation; hence 3500 automatic raingauges are being planned. Similarly, 700 automatic Weather Stations proposed herein would ultimately be a part of 1000 strong network at 80 km x 80 km density.

- All the locations where upper air wind measurements are presently done using Radars will be provided with theodolites for the specific purpose of tracking balloons thereby relieving the Radars to carry out storm detection. A large number of stations measuring upper air winds up to 10 -12 km using the method of optical balloon tracking will also be refurbished by replacing old theodolites. Test equipment called wind tunnel is also proposed for replacement for extending the range and accuracy of wind instrument calibration.

4. Instrumentation Development

The quality of sensors at weather observation stations needs improvement and conversion of analog systems their to digital systems to simplify data handling will be undertaken. New balloon sounding equipment of indigenous design would replace the ones used presently in the network. The data from the new system is expected to improve upper air data quality and therefore the predictions as well.

5. Cyclone Warning & Research

An additional 25 numbers of Doppler Weath Doopler Weather Radars (DWRs) would be procured to cover the entire coastline and thunderstorm prone areas with priority. These Radars will be used to forecast several devastating phenomena like tornadoes, squalls, hail storms, cyclones etc. In addition, their digital outputs will be directly assimilated into Numerical Prediction Models for the purpose of forecasting and Research.

6. Forecasting Services

A nested global and regional data assimilation system will be procured and installed by IMD to make it completely self reliant in numerical weather prediction for operational purposes. Running both global and nested regional models on the same computer platform would give tremendous tactical advantages and can pin point sources of error for the purpose of R&D. High end computers and supporting workstations clustered around in the network at various forecasting offices would be installed.

7. Specialized Meteorological Services

- Airport Met facilities would be modernized to facilitate easy transmission of complete data and information to Airport Authority, Airlines and Pilots.
- A system based on a strong IT system will be setup with Agricultural Colleges, ICAR institutes, NCMRWF, State Governments and local and National level TV, Radio etc will be accomplished so that a single window service can be issued from IMD to reach the farmers and managers both.
- Hydrologicalgical services would be strengthen with installation of Satellite telemetry rainguages so that large data would be available on real time basis for drought and flood monitoring. The extension of World Bank aided Hydrology Project into Phase II covering northern India shall further strengthen the District rainfall monitoring programme in the region.

8. Environmental Studies

- The ozone network will be extended to the Northeast.
- Atmospheric composition with respect to green house gases, aerosols, ozone and acidic precursors are planned to be monitored comprehensively and linked with global climate models in order to understand the nature of their impacts.

9. Seismology and Earthquake Risk Evaluation

The Seismic network will be increased in density to be able to capture earthquakes of lower magnitude, which are required for precursor studies, and more detailed zoning of vulnerability. In addition it will be connected by telemetry to reduce the time lag of occurrence and detection. Such a system will be especially required for Tsunami genic earthquake detection. Geo technical evaluation of vulnerability at map scales of 1:10,000 is required by town planners to redefine building byelaws. In this proposal some of the important cities with high risk shall be taken up for such studies.

10. Human Resource Development

Appropriate Training has been planned to cater to induction and maintenance of new technologies such as Radars, Numerical Models, Satellite data retrieval and observational equipment. In addition to the primary training there have been plans to strengthen the routine in-house training programs to sustain the programs by ensuring a steady availability of specialized manpower.

11. District Meteorological Information Centre and Early Warning System

The outreach component of IMD’s activities such as forecasts needed to reach to the end user at district, state and institutional levels will be strengthened so that graphically displayed and well structured advisories can be made available at the destination be it an official desk or a media room. IMD has a system of intimating official agencies but played a relatively less important role in dissemination of its products directly to the public. On the request of the newly formed Disaster Management Authority and the official electronic media agencies the XIth Plan, therefore, includes a series of projects to improve outreach at District levels and to the public at large.

16.3 National Centre for Medium Range Weather Forecasting

The main goal during the XIth plan is to enhance the accuracy, reliability and range of medium range weather forecasts and its outreach. In the XIth Five Year Plan, NCMRWF is recasting its mandate towards a Centre of Excellence in Numerical Weather Modeling and it is proposed to focus on the following thrust areas

- To increase temporal range and spatial resolution of operational Medium Range Forecasts.
- To deliver district level medium range weather forecasts based agromet advisory services.
- To develop capability for providing site and event specific prediction system. The immediate demand for such a system is for upcoming Commonwealth Games in 2010.
- Further improving the accuracy, reliability, range, and scope of Medium Range Forecasts entails:
  - Development of higher resolution (40 km for operational and 25 km for research; 60 levels) global model with much improved physics, dynamics. Use of large member based (50-60 members) ensemble system as well as multi-model approach.
  - Development of advanced data assimilation system capable of utilizing direct satellite radiances, clouds and rain data.
  - Further improvement in meso-scale models and corresponding assimilation for dynamic downscaling focussing on high impact weather systems for agricultural risk management at district level.
- Weather modelling support for early warning system for weather related disasters.
- Development of a coupled modelling and assimilation system for improving monsoon prediction over medium and extended scale.
- Manifold increase in the activities of Ocean Development To significantly enhances manpower, computing, networking, data handling, library, and related infrastructure including additional building construction.
- At present there are 32 scientists, 2 technical support staff, and 7 administrative support personnel are in place as against the sanctioned strength of 241 a the time of creation of the centre. This number is one order less than the minimum required for NWP, a highly specialized and strategically important field. Accordingly, additional consolidated manpower of 233 is projected to meet the requirements of plan projects.

16.4 Indian Institute of Tropical Meteorology

A new programme on **"Climate Dynamics and Extended Range Prediction of Monsoon"** is proposed. The science plan of the programme and infrastructure and manpower required for this purpose is as follows:

- A system for long range prediction of seasonal mean monsoon and extended range prediction of active / break spells is proposed to be developed. It would involve assessing component models, coupling strategy, assessment of bias of the coupled model, data assimilation, development of forecast strategy etc. A quantum jump in the computing resource and existing research staff in the area will be required.

- Estimation of monsoon climate under different climate change scenarios through downscaling using a regional climate model, quantification of uncertainty in estimation of monsoon climate under climate change scenarios and study of sensitivity of the estimate of monsoon climate under climate change due to downscaling of the output from a large number of global models and understanding of roles of internal variability and external forcing in predicting the future monsoon climate have also been proposed.

- For improvement of the climate models, it is important to improve formulation of convection in the GCMs. A focused observational and modeling effort to improve understanding of clouds and its interaction with environment leading to precipitation is proposed. This would involve simultaneous observations of cloud processes and environment involving a cloud and weather radar system, GPS radiosonde, a network of lightning discharge etc.

- A large pool of trained manpower on specialized area is required for success of the above programmes. A multi pronged approach to build this manpower is proposed. Training programme for the existing junior level scientists and research fellows at the IITM will produce a pool of scientists to take up exciting problems and develop necessary skills to address them in the field of atmospheric sciences especially in climate dynamics and development of capabilities in extended range prediction of monsoon. Hence Training Programme is proposed as an integral part of the XIth Plan programme. Training to the Institute's scientists within the Institute and at the selected international centres of excellence in other countries, as well as inviting a few internationally reputed scientists to impart training in specialized areas is proposed in this programme. In addition it is proposed to vigorously and proactively recruit a large pool of experts required for different aspects of the programme.

- Development of infrastructure is essential for promoting the research programmes on a sustained long-term basis. An appropriate computing system with very high number crunching capability and having large memory, automatic data storage and retrieval system with sufficient storage capacity is very much needed at the Institute to carry out the work relating to the climate modelling and extended range prediction. Upgradation of the existing laboratories, renovation of workplace, modernization of library, information, publication and other supporting facilities like workshop, and limited Capital Works programme for construction of residential quarters of higher types and a students hostel are proposed in the XIth Plan programme.

17

Eleventh Five Year Plan Programme – Department of Scientific and Industrial Research (DSIR)

17.1 DSIR

- It proposes to continue the TPDU programmes in the XIth Plan with an outlay of Rs. 253 crore and lay increased emphasis on the TePP and the TDDP programmes.
- It also proposes to operationalize an Indo-Australian Bi-national Industrial Research and Development (BIRD) Programme.
- It will undertake technology benchmarking and audit exercise, establish technology management national resource centers and set up a portal, which would serve as a national clearing house for S&T information.
- The outlay proposed for CEL is Rs. 43 crore with an aim to achieve 25 MWp per annum solar photovoltaic production and a production of 30,000 to 40,000 nos. of phased control modules per year.
- Proposed outlay of NRDC is Rs. 168 crore with focus on incubation and venture capital funding, development of basic design engineering packages, development of rural clusters in dairy and sericulture industries and programmes for development of women entrepreneurship and the north east region.
- Outlay for Consultancy Development Centre (CDC) is Rs. 10 crore with a focus on Consultancy Services Export and implementing the Technical Consultancy Development Programme for Asia and the Pacific (TCDPAP).
- Besides, three new initiatives proposed are: (i) Small Business Innovation Research Initiative (SBIRI) in areas other than bio-technology for which the proposed outlay is Rs. 500 crore; (ii) Fund for Accelerating Start-ups in Technology (FAST), emanating out of the recommendation of Nitin Desai Committee on Innovation and Venture Capital, set up by the Planning Commission. Here the objective is to prepare the start-up companies for venture capital funding. The proposed outlay is Rs. 75 crore; and (iii) IPR Programme, where the objectives are to provide support for patent filing, patent searches using modern software tools and supporting commercialization of patented inventions. The proposed outlay for this programme is Rs. 100 crore.

17.2 CSIR

The guiding beacon for CSIR during the XIth Plan would continue to be its mission Statement which is to provide "Scientific industrial research and development that maximizes the economic, environmental and societal benefits to the people of India".CSIR would continue to foster the organization values of:

(i)	Excellence in Science	Science that will lead and not follow
(ii)	Global competitiveness	In technology based on high science, rooted wherever feasible in India's rich heritage of knowledge
(iii)	Local relevance	Finding holistic and optimal solutions to the pressing problems of the country by deploying technologies, ranging from the simplest to the most sophisticated often disruptive, suited to socio-cultural, economic ethos of the people; and
(iv)	Innovation	In all sphere of activities ranging from science, technology, management and financing.

CSIR's XIth Plan approach would be focused on "**technology led accelerated inclusive growth"**. The approach to the plan would be three pronged:

(i) First is to conceptualize, plan and work, in network mode, on R&D of relevance both nationally and globally – and to align it with public, private, strategic or social needs as the case may be. There would be a strong paradigmatic link between network and PPP modes.

(ii) Second is to forge viable, defined and scientifically challenging R&D projects in Supra institutional mode to make each laboratory a cohesive and close knit unit; much away from thinly spread and diffused units of the past. This would help align and reinforce the core competency of the lab.

(iii) Third is to build within each lab Centres of Sustainable Growth, a kind of magnet to attract Scientists/Technologists of Indian origin, a large number of trainees, industry-both national and foreign, and above all help create a Think Tank to look at the future with a clear vision and shape that into a mandate.

17.3 Core Operative Strategy

Thus during the XIth Plan, CSIR laboratories shall seek to enhance the leverage of their unique scientific and technological capabilities to attain goals working through:

- **Supra-institutional project** wherein the laboratory will have at least one flagship project in which the majority of the groups within the laboratory participate. This would synergize the in-house capabilities to optimize the outputs.

- **Inter-laboratory network mode**, as initiated in Xth Plan. In the XIth Plan, these networks will be further strengthened with a sharp focus to develop products / processes and knowledge, which is of interest to the nation.
- **Network mode**, with institutions / agencies outside CSIR to develop advanced technologies / products / prototypes / knowledge base that require multi disciplinary inputs and synergies.
- Offering and augmenting existing facilities as national facilities in R&D service mode to other academic and R&D institutions to help maximize their outputs and build synergies with them. In the XIth Plan, few **major national facilities** will be created in frontier areas to help in generation of competitive knowledge capabilities at par with international standards of future relevance.
- The emerging areas in each sector and building projects around them to generate competency. This will help India to secure global leadership position.

The core operative strategies would also include:

17.3.1 Creating, nurturing and sustaining the core knowledge frontier

CSIR recognizes the role of continuously enhancing core competencies of its establishments in basic and applied research through appropriate blue sky projects. These are a means of building a national knowledge base and an expression of national culture in which knowledge is valued and the search for new knowledge is appreciated. It would support such endeavor in its laboratories / institutes.

17.3.2 Projects in public private partnership mode

NMITLI has created a brand image and is viewed today as a benchmark of PPP schemes. It has shown a new way of managing the R&D projects, appropriate to Indian conditions. As India is entering into a new era of R&D, more such newer approaches of innovation development would be evolved and experimented.

17.3.3 Development of R&D Human Capital

In the XIth Plan, some of the select CSIR laboratories, that have consistently achieved excellence would be helped to take on the role of affiliated Research centres under the deemed to be university status. Other laboratories would also be encouraged and facilitated to forge symbiotic, seamless linkages and partnerships with institutions for higher learning by sharing with them their facilities, human resources (faculty) and infrastructure to develop specialized human resources in transdisciplinary niche areas and later on to become part of the deemed University.

Over the years a large number of scientists have superannuated in CSIR and new recruitments have not taken place. In the process it has become an aging organization. This needs to be corrected in the XIth Five Year Plan by fresh induction of manpower, primarily in the scientific and technical cadres. In addition it is also proposed to create mechanism for hiring temporary scientific & technical manpower for implementation of R&D programmes to overcome the problems posed by ageing and shortage of manpower.

17.4 New Initiatives Proposed

17.4.1 Centres of excellence: it is proposed to institute 6 Chairs of Excellence, one each in the areas of Chemical Sciences, Biological Sciences, Material Sciences, Leather, Engineering and Physics, and S&T Planning.

17.4.2 Centres for sustainable growth: CSIR plans to create a core thematic group built around a central theme to attract Scientists and Technologists of Indian origin to work, in some of the performing laboratories on short duration basis, in R&D areas of national relevance and global opportunity. These Centres, which would act as centres for sustaining growth of the laboratory and would also induct students to work on cutting edge research projects.

Early Stage Venture Fund(ESVF): to help those entrepreneurs who can come forward to commercialize and market the products and process developed by CSIR a ESVF is proposed in the XIth Plan.

17.4.3 CSIR-University R&D centres for excellence: CSIR is proposing CSIR-University R&D centres for excellence where universities would have access to state-of-art infrastructure and expertise available in various CSIR laboratories to enable universities to generate quality manpower in frontier areas of S&T.

17.4.4 Scale up and Validation of leads developed in-house: CSIR proposes to initiate focused activity in the areas of validation and scale up. First, this would enable CSIR to take the leads / targets it has developed to the next stage and develop a strong pipeline of potential compounds / libraries. Second, with this set up it could effectively partner with industry to address some of their issues that need advanced R&D interventions. This would provide platform for linking CSIR's knowledgebase to economic and social benefits. Third, it would provide on the job training to create a pool of trained scientists / lab resources. These activities by themselves would lead to innovation and help position CSIR in global R&D space.

Open source drug discovery programme for infectious disease: In the XIth Plan it is proposed that CSIR would set up programmes for open source drug discovery through national and international collaborations involving National Laboratories and Academia. "Open Source Drug Discovery Movement" is a new concept and has major advantage of reducing the cost of development by bringing like-minded scientists with complementary diverse skill set together under a single umbrella.

CSIR's reach for Rural development: It is proposed to focus on this aspect and reach masses through NGO's, Educational institutions and State Government Agencies and at the same time continue to add to this national priority during the XIth Plan.

17.4.5 CSIR for North East development: CSIR, during the XIth Plan, will involve developmental agencies as the vehicle for propagation in defusing this knowledge to a large section of the society. This is expected to result in a long-term rewarding partnership to accelerate S&T base development of the region.

17.5 XIth Five Year Plan Programmes & Activities

CSIR, based on the indications emerging out of the sector specific SWOT analysis and ZBB and considering approach to S&T as the backdrop, would be implementing Six Plan schemes during the XIth Plan. While, the first five following schemes would be the continuing schemes with new programmes / projects / tasks & activities, the sixth scheme would be the new scheme:

i. **National Laboratories**

ii. **National S&T Human Resource Development**

iii. **Intellectual Property & Technology Management,**

iv. **R&D Management Support**

v. **New Millennium Indian Technology Leadership Initiative and**

vi. **Setting-up of translational research institute**

(i) National Laboratories

Under the scheme National Laboratories the programmes are more specifically addressed as:

(a) Supra Institutional Projects

Each laboratory will have balanced portfolio of projects in the ‘knowledge-market, space. Keeping in view its R&D domain, it would formulate at least one overarching programme drawing strength and participation from a majority of the groups within the laboratory. This would be termed as Supra-Institutional project.

(b) Network Projects

CSIR has endeavoured to carve out a niche for itself by working through network projects in the Xth Plan. The emphasis has been laid on networking on expertise, resources and facilities so that the project would target substantial increase in value of inputs of Science & Technology in knowledge driven areas. In the XIth Plan, experience drawn from the Xth Plan has emboldened CSIR to launch yet another set of network projects of multi disciplinary nature. The output of network projects is expected to bring in a new direction and also generate new areas of business for CSIR.

(c) Inter - agency Projects

The present day process of knowledge generation and diffusion is characterized by a shift from research based stand alone scientific disciplines to trans-disciplinary and inter - institutional networking.

CSIR would synergise with academia, industry and Government to build World Class facilities and identify, niche areas where CSIR as a part of 'Team India' can make a major impact.

(d) Facilities

CSIR would consciously develop and sustain select laboratories to maintain internationally competitive knowledge generation capabilities in key technology areas and will build World Class facilities.

The programmes and projects under National Laboratories have been classified in sixteen sectors. A total of 226 projects have been identified for implementation during the XIth Plan, out of these 37 as Supra-institutional projects, 143 as Network projects, 18 as Inter-agency projects and 28 as creation of Facilities.

Some of the major programmes are:

- Technology Development and R&D Initiatives in Aerospace.
- Designing and developing a regional aircraft specially suited for developing economies (Phase-1).
- Niche food processing technologies for outreach of cost effective, safe, hygienic, nutritious food to the targeted population.
- High value products from agro forestry resources from the Himalayan region & improving productivity and quality of product development.
- Technology intervention for quality products from cereals and legumes for convenience/ traditional foods.
- Design and development of equipment with automation and semi-automation for the production of ethnic/traditional foods in small scale industry.
- Nutraceuticals and bioactive molecules from food and non food sources.
- An Integrative Biology Approach in Deciphering Genotype - Phenotype Correlation for Human complex Disorders.
- Therapeutic proteins, ultra stable enzymes and other proteins of importance: Science, Engineering & Technology Development.
- New Insights in cancer Biology: Identification of novel targets and development of target based molecular medicine.
- Cell and Tissue Engineering of Plants.
- Regulatory RNA in Development, health and disease.
- High Altitude biology with focus on Indian Cold deserts.
- Exploitation of India's rich microbial diversity.

- Biological & Chemical Transformation of Plant Compounds for Production of Value Added Products of Therapeutic / Aroma Value.
- Novel approaches for detection of incorporated genes in modified GM crops.
- Evolution of the Indian Lithosphere - Focus on major earth processes natural resources and the geo-environment since the break-up of Gondwana Super content.
- Science for development of a forecasting system for the waters around India.
- Development of New Adsorbents and Membranes for Potential Application in Separation Technologies.
- Uncertainty reduction, vulnerability impact assessment, mitigation policy intervention and capacity building for Global Change.
- Competence building in the Molecular Environmental Science.
- Resource conservation through recycle / reuse of wastes with recourse to recovery of value added products.
- Energy for cleaner and greener environment.
- To develop know-how and technology for environmental friendly conversion and utilization of biomass to fuels, lubricants and additives.
- Development of a composite approach suitable for clean coal initiative.
- Development of Lithium-ion batteries for multifarious applications.
- Development of Underground Coal Gasification and IGCC Technology in India; Functional organic materials for Energy Efficient Devices.
- Development of gas to liquid (GTL) Processes for DNE & Fischer-Tropsch fuels.
- Hydrogen economy initiative.
- Development of Coal to liquid (CTL) technology for synthesis of liquid from hydrocarbons.
- Technology development of Smart Systems.
- Capability development in manufacturing of Mobile Robotic system for national security, disaster management and Hazardous Applications.
- MEMs and Mocrosensors for Requirements in Food, Health Environmental and social Sectors.
- Design and Fabrication Capabilities for Very High Power, High Efficiency and Very High Frequency Microwave Tubes.
- Fabrication of LED Devices and Systems for Solid State Lighting Applications.
- Photonics for Communication, Sensor and Laser Technology.
- Instrumentation for applications in Agriculture, Food and public safety.

- Development of speciality glasses for strategic and industrial application.
- Ceramic materials for emerging technologies involving liquid and gas separation.
- Capability development in manufacturing of Mobile Robotic system for national security, disaster management and Hazardous Applications.
- Development and forming of performance driven specal steels.
- Technology for Assessment and Refurbishment of Engineering Materials and Components.
- Development of Advanced Lightweight Metallic Materials for Engineering Applications.
- Capability Building of Advanced Manufacturing Processes of value added Components.
- Modular Re-configurable Micro Manufacturing Systems (MRMMS) for Multi Material Desktop Manufacturing Capabilities.
- Development of suitable biomaterials and process techniques for preparation of patient specific implants for rehabilitation.
- Diabetes Mellitus -New Drug discovery R&D, Molecular mechanisms and genetic factors.
- Cell and Tissue Engineering of Animal and Human Cells.
- Development of comprehensive insilico tool for cost effective clinical trials.
- Validation of Identified Models and Development of new alternative models for evaluation of new drug entities.
- Nanomaterial and Nanodevices in Health and Disease.
- Comparative Genomics and Biology of non-coding RNA in the human genom.
- Discovery and Preclinical studies of new bioactive molecules (natural and semi-synthetic) & Traditional Preparations.
- New drug development programme for parasitic diseases and microbial infections.
- New drug development programme for reproductive health and life-style diseases.
- Development of novel target based anticancer therapeutics.
- Validation of Ayurvedic Concepts of Prakruti in metabolic disease Predisposition, progression and Drug response with special focus on metabolic disorders.
- Management tools for maintenance, Scheduling and life enhancement of special structures.
- Development of a Management System for Maintenance Planning and Budgeting of High Speed Road Corridors under NHDP.
- Nutraceuticals and bioactive molecules from food and non food sources.
- Track-bridge interaction studies in Indian Environment.
- Energy Efficient Structural Systems.

- Performance Evaluation of Highway.
- Comprehensive Traditional Knowledge Digital Library.
- National Science Digital Library.
- Consortium Access to Electronic Journals for the benefit of CSIR labs.
- Scientific Knowledge Grid, High Power Computing, Data Centres.
- R&D in Core Information Technology.
- Process & product innovation for leather sector.
- Advancement in Metrology; Development of hollow fiber membrane technology for water disinfection / purification and wastewater reclamation.
- Membrane technology for water purification and desalination.

17.6 CSIR proposes to build following major facilities during the XIth Plan

- Advanced centre for High Mechanics & control.
- Regional facility for nutraceuticals / cosmetically / value added products.
- Model food processing incubation centers.
- CSIR centre for human resource development in food science and technology.
- Nodal codex food laboratory and referral centre for organic nutraceuticals & GM foods.
- Centre for plant biotechnology.
- Facilities for Functional Genomic Research (IGIB) (i) Cellomics Facility (ii) Zebra fish Facility (iii) LC-NMR facility.
- Setting up a compact high-energy light source radiation for the structural analysis of bio-macromolecules.
- National Center for Genomics and Advanced Center for Protein Informatics, Science, Engineering & Technology.
- Enter of Excellence for Lipid Research
- The Indian SHRIMP Facility.
- Sophisticated Environmental Analytical Instrumentation Facility.
- Development of Fuel Cell Testing and Validation Facility.
- Autonomous Centre for Battery Testing (ACBT).
- Centre of Excellence on Plasma Processing of Minerals and Materials.
- Advanced centre on mechano-chemistry and reactivity of solids.

- Establishment of Dog Facility for research and testing purposes.
- Functional MRI and MRS facility for investigation of molecular & cellular processes in rat and Human.
- High throughput fragment based screening using X-RAY / NMR on proteins from pathogenic sources and rational inhibitor optimization
- Establishment of National Facility for Remote Structural health monitoring; Centre of Excellence for Advanced Structural.
- State-of-the-art multi-teraflop High Performance Computing (HPC) facility.
- Design Centre for Leather Products.
- Material design and development center.
- State-of-the-art analytical facility for North East.
- In addition to above CSIR would complete 13 projects of the Xth Plan, which have spilled over to the XIth Plan. The other programmes under National Laboratories would be for:
  - **Creating, nurturing and sustaining the knowledge frontier**
  - **Scale-up and validation of leads developed in-house**
  - **Open source drug discovery programme for the infectious disease**:
  - **Laboratory modernization for eco-friendly sustainable growth**
  - **Civil infrastructure renovation, staff quarters and amenities**

17.7 A brief summary of the other five schemes are outlined below:

17.7.1 National S&T Human Resource Development

In the XIth Plan CSIR proposes the following programmes:

1	CSIR Programme on Youth for Leadership in Science (CPYLS)
2.	Technological Entrepreneurship Programme for Research Scholars
3	Trans Disciplinary Fellowship Scheme
4	Shyama Prasad Mukherjee Fellowship Scheme (SPMF)
5	Faculty training and motivation and adoption of schools and colleges by CSIR laboratories
6	Research Fellowships in Basic Sciences & Interdisciplinary areas
7.	Conduct of JRF NET & SPM Examination
8	GATE qualified Junior Research Fellowship(JRF-GATE) Scheme
9.	Adjunct / Visiting Scientist Scheme for CSIR Labs (being formulated)
10.	CSIR - NIF Innovation Fellowship Scheme
11.	Setting up of Centres for Knowledge / Innovation / R&D / Technology Management
12.	Training program on Knowledge and R & D Management
13.	Special assistance scheme to promote research in universities
14.	Floating Faculty Scheme
15.	Project Interns Award Schemes for CSIR Labs
16.	Research Schemes in Emerging, Critical & Thrust Areas

17.7.2 Intellectual Property & Technology Management

Encompassing the above, the programmes proposed for the XIth Five Year Plan are listed below:

- Filing, capturing, prosecution and maintaining of IPR for CSIR R&D outputs
- Valuation and valorization of patent and IP portfolios
- Surveillance for infringement and enforcement of IPR
- Human Resource in IP cells of CSIR laboratories
- Modernization of computing, communication and related facilities and infrastructure

17.7.3 R&D Management Support

CSIR headquarters, through various functional Units / Divisions provides the R&D management support and common and unified infrastructure to all its National Laboratories. the Headquarters functions as the nerve centre for the organization and catalyses and facilitates the laboratories by establishing, equipping and realizing excellence in R&D, promoting brand equity, financial self-sufficiency, global competitiveness and disseminating organizational learning. The programmes proposed under the scheme are given below:

- Early-Stage Venture Fund (ESVF)
- CSIR Chairs of Excellence
- CSIR Centres for Sustainable Growth
- National Innovation Foundation
- New Idea Fund
- Human Resource Development Centre (HRDC)
- R&D management and Business development
- International Scientific collaboration
- Science dissemination

17.7.4 New Millennium Indian Technology Leadership Initiative (Nmitli)

During the Xth Plan NMITLI has created a brand image and is viewed today as a benchmark of PPP schemes which is being emulated by various other government departments. In this context it is proposed to expand the programme with new approaches of innovation development. Following are among other concepts to enlarge under NMITLI:

- Pre and post NMITLI
- Funding with industry (50:50 Initiative)
- Co-financing with Venture Capital funds
- Long term sustained efforts in selected areas (NMITLI innovation centres)
- Acquisition of early stage relevant knowledge / IP for portfolio building.

17.7.5 Setting up of Institute of Translational Research

Biological/clinical research is increasingly becoming interdisciplinary. At the same time, translational research/stem cell research etc need focused attention of scientists from different fields. A new institute would be to carry out such work in mission mode, which would be more productive than trying to network scientists with diverse interests from different cities.

18

Eleventh Five Year Plan Programme – Department of Space

18.1 The XIth five year plan proposals have been formulated under the framework of a long-term Plan after extensive interactions, detailed studies and consultations within the organisation as well as with user community. The programmes and the Mission Profile have been based on the national developmental needs in the social and economic sectors. An inter-ministerial Working Group constituted by the National level S & T steering Committee has reviewed the plan proposals during the meeting held on 23rd August 2006 and has recommended to adopt the XIth Plan proposals in totality.

The overall thrust of the Space programme during XIth Plan will be to sustain and strengthen the already established space based services towards socio-economic development of the country. The following are the brief summary of the plan programmes envisaged during the XIth Plan in the area of Launch Vehicle Development, Earth Observation Systems, Satellite Communications & Navigation (INSAT, GSAT & IRNSS), Space Science Programme, Atmospheric Science Programme and Disaster Management Support.

18.2 Highlights Of The Plan Proposal

Major thrust on large-scale applications of space technology in the priority areas of National development and to undertake advanced space endeavors in the frontier areas of space research.

Major Goals of XIth Plan

18.2.1 Capabilities in Space Communications and Navigation

- Augmentation of INSAT / GSAT space segment to meet the demand of 500 transponders by end of the plan period.
- Development of high power Ka band satellites and ground systems for point-to-point connectivity.
- Building Navigational Satellite Systems & related services.
- Focus on R & D in Satellite Communications.
- Institutionalisation of Tele-medicine, Tele-education and VRCs

- Communications systems / support for Disaster Management.
- Progress towards self sustenance of INSAT/GSAT system.

18.2.2 Leadership in Earth Observations

- Improved imaging capability and continuity of data / services through three thematic series of EO systems – Land & Water resources, Cartography and Ocean / Atmosphere.
- Development of advanced microwave imaging capability.
- Strengthening Ground Systems and SNRMS.
- Establishment of National Natural Resource Data base.
- Undertake major applications projects in the area of Agriculture, land and water resource management, DMS, infrastructure and urban / rural development, etc,

18.2.3 Major thrust in Space Transportation System

- Operationalisation of GSLV Mk III with 4T launch capability.
- Perfect payload recovery and reentry technologies.
- Conduct Demonstration flights of Reusable Launch Vehicle.
- Critical technologies for Manned Mission.

18.2.4 Space Science Enterprise

- Advanced space science endeavors – Chandrayaan, Multi-wavelength X-ray astronomy, Mission to Mars and Asteroid / Comet fly by missions.
- Establish Space Science Instrumentation Facility and Indian Space Science Data Centre.

18.2.5 Promoting Spinoffs

- Human Resource Development, Space science & technology education, Industry Interface, Academia interface and International cooperation.

18.3 In the area of ***launch vehicle development,*** the major target for XIth Plan is to complete the development of GSLV Mk III capable of launching 4T class INSAT satellite and operationalise the vehicle. PSLV and GSLV will continue to be workhorse vehicles for launching IRS and INSAT (2T class) satellites and their capabilities will be further improved. Technology development and demonstration missions on Reusable Launch Vehicle including space recovery technologies and air breathing propulsion are also planned.

18.4 Building up large space systems like space stations, servicing and refuelling of satellites in space and material processing are promising greater economic benefit to the nation. These require a large scale involvement of human beings in space for building and maintaining space assets. Space has emerged as the next frontier of human endeavour and manned missions are the logical next step to space research. Therefore, it was considered necessary to initiate the ***development of Manned Missions*** during XIth Plan period by development of critical technologies. The major objective of the Manned Mission programme is to develop a fully autonomous manned space vehicle to carry two crew to 400 km LEO and safe return to earth.

18.5 The Earth Observation (EO) Systems during XIth Plan is driven by two major considerations viz., ensuring continuity of EO data with improved quality duly addressing the current gap areas and the urge to maintain the global leadership in EO systems. The EO series of satellites, both in IRS and INSAT/METSAT series, addressed broadly the thematic applications in three streams viz., Resourcesat series, Cartosat series and Atmosphere series. An important specific target for XIth Plan is to realize the Microwave remote sensing satellite RISAT which provides all-weather remote sensing capability critical for applications in Agriculture and Disaster Management. Strengthening ground segment to ensure and enhance effective utilization of the remote sensing data will be an important thrust area. Creation of Natural Resource Inventory and Data bases, Food security, Water security, Disaster Management support, Infrastructure development, Weather forecasting, Ocean State Forecasting, Environment protection, climate variability and change are some of the thrust areas of EO systems applications identified for XIth Plan.

18.6 The major emphasis in Satellite Communications during XIth Plan will be towards meeting the growing demand for transponders, ensuring continuity of quality services, protection of space systems, efficient spectrum management and continuous improvement in technology. Based on the demand, the INSAT system capacity will be progressively augmented to about 500 transponders (current 175) by end of XIth Plan. Development of cost-effective 4T-12KW bus with capacity of more than 50 transponders and flexible enough to accommodate wide range of payloads will also be undertaken. The thrust areas of applications include expansion and growth of tele-education, telemedicine and village resource centers, strategies for operationalisation and institutionalisation with the involvement of Central Government Ministries / Departments, State Governments and NGOs, self-sustenance and large scale training.

18.7 Satellite Navigation is emerging as a vital area not only for civil aviation but in many other areas such as mobile telephones, surface transport, intelligent highway system, maritime transport, rail, oil and gas, precision agriculture, fisheries, survey and marine engineering, science, electricity networks and leisure. Besides completing the ground augmentation system GAGAN, a major target for XIth Plan is to establish Indian Regional Navigational Satellite System with a constellation of 7 satellites. Co-operation and participation in global navigational systems will also be pursued.

18.8 Broadly, the Space Science research during XIth Plan is planned under four major areas viz., Planetary Exploration / Science, Astronomy and Astrophysics, Space Weather and Weather and Climate. The Space Science research in the country has gained impetus in the recent years with the undertaking of Planetary mission Chandrayaan-1, Multi-wavelength X-ray astronomy satellite ASTROSAT and climatic research satellite Megha-Tropiques and created special awareness and enthusiasm amongst the younger generation. A major target for XIth Plan, therefore, is to complete these ongoing missions and further undertake newer missions to sustain and promote the wherewithal created for space science research. Akin to this, a major challenge lies in creating the human resource based in the country for analysis of the enormous amount of scientific data that would be available from these missions.

18.9 Disaster Management Support, is intended to provide timely and reliable space inputs and services to the DMS in the country and is a vital area of space applications during XIth Plan. The major initiatives planned during XIth Plan include realization of a National Data Base for Emergency Management, Impact mapping and monitoring support for Disaster events, Satellite based communication support for Disaster Management, strengthening of early warning systems and development of tools and techniques for decision support systems for Disaster Management.

18.10 Considering the need to provide an impetus on studies and research in the critical area of atmospheric research, an ***Atmospheric Science Programme*** (ASP) has been planned with special emphasis on use of satellite and advanced observation tools, techniques of modeling and a mechanism for interactions with scientific departments and academia for initiating suitable projects, leading to operational end user products in different domains. The primary goals of the Atmospheric Science Programme will be to pursue high quality research and development work in Meteorology, Atmospheric processes, Atmospheric dynamics with emphasis on use of satellite inputs.

18.11 Human Resource Development, International co-operation, Industry and Academia interface, indigenous development of space materials and components and Space commerce will continue to be priority areas during XIth Plan.

18.12 The Indian Space Programme has paved the way for creating cost-effective space infrastructure for the country in a self-reliant manner and the economic and social benefits brought in by the application of space technology to the national development have been significant. The Space Programme is poised to play a pivotal role in the national development in the forthcoming decade.

19

Eleventh Five Year Plan Programme-Department of Science and Technology

19.1 Planned interventions are proposed to cover the issues relating to Talent Supply Chain Problem, Investment Limitations in S&T, Strengthening Institutional Frameworks and Quantification of Outcome and Impacts. In a deliberate change in its approach, DST is developing a suitable mechanism and structure for monitoring, in real time, the outputs and outcome of S&T and measurement of proportions of technology-led growth of GDP of India. DST, has planned during the XIth Plan that a certain percentage of R&D support be directed towards coordinated programs involving multiple agencies and disciplines with super ordinate goals and targets. DST has thus far adopted mostly bottom up models for planning. During the XIth Plan a balanced mix of both bottom up an top down models are envisaged.

Public –Private partnership has already emerged a critical need for enhancing the resource support for R&D. Innovative schemes to seed and support R&D in private systems also may also have to be developed. DST, therefore, will prepare proactively the S&T system in the country in some select domain areas which are most suited to private-public partnership.

In International Cooperation, Technology synergy programs with nations embracing India in S&T cooperation will require a funding facility for matching their contributions. The XIth Plan budget of DST will include a certain lump sum provisions for technology synergy programs with a provision to match the contributions of partnering countries. The XIth Plan of DST will include impact making programs on water and energy security. Some R&D initiatives of DST requires that the department partnered with the concerned line ministries and the departments. DST plan to work in networked fashion.

19.2 Programs for Attraction of New Talents: It is imperative that Indian science and technology system is able to attract talents. A special Scheme titled "Innovation in Science Pursuit for Inspired Research" (**INSPIRE**) has been developed. The main features of proposed scheme, INSPIRE, are

- Innovation funding in schools (one million young innovators)
- Summer camp with Science icons (for high performers)
- Assured opportunity schemes for proven talent force
- Retention of talents in public funded research through PPP

19.3 Assured Career Opportunity Schemes in Science and Technology Sector: There is a need for providing assured opportunities to talented youth for career 'with science'. There may be a need to create at least 1000 new blood positions under plan mode in the research and development sector during the next five years. These positions would need to be supported with R&D funding support for five years. These positions may be available for competitive bidding by Universities as well as institutions in under both public and private funded modes.

19.4 Creating An Innovation Culture: The joy of experiencing innovation needs to be rooted early. A mission to reach at least one million young people to experience the joy of enquiring into science is necessary.

19.5 Fostering Excellence and Creativity: A scheme to attract gifted youth in the age group of 15-18 to summer camps, where they rub shoulders and receive mentoring from the icons of the world of science is one mechanism of fostering excellence.

19.6 Developing a Super Grid for Attracting Talent to Science and Technology Landscape: Departments of Science and Technology embedded within the State machineries and the Centre need to be effectively networked into a fully functional grid of support system to deliver innovative S&T initiatives.

19.7 Retention and Fostering of Talent and Excellence: Special efforts are required to retain talent and excellence in the S&T streams. There may be a need for innovating, and other mechanisms for providing flexible pay and perks for S&T groups. An effective interplay of private sector would be required for the public institutions in attracting and retaining talent in S&T streams.

19.8 Strengthening Research and Development Support Mechanisms: Further strengthening of SERC programs under an autonomous body of National Science and Engineering Research Foundation has been approved already. The budget allocations sought by DST include also those for the proposed Foundation. Nano mission, Pharma technology programs initiated during the X^{th} Plan period will require added funding.

19.9 Special programs for rejuvenation of research in University and Academic Sector: Several national committees have strongly advocated for special programs for rejuvenating research capabilities in the university and academic sectors through special assistance programs. A need for top-down approaches for rapidly revitalizing the S&T capacities in the academic sector has also been expressed at various platforms. The mandate and function of DST demand that the department enrolls into such time bound programs and deliver the outputs on mission mode during the XI^{th} Plan period. A different approach for making supply and delivery side interventions has been recommended by the scientific community. DST assumes those roles as a natural responsibility and function.

19.10 Technology Development Programs for Technology-led Growth Paths for GDP

19.10.1 Quantification of role of technology in National Growth process: There is now a need to make conscious attempts to estimate and increase the technology contributions to the GDP growth of India. A measurement system is required for India. DST has proposed to commission such a cell as an in-house unit.

19.10.2 Assisting National growth Agenda in Agriculture through technology support: Agriculture forms an important element of the growth engine. However, the share of agriculture in the GDP growth is estimated at <2% per annum. There are plans and targets within the Government to raise the share of agriculture sector to 4.0% in the GDP growth paradigm of India during the next few years. This is possible only if new technologies are added to the agriculture sector with dramatic results on land, labour, water and system productivities. It should be possible to relate high technology to serve the common man involved in agriculture. Spatial Data Infrastructure along with necessary microzonation could provide valuable insight to the farmers. Advanced information on rainfall, monsoon, agronomical data, watershed management systems and measures for increasing substantially the efficiency of the use of water in agriculture should reach the people when needed. Weather science and water saving technologies could form two important elements. Majority of operational and other technological aspects of earth science will be implemented through the new ministry. DST will be involved in S&T support systems in the universities in Earth science through Extra mural support and Survey of India related services.

19.10.3 Technology support systems for Growth Engines of Manufacturing Sector: The manufacturing sector has registered significant growth in the last few years. The percentage contributions of the manufacturing sector to the GDP growth are significant. A large percentage of growth in the manufacturing sector is, however, through the Small and Medium Enterprise segment. Manufacturing in such segments is driven by access to materials and market forces. The level of value addition to materials through technology in such segments is limited to 5-7%. Technology and innovation-driven manufacturing should be able to add values to materials by 15-20% and 25-30% respectively. Our manufacturing systems should adopt best manufacturing practices. Value addition through technology should increase the income of the people. Both volume and value of employment will become important. Technology should be used gainfully to increase the value of employment.

In some sectors of high economic growth potentials such as drug and pharmaceuticals, textiles, and chemicals on the one hand and emerging areas like biotechnology and nano technology for advanced materials on the other, it should be possible for the Indian S&T system to quantify the scope and opportunities to provide a technology-led growth path. Perhaps the S&T system should target doubling the technology contributions to growth in such sectors by 2010.

19.10.4 Technology support for the Services Sectors: Indian GDP growth is enabled by developments in the services sectors like Information Technology and BPOs. On the one hand, there is a mushrooming of colleges. On the other, the services sector is languishing for want of appropriately skilled people. Now, there are discussions regarding finishing schools. Perhaps, applications of new educational technologies and training systems can help in accelerating the skilling of people to suit the needs of the services economy, which creates large scale employment in the private sector.

19.10.5 Need for Private-Public Partnership: A technology partnership needs to be developed among our public funded R&D institutions and industries. New models such as the one launched by the Council of Scientific and Industrial Research through New Millennium Indian Technology Leadership Initiative (NMITLI) is a good model. We need to enlarge the scope and scale of such programs under various PPP models.

19.11 Technology Diplomacy: in Nation Building

19.11.1 Gaining leaderships through Technology-led Diplomacy: The world order is changing. Trade advantages polarize the nations. New alliances and groups of Nations are being formed based on economic indicators. Technology-led growth of economy is the global model of developed nations. Balancing political and economic freedoms of nations has brought technology-led diplomacy to the center stage in international cooperation. India needs to leverage technology-led diplomacy in international cooperation. For several developing countries, India is a role model for science and technology-based growth. India can play an enabling role for many nations.

19.11.2 Technology Synergies for Promotion of Innovation Cultures: There are several developed nations which target the young population of India for the growth of their own science and technology systems. Other nations are targeting Indian's young population for developing their science. India can not remain a supply system talents alone. It is possible for India to develop educational and S&T enterprises based on successful global models of twinning capacity building in S&T landscape. This process needs to be based on win-win formula for both nations. Our strategy for international cooperation needs to be based on mutual gain and complemental strength. Bold initiatives to attract Indian Diaspora for building active research schools in frontier areas by providing critically sized R&D grants is another way of building international cooperation in a sustained manner with mutual gain for both nations.

19.11.3 Technology Acquisitions under S&T Cooperation for Faster Growth: There are nations from which India may stand to gain and receive in certain sectors of development. Balancing overall growth of India in much needed sectors of economic activities cannot be based on total self-reliance in everything. Re-inventing and reverse engineering models of growth are not sustainable in modern India. In such domains, India would need to develop strategic partnerships with other nations after appropriate cost benefit analysis. Energy-, water-, eco- and nutrition-security of India would call for large global models of S&T cooperation. Then there are areas of research like high energy physics, nuclear physics, accelerator physics and technology, etc. which are manifestly international in character. Suitable collaborative projects by mobilizing the national strengths in these areas will be evolved and funded in coordination with sister agencies like DAE.

19.12 Technology outreach for inclusive growth of rural India: A Foundation under one of the S&T departments would be required to be established to increase the reach of technology to villages. Development process through applications of S&T should be rooted in our villages, if the public faith and interest in S&T systems need to be enhanced.

19.13 Water and Energy Technologies: Water and energy security of the nation form two ideal areas for the S&T landscape in the country to provide a protective cover through a combination of incremental, systemic and leap-frog innovations. This would call for convergence of minds. S&T plan of DST needs to include coherence, synergize and cohesiveness work.

19.14 Grand Challenge Programs: The Department of Science and Technology has planned two key programs of grand challenges to be explored and developed during the XIth Plan period. The following programs will be developed using best models of Indian S&T system:

19.14.1 Science of Human Cognition: DST proposes a new program initiative on Science of human cognition using a knowledge network. Under this model, an effort to link traditional Indian systems of biofeedback including yoga and the modern tools of measurements of interactions of brain, mind, behavior and consciousness using modern scientific methods is planned.

19.14.2 Security Technology Initiative: DST proposes a major high science based network initiative to develop new tools and techniques to recognize pre-emptively people with terrorist intent. The objective of the effort will be counter terrorism.

19.14.3 Rural Technology Delivery Mechanisms: DST proposes to establish a new foundation and mechanism to increase the outreach of technology and deepen the social contract of S&T. DST would focus on spreading technologies suited for domestic use for ensuring the safety of drinking water with a spread effect.

19.14.4 Mega Science Support: DST proposes to collaborate with Departments of Atomic Energy and other science departments in the creation of mega science programs and facilities in and out of the country to improve the access of advanced global research facilities like Synchrotron, ILC,ITER,FAIR,SKA etc to the university and academic sector.

19.15 Objectives of Plan Programs of DST for the XIth Plan Period

- To facilitate the formation of a National Science and Engineering Research Board with functional autonomy
- To participate in the formation of Earth commission by enlarging the scope of IMD, NCMRWF, IIPM and some operational activities relating to earth sciences
- To launch and commission an intensive Nano science and technology mission mode program
- To strengthen research and developmental activities undertaken in Autonomous institutions and create new centers in five select areas of national priority

- To expand science communication and Vigyan Prasar functions to commission mission mode National Innovation Campaign among young learners
- To lead a joint initiative of center with state functionaries as a super grid for science promotion
- To enlarge the national program on technology development for select industries including Pharmaceutical research and Development
- To establish a new cell for technology intelligence and S&T policy building
- To revitalize the programs of Technology Development Board and Technology Information, Forecasting and Assessment Council
- To enable modernization of Survey of India through a mission mode program
- To partner socio economic ministries in the areas of new energies, petroleum, environment, textile, pharmaceuticals, leather and coal in research and development support and link S&T systems for addressing the needs of global change programs

19.16 XIth Plan deliverables from programs of The Department of Science and Technology

- National Science and Engineering Research Board
- Enabling 33% of the Autonomous institutions to global standards of S&T output indicators through a well balanced budget support per scientist
- Nano science and Technology mission building capacity in the emerging area in at least 25 public funded institutions and 25 industries building PPP to mobilize about 25% of the budget needs from the industrial sector
- Launch of Five new autonomous S&T institutions in areas like, Molecular materials, Glaciology, ICT, drug and pharma, and Textiles.
- Creating innovative experience among one million school children and mentoring by icons of global science in 45,000 children
- A super grid of science network in all states and regions of the country
- Modernization of Survey of India
- Foresight Unit for Science and Technology for Evidence based Policy formulation
- Ten fold expansion of activities and programs under TDB, International cooperation program , TIFAC
- Participation in a Pan-India Initiative for anthropogenic emission measurements and mitigation
- A water technology mission for safe drinking water in at least 100 locations as proof of concept

- Launching of Security Technology Initiative for improving internal security
- Establishing a National Foundation for Technology for Rural Enterprises and Employment, TREE with defined targets for the XIth Plan period
- Evidence based interventions and Quantification of technology growth potentials to GDP growth in select three industrial sectors and technology proving exercises in three select industrial sectors

19.17 Supporting S&T Programs

19.17.1 Science and Technology Plan for India

Science and Technology plan for the country for the XIth Plan period has received inputs from various expert groups in addition to those constituted by the various departments. In view of the increasing concerns and the public opinion that Indian competitiveness in the areas science and technology, science and engineering academies, Scientific Advisory Committee to the Cabinet, Scientific Advisory Council to the Prime Minister and other high science bodies have been making important proposals for rapidly gaining for India a positional strength. Some of the proposals made have large bearing on the XIth Plan initiatives of the Department of Science and Technology. Therefore, it is likely that several support programs in addition to those contained in the proposal of the Department of Science and Technology may need to be considered by the Planning Commission. Some such support programs in which the department of Science and Technology could participate meaningfully and serve the role of implementing agency have been listed here for further consideration.

19.17.2 Massive Interventions in the University and Academic Sector

University forming the root of the scientific research in the country, it may be necessary to make more massive interventions in the university sector than what has been projected in the XIth Plan proposal of the Department of Science and Technology. DST recognizes that these initiatives would need to be implemented in close collaboration with Ministry of Human Resource Development. DST offers to enroll itself in the support programs for the university sector in addition to what is already planned by the department.

19.17.3 Support to Science Academies

DST has proposed a level of support to the science academies on the basis of sustainability of the ongoing initiatives. However, there is a need to launch new programmes for fostering existing talent in the scientific community. DST foresees a proactive role for the department in supporting the project mode actions of the academies which play an important part in supporting excellence in research.

19.17.4 Schemes for Teachers and Research Students

One of the important aspects of the proposal of DST for the XIth Plan period is in the area of science education and teaching. The department does propose a number of initiatives for attraction of talents to study and careers with science. The department proposes to play some supporting roles with the education sector in conducting motivational programs for teachers in science. In these activities, DST proposes to work with the education sector.

Report of
The Steering Committee
on

Science and Technology

for
Eleventh Five Year Plan
(2007-12)

SUPPLEMENT

सत्यमेव जयते

Government of India
Planning Commission
December, 2006

Report of The Steering Committee

on

Science and Technology

for

Eleventh Five Year Plan

(2007-12)

SUPPLEMENT

(Composition of the Steering Committee and the Working Groups)

Office of the Principal Scientific Adviser to the Government of India
Vigyan Bhawan Annexe, Maulana Azad Road, New Delhi-110 011

December, 2006

1. The Steering Committee on Science and Technology for the Formulation of the Eleventh Five Year Plan (2007-12)

I. Composition

1.	Dr. R. Chidambaram, Principal Scientific Adviser to the Government of India	Chairman
2.	Prof. V.L. Chopra, Member, Planning Commission	Co-Chairman
3.	Dr. Anil Kakodkar, Secretary, Department of Atomic Energy	Member
4.	Dr. G. Madhavan Nair, Secretary, Department of Space	Member
5.	Dr. V.S. Ramamurthy, Secretary, D/O Science and Technology	Member
6.	Dr. R.A. Mashelkar, Secretary, D/O Scientific and Industrial Research	Member
7.	Dr. M.K. Bhan, Secretary, Department of Biotechnology	Member
8.	Dr. P.S. Goel, Secretary, Department of Ocean Development	Member
9.	Shri M. Natarajan, Secretary, DRDO & Scientific Adviser to RM	Member
10.	Dr. N.K. Ganguly, Director General, ICMR	Member
11.	Dr. Mangala Rai, Director General, ICAR	Member
12.	President, Indian National Science Academy	Member
13.	President, National Academy of Sciences	Member
14.	President, Indian Academy of Sciences	Member
15.	President, Indian National Academy of Engineering	Member
16.	Prof. P. Balram, Director, Indian Institute of Science, Bangalore	Member
17.	Chairman, University Grants Commission	Member
18.	Prof. Deepak Pental, Vice Chancellor, University of Delhi	Member
19.	Prof. M.S. Ananth, Director, Indian Institute of Technology, Chennai	Member
20.	Prof. P. Venkatarangan, Vice Chancellor, Amrita Vidyapeeth, Coimbatore	Member
21.	Dr. A.E. Muthunayagam, Executive Vice President, Kerala State S&T Council	Member
22.	Dr. V. Sumantran, Ex-Executive Director, Tata Motors Limited	Member
23.	Dr. Kiran Majumdar Shaw, CMD, Biocon Ltd.	Member
24.	Prof. (Ms) Rohini Madhusudan Godbole, Centre for Theoretical Studies, IISc, Bangalore	Member
25.	Prof. M.S.Valiathan, National Professor, Manipal Academy of Higher Education, Manipal	Member
26.	Dr. M.S. Bamji, Emertius Scientist, Dangoria Charitable Trust, Hyderabad	Member
27.	Dr. Sudha Nair, Director, MS Swaminathan Research Foundation, Chennai	Member
28.	Dr. Indira Nath, INSA Senior Scientist.	Member
29.	President, CII	Member

30.	Prof. Anand Patwardhan, Executive Director, TIFAC	Member
31.	Dr. S.K. Sikka, Scientific Secretary to PSA to GOI	Member Secretary
32.	Shri S. Chatterjee, Adviser, Office of PSA to GOI	Convenor

II. Terms of Reference

1. To evolve a vision and develop an approach for Science and Technology for the Eleventh Five year Plan in the light of global developments and our country's needs.

2. To make an analytical assessment (SWOT) of the performance of schemes/ programmes pursued by Central S&T Departments.

3. To identify thrust areas for the Eleventh Five Year Plan and suggest their *inter-se* priorities.

4. To suggest ways by which inter-agency and inter-institutional collaborations are leveraged for higher efficiencies and better outcomes.

5. To suggest means of catalyzing Industry-Academia collaborations for development, application and flow of technologies from lab to the market place and for the industry to invest more in strengthening national level S&T infrastructure.

6. To recommend strategies for developing high quality S&T human resource including attracting the bright to a rewarding career in science.

7. To suggest strategies for expanding and strengthening societal applications of technologies for improving the quality of life of the Indian population.

8. To suggest measures for kindling innovative spirit so that scientists translate R&D leads into scalable technologies which yield wealth generating products and processes.

9. To identify areas of international S&T cooperation/collaboration and setting up of world class R&D facilities in the country with participation from other countries.

10. To suggest parameters for scientific audit and performance measurement of scientists and scientific institutions to inject efficiencies and maximize impacts.

11. To suggest plans and programmes for the various Central S&T Departments based on the policy, vision, approach, thrust and priorities of the S&T Sector. These should take into consideration the concept of Zero-based budgeting, convergence of ongoing schemes, weeding out of the schemes which are no-longer relevant and completion of ongoing schemes on a priority basis. To suggest an optimum outlay for the S&T sector, comprising of the on-going commitment and new programmes proposed to be undertaken.

III. The Chairman may constitute Working Groups/Sub-groups as considered necessary and co-opt members for specific inputs.

IV. The expenditure on TA / DA in connection with the meetings of the Steering Committee in respect of the official members will be borne by their respective Ministry / Department. However, in the case of non-official members, they will be entitled for TA / DA as admissible to Grade-I Officials of the Government of India and the expenditure in this regard would be met by the Planning Commission.

V. The Secretariat support for the Steering Committee meetings would be provided by the Office of the PSA / Technology Information, Forecasting and Assessment Council (TIFAC).

VI. The Steering Committee would submit its report before 31st August, 2006.

2. Working Groups

i) Department of Atomic Energy (R&D Sector)

Composition

1.	Dr. Anil Kakodkar, Secretary, Department of Atomic Energy, Mumbai.	Chairman
2.	Dr. Srikumar Banerjee, Director, Bhabha Atomic Research Centre, Trombay, Mumbai.	Member
3.	Mr. S.K. Sharma, Chairman, Atomic Energy Regulatory Board, Mumbai.	Member
4.	Dr. P. Ramarao,Chairman, Board of Research in Nuclear Sciences, Department of Atomic Energy, Mumbai.	Member
5.	Dr. Praveen Chaddah, Director, UGC-DAE Consortium for Scientific Research, Indore.	Member
6.	Prof. P. Balaram, Director, Indian Institute of Science, Bangalore.	Member
7.	Dr. R.B. Grover, Director, SPG, Department of Atomic Energy, Mumbai.	Member
8.	Prof. Ashok Mishra, Director, Indian Institute of Technology, Bombay, Mumbai.	Member
9.	Prof. J.B. Joshi, Director, University Institute of Chemical Technology, Mumbai.	Member
10.	Dr. Baldev Raj, Director, Indira Gandhi Centre for Atomic Research (IGCAR), Kalapakkam.	Member
11.	Shri K.A. Dinshaw, Director, Tata Memorial Centre, Mumbai.	Member
12.	Prof. Sabyasachi Bhattacharya, Director, Tata Institute of Fundamental Research, Mumbai.	Member
13.	Dr. Bikash Sinha, Director, Saha Institute of Nuclear Physics, Variable Energy Cyclotron Centre, Kolkata.	Member
14.	Dr. C.V. Ananda Bose, Joint Secretary (R&D), Department of Atomic Energy, Mumbai.	Member
15.	Representative, Department of Science & Technology	Member

16.	Representative, M/o Information & Technology	Member
17.	Representative, Indian Council of Medical Research	Member
18.	Representative, CSIR	Member
19.	Representative, UGC	Member
20.	Shri Arun Srivastava, SPG, Department of Atomic Energy, Mumbai.	Member Secretary

Terms of Reference

1. To review and assess the progress made by the various constituent units and grant-in-aid institutes of DAE during the Tenth Five Year Plan identifying the achievements, weaknesses/shortfalls and gap areas.
2. To suggest plans and programmes of the various constituent units and grant-in-aid institutes of DAE based on the policy, approach, thrust and priorities for the Eleventh Five Year Plan taking into consideration convergence of various ongoing schemes including weeding out of the schemes which are no longer relevant and completion of ongoing schemes on a priority basis and also to suggest an optimum outlay for the R&D Sector, comprising, the ongoing commitment and new programmes proposed to be undertaken, keeping in view the overall resource position in the country.
3. The Chairman may co-opt members for specific task.
4. The expenditure on TA/DA in connection with meetings of this group would be met by the concerned department.
5. The report of the Group would be submitted by 15th July, 2006.

ii) Department of Bio-technology

Composition

1.	Dr. M.K. Bhan, Secretary, Department of Biotechnology, Block New Delhi.	Chairman
2.	Prof. G. Padmanaban, Emeritus Scientist & Honorary Prof., IISc., Bangalore.	Co-Chairman
3.	Prof. P.N. Tandon, Former INSA President, Delhi.	Member
4.	Dr. K. Vijay Raghavan, Director, National Centre for Biological Sciences, Bangalore.	Member
5.	Dr. E.A. Siddiq, Emeritus Professor, Hyderabad.	Member
6.	Dr. S. Nagarajan, Chairperson, Protection Plant Variety Farms Rights Authority, New Delhi.	Member
7.	Dr. R.P. Sharma, IARI, Ex-Director, NRC on Plant Bio-technology, New Delhi.	Member
8.	Prof. Akhilesh Tyagi, Professor & Director (ICPG), Deptt. of Plant Molecular Biology, Inter-Disciplinary Centre for Plant Genomics, University of Delhi, Delhi.	Member

9. Dr. P.S. Ahuja, Institute of Himalayan Bio-resource Technology, Palampur. Member

10. Dr. P.N. Bhat, Ex-DDG, ICAR, New Delhi. Member

11. Dr. I. Karunasagar, National Professor, Karnataka Veterinary, Animal and Fisheries Sciences University, College of Fisheries, Mangalore. Member

12. Prof. K. Darmalingam, Head & Sr. Prof., Deptt. of Genetic Engg., School of Bio-technology, Madurai Kamaraj University, Madurai. Member

13. Prof. Alok Ray, IIT Delhi, Centre for Biomedical Engineering, New Delhi. Member

14. Dr. M.M. Sharma, Ex-Director, UICT, Mumbai. Member

15. Ms. Kiran Mazumdar Shaw, Chairman & Managing Director, Biocon Ltd., Bangalore. Member

16. Ms. Deepanwita Chattopadhyay, CEO, ICICI Knowledge Park, Hyderabad. Member

17. Dr. Usha Bharwhle, Mahyco Life Sciences Research Centre, JALNA (Maharashtra). Member

18. Sh. Sharad Naru, APIDC Venture Capital Ltd., Hyderabad. Member

19. Dr. Kameshwar Rao, Executive Secretary, Foundation for Bio-technology Awareness and Education, Bangalore. Member

20. Dr. S.R. Rao, Adviser, Department of Biotechnology, New Delhi. Member Secretary

Terms of Reference

1. To review and assess the progress made in the areas of Biotechnology through support to various programmes and activities during the 10th Five Year Plan, identifying the achievements, weaknesses/ shortfalls and gap areas., including those identified in the Biotechnology strategy.

2. To suggest plans and programmes to be taken up during the 11th Plan period based on the policy, approach, thrust and priorities of the Biotechnology sector, the new plans and schemes suggested should take into consideration convergence of various ongoing schemes schemes on a priority basis, closure/ merger of certain schemes based on new strategic & priorities and suggest an optimum outlay for the Biotechnology sector for the 11th Plan period.

3. The modalities of R&D funding, interagency linkages including public private partnership models may also be assessed and new strategies suggested for enhancing the growth of the sector.

4. The Chairman may co-opt members for specific task.

5. The expenditure on TA/DA in connection with meetings of this group would be met by the concerned department.

6. The report of the Group would be submitted by 15th July, 2006.

iii) Department of Ocean Development

Composition

1.	Dr. P.S. Goel, Secretary, Department of Ocean Development, New Delhi	Chairman
2.	Prof. U.R. Rao, Chairman, Physical Research Laboratory Council, Bangalore.	Member
3.	Dr. T. Ramasami, Secretary, Department of Science and Technology, New Delhi	Member
4.	Dr. H.K. Gupta, Ex-Secretary, Department of Ocean Development, Hyderabad.	Member
5.	Prof. B.L. Deakshatulu, Former Director NRSA and UNCSSET-AP, Secunderabad.	Member
6.	Prof. M. Ravindran, Ex. Director, National Institute of Ocean Technology, Chennai.	Member
7.	Dr. Dev Raj Sikka, Ex-Dir., IITM, Delhi	Member
8.	Prof. V.S. Raju, Ex-.Dir., Indian Institute of Technology DelhiHyderabad.	Member
9.	Dr. S.A.H. Abidi, Ex. Director, CIFE, Lucknow.	Member
10.	Dr. B.N. Goswami, Director, Indian Institute of Tropical Meteorology, Pune.	Member
11.	Shri M.S. Nagar, Ex-CMD, Indian Rare Earths Limited, New Delhi.	Member
12.	Dr. Satish R. Shetye, Director, National Institute of Oceanography, Goa.	Member
13.	Dr. Somvansi, Director General, Fishery Survey of India, Mumbai.	Member
14.	Dr. V. Chander, Director, National Physical and Oceanographic Laboratory, Kochi.	Member
15.	Dr. V. Rajagopalan, Chairman, Central Pollution Control Board, Delhi.	Member
16.	Dr. Ganpat S. Roonwal, Department of Geology, University of Delhi.	Member
17.	Dr. C.M. Gupta, Director, Central Drug Research Institute, Lucknow.	Member
18.	Shri S.K. Das, Adviser, Deptt. of Ocean Development, New Delhi.	Member-Secretary

Terms of Reference

1. To review the Xth Five Year Plan achievements vis-à-vis the objectives and carry out a SWOT analysis.
2. To examine Departmental policy aspects and long term profile.
3. To formulate programmes for XIth Five Year Plan, both for ongoing and new initiatives including mega programmes and societal applications.
4. To finalize programmatic activities and budgetary requirements.
5. The Chairman may co-opt members for specific task.

6. The expenditure on TA/DA in connection with meetings of this group would be met by the concerned department.

7. The report of the Group would be submitted by 15th July, 2006.

iv) Council of Scientific Research & Industrial Research (CSIR)

Composition

1.	Dr. R.A. Mashelkar, Secretary, Deptt. of Scientific and Industrial Research & DG-CSIR, New Delhi	Chairman
2.	Dr. V. Sumantran, Consultant Advisor, Chennai.	Member
3.	Dr. A.S. Abhiraman, Executive Director, Hindustan Lever Ltd. Research Centre, Mumbai.	Member
4.	Dr. Sudershan Arora, President, NCE-Research, Lupin Ltd., Pune	Member
5.	Mr. Sujit Banerjee, President (Polymer), Reliance Industries Ltd., Mumbai.	Member
6.	Dr. Seyed E Hasnain, Vice Chancellor, University of Hyderabad, Hyderabad	Member
7.	Prof. Ashok Mishra, Director, Indian Institute of Technology Bombay, Mumbai	Member
8.	Dr. Ashok Jhunjhunwala, Professor, Indian Institute of Technology Madras, Chennai.	Member
9.	Prof. Deepak Pental, Vice Chancellor, University of Delhi, Delhi	Member
10.	Prof. R. Kumar, Honorary Professor, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore	Member
11.	Dr. P. Ramarao, Ex Secretary, Deptt.of Science & Technology, Ex Vice Chancellor, Hyderabad University, Hyderabad	Member
12.	Dr. N.K. Ganguly, Director General, Indian Council of Medical Research, New Delhi	Member
13.	Prof. S. Bhattacharya, Director, Tata Institute of Fundamental Research (TIFR), Mumbai	Member
14.	Dr. T. Ramasami, Secretary, DST, New Delhi.	Member
15.	Prof. S.K. Brahmachari, Director, Institute of Genomics and Integrative Biology, Delhi	Member
16.	Dr. Vikram Kumar, Director, National Physical Laboratory, New Delhi	Member
17.	Dr. S. Sivaram, Director, National Chemical Laboratory, Pune	Member
18.	Prof. S.P. Mehrotra, Director, National Metallurgical Laboratory, Jamshedpur	Member
19.	Dr. Satish R. Shetye, Director, National Institute of Oceanography (NIO), Goa.	Member
20.	Dr. N. Ramakrishnan, Director, Regional Research Laboratory, Bhopal	Member

21. Dr. Rakesh Tuli, Scientist G, National Botanical Research Institute, Lucknow. Member

22. Mrs. Rama Murali, Financial Adviser, Council of Scientific and Industrial Research, New Delhi. Member

23. Dr. Naresh Kumar, Head R&D Planning Division, Council of Scientific and Industrial Research, New Delhi Member Convenor

Terms of Reference

1. To review and assess the progress made by CSIR during the 10th Plan identifying the achievements and shortfalls if any;

2. To suggest strategies & approach for the Eleventh Plan keeping in view the national S&T perspective and R&D priorities;

3. To help plan programmes/ projects in network mode driven by synergy of CSIR system to deliver tangible outputs & outcomes;

4. To identify Supra-institutional projects for each laboratory/ institute as flagship projects and dovetail other activities with national S&T Programmes;

5. To identify few major world class national facilities to be created to address the critical requirement of S&T sectors; and

6. To estimate resource requirement – Plan & Non Plan based on Zero Based Budgeting (ZBB) from the government budgetary support and also supplement the same from external earnings.

7. The Chairman may co-opt members for specific task.

8. The expenditure on TA/DA in connection with meetings of this group would be met by the concerned department.

9. The report of the Group would be submitted by 15th July, 2006.

v) Department of Space

Composition

1. Dr. G. Madhavan Nair, Secretary, Department of Space, Bangalore. Chairman

2. Dr. P.S. Goel, Secretary, Department of Ocean Development, New Delhi. Member

3. Smt. Radha Singh, Secretary, Deptt. of Agriculture and Co-operation, Ministry of Agriculture, New Delhi. Member

4. Dr. J.S. Sarma, Secretary, Deptt. of Telecommunications. Member

5. Dr. R.R. Navalgund, President ISRS & Director, Space Application Centre, Ahmedabad. Member

6.	Prof. J.N. Goswami, Director, Physical Research Laboratory, Ahmedabad.	Member
7.	Prof. P. Venkatarangan, Vice Chancellor, Amrita Vishwa Vidyapeetham, Deemed University, Coimbatore.	Member
8.	Prof. M.S. Ananth, Director, Indian Institute of Technology, Chennai.	Member
9.	Sh. Kiran Karnik, President, National Association of Software and Service Companies, New Delhi.	Member
10.	Sh. N. Sitaram, Distinguished Scientist/ Chief Controller (ECS), DRDO, Ministry of Defence, New Delhi.	Member
11.	Lt.Gen. H.S. Lidder, UISM YSM CSM, Chief Integrated Stock Committee (CISC),HQ Integrated Defense Staff, Ministry of Defence, New Delhi.	Member
12.	Shri B. Lal, Director-General of Meteorology, India Meteorological, Department, New Delhi.	Member
13.	Dr. A.K. Bohra, Director, NCMRWF, New Delhi	Member
14.	Major M. Gopal Rao, Surveyor-General, Survey of India, Dehradun.	Member
15.	Sh. P.G. Dhar Chakraborthy, ED, National Institute of Disaster Management, Ministry of Home Affairs, New Delhi.	Member
16.	Sh. V.S. Sampath, Director-General, National Institute of Rural Development, Hyderabad.	Member
17.	Dr. A.K. Singh, Director, Institute of Agricultural Research, New Delhi.	Member
18.	Sh. R. Jayasheelan, Chairman, Central Water Commission, New Delhi.	Member
19.	Director, Town and Country Planning Commission, New Delhi.	Member
20.	Sh. P.S. Thangkhiew, Planning Advisor, North East Council Secretariat, Shillong.	Member
21.	Prof. Pramod Tandon, Vice Chancellor, North-Eastern Hill University, Shillong.	Member
22.	Sh. M.K. Prasad, Addl. DG, Forests, Ministry of Environment and Forests, New Delhi.	Member
23.	Sh. R.R. Prasad, Chief Engineer (Project), All India Radio, New Delhi.	Member
24.	Sh. M.C. Agrawal, Chief Engineer, Directorate General, Doordarshan, New Delhi.	Member
25.	Sh. A.K. Chaturvedi, Adviser (HRD), Telecom, Department of Telecommunications, New Delhi.	Member
26.	Sh. Ajit Singh, Pr. General Manager (Operations), O/o Chief General Manager, Ahmedabad.	Member
27.	Sh. Sunil Kumar, Joint Secretary, HRD, New Delhi.	Member
28.	Sh. Deepak Gupta, Addl. Secretary, Deptt. of Health and Welfare, New Delhi.	Member

29.	Sh. Ashok Bhaweja, Chairman and Managing Director, Hindustan Aeronautics Ltd., Bangalore.	Member
30.	Dr. V. Sundararamaiah, Scientific Secretary, Department of Space, Bangalore.	Member Secretary

Terms of Reference

1. To review and assess the progress made during the Tenth Five Year Plan (2002-2007) identifying the achievements, weaknesses/ shortfalls and gap areas.
2. To suggest plans and programmes for the Eleventh Five Year Plan 2007-12 including thrust areas.
3. To suggest an optimum outlay for the Eleventh Plan keeping in view the overall resource position in the country.
4. The Chairman may co-opt members for specific task.
5. The expenditure on TA/DA in connection with meetings of this group would be met by the concerned department.
6. The report of the Group would be submitted by 15th July, 2006.

vi) Department of Science & Technology

Composition

1.	Dr. T. Ramasami, Secretary, Department of Science & Technology.	Chairman
2.	Prof. M.R.S. Rao, JNCASR, Bangalore.	Member
3.	Prof. M. Vijayan, Honorary Professor/ Distinguished Biotechnologist, IISc., Bangalore.	Member
4.	Ms. Swati Piramal, Nicolas Piramal India Ltd., Mumbai.	Member
5.	Prof. A.K. Sood, IISc., Bangalore.	Member
6.	Dr. T.K. Chandrasekhar, Professor & Director, Department of Chemistry, Regional Research Laboratory (RRL), Trivandrum.	Member
7.	Dr. G. Sundararajan, Director, International Advanced Research Centre for Powder Metallurgy and New Materials, Hyderabad.	Member
8.	Dr. S.P. Sukhatme, Former Chairman, Atomic Energy Regulatory Board, Mumbai.	Member
9.	Dr. Harsh K. Gupta, Former Secretary, Department of Ocean Development, Hyderabad.	Member
10.	Dr. V. Sumantran, Consultant Advisor, Chennai.	Member
11.	Dr. S.K. Joshi, Vikram Sarabhai Professor, NPL, New Delhi	Member

12.	Dr. Kota Harinarayan, Emeritus Scientist, NAL, Bangalore.	Member
13	Dr. Anand Patwardhan, Executive Director, TIFAC, New Delhi	Member
14.	Mr. Jayasimha Sriram, Signion Systems Pvt. Ltd., Hyderabad.	Member
15.	Mr. D. Raghunandan, Centre for Technology Development, New Delhi.	Member
16.	Shri H.K.Mittal, Adviser, DST, New Delhi	Member Secretary

Terms of Reference

1. To review and assess the progress made by the various Central S&T Departments/ Agencies during the Tenth Five Year Plan identifying the achievements, weaknesses/ shortfalls and gap areas.
2. To suggest plans and programmes of the various Central S&T Departments/ Agencies based on the policy, approach, thrust and priorities of the S&T Sector for the Eleventh Five Year Plan taking into consideration the concept of Zero-based budgeting, convergence of various ongoing schemes including weeding out of the schemes which are no longer relevant and completion of ongoing schemes on a priority basis and also to suggest an optimum outlay for the S&T Sector, comprising, the ongoing commitment and new programmes proposed to be undertaken, keeping in view the overall resource position in the country.
3. The Chairman may co-opt members for specific task.
4. The expenditure on TA/DA in connection with meetings of this group would be met by the concerned department.
5. The report of the Group would be submitted by 15th July, 2006.

vii) Attracting and Retaining Young People to Careers in Science and Technology

Composition

1.	Dr. S.K. Joshi, Vikram Sarabhai Professor, NPL, New Delhi and Dr.R. Natarajan, Former Chairman, AICTE	Co-Chairmen
2.	Prof. N. Satyamurthy, IIT, Kanpur	Member
3.	Prof. J. Sashidhar Prasad, VC, University of Mysore	Member
4.	Dr. R. Pillai, Dy Chairman, UGC, New Delhi	Member
5.	Prof. N. Mukunda, IISc, Bangalore	Member
6.	Dr. P. Chaddah, Director, IUCDIF, Indore	Member
7.	Prof. Vijay Khole, VC, University of Bombay	Member
8.	Prof. Deepak Pental, Vice Chancellor, Delhi University, Delhi.	Member
9.	Dr. Arvind Kumar, Director, Homi Bhaba Centre for Science Education, Mumbai	Member Secretary

Terms of Reference

1. To evolve S&T manpower development strategies for attracting and retaining highly talented persons in science and technology. In particular to suggest measures for attracting talented students to remain in science at 10+2 level, and for encouraging the best students among science/ technology graduates to opt for research and development.

2. To suggest steps to improve the quality of undergraduate, post-graduate education and research in universities.

3. Recommendations already made by other recent reports/ initiatives i.e. (SAC-C report by Prof. Mukunda, et al; March 31, 2005 seminar of the Office of PSA and the follow-up, UGC report, etc.), may be the starting point for discussions.

4. To suggest ways to decouple the remuneration structure for outstanding researchers/ faculty members from the prevailing government/ UGC scales of pay with the aim to establish some parity with the compensations in private/ MNC R&D organizations.

5. To consider any other important and relevant item.

6. To indicate approximate financial outlay for implementation of the recommendations.

7. The Co-Chairmen may co-opt other members, if required.

8. The expenditure on TA/DA in connection with the meetings of the Working Group in respect of the official members will be borne by their respective Ministry/ Department. However, in the case of non-official members, they will be entitled for TA/DA as admissible to Grade-I Officials of the Government of India and the expenditure in this regard would be met by the Planning Commission.

9. The Working Group would submit its report by 15th July, 2006.

viii) Thrust Areas in Basic Sciences

Composition

1.	Prof. T.V. Ramakrishnan, President, Indian Academy of Sciences and Prof. P. Balaram, Director, IISc, Bangalore	Co- Chairmen
2.	Prof. S. Bhattacharyya, Director, TIFR, Mumbai	Member
3.	Prof. G.R. Desiraju, University of Hyderabad, Hyderabad	Member
4.	Prof. R. Balasubramanian, Director, The Institute of Mathematical Sciences, Chennai.	Member
5.	Dr. R.K. Sinha, Director, RDDG,BARC, Mumbai	Member
6.	Prof. M.S. Valiathan, National Research Professor, Manipal Academy of Higher Education, Karnataka	Member

7.	Dr. K.B. Sainis,Director, Bio-Medical Group, BARC,Mumbai	Member
8.	Prof. Rajiv Raman, Department of Zoology, BHU	Member
9.	Prof. Devang Thakkar, Department of Chemical Engg, IIT Bombay	Member
10.	Prof. Ajay Sood, IISc, Bangalore	Member Secretary

Terms of Reference

1. To suggest a 5 to 10 year road map relating to emerging/ frontier areas in science in which research should be encouraged.

2. To suggest mechanisms for the linkages between basic research and its applications in cutting-edge technology-related areas (e.g. nano-technology).

3. To suggest mechanisms for enhancing cooperation between Mission oriented Departments/ National Laboratories and Universities.

4. To suggest infrastructure improvements in the short and long term, particularly in the university system.

5. To consider any other important and relevant item.

6. To indicate approximate financial outlay for implementation of the recommendations.

7. The Co-Chairmen may co-opt other members, if required.

8. The expenditure on TA/DA in connection with the meetings of the Working Group in respect of the official members will be borne by their respective Ministry/ Department. However, in the case of non-official members, they will be entitled for TA/DA as admissible to Grade-I Officials of the Government of India and the expenditure in this regard would be met by the Planning Commission.

9. The Working Group would submit its report by 15th July, 2006.

ix) Mega-Science Projects

Composition

1.	Dr. Anil Kakodkar, Secretary, DAE, Mumbai	Chairman
2.	Dr. T. Ramasami, Secretary, DST, New Delhi	Member
3.	Dr. M.K. Bhan, Secretary, DBT, New Delhi	Member
4.	Dr. P.K. Kaw, Director, Institute of Plasma Research, Gandhinagar	Member
5.	Dr. B.C. Sinha, Director, Saha Institute of Nuclear Physics, Kolkata	Member

6. Dr. R. Nityanand, Director, National Centre for RadioAstrophysics, Pune — Member
7. Prof. Rohini Godbole, IISc, Bangalore — Member
8. Dr. R.B. Grover, Director, SPG, DAE, Mumbai — Member Secretary

Terms of Reference

1. To suggest Mega Science & Technology Projects which may be taken up during the next 5 years.
2. To identify the institutions/ research laboratories/ universities and other partners who would be the key stakeholders in these projects.
3. To recommend the infrastructure requirement for these projects.
4. To propose the steps needed for inter-agency collaboration for implementation of these Mega Science projects.
5. To consider any other important and relevant item.
6. To indicate approximate financial outlay for implementation of the recommendations.
7. The Chairman may co-opt other members, if required.
8. The expenditure on TA/DA in connection with the meetings of the Working Group in respect of the official members will be borne by their respective Ministry/ Department. However, in the case of non-official members, they will be entitled for TA/DA as admissible to Grade-I Officials of the Government of India and the expenditure in this regard would be met by the Planning Commission.
9. The Working Group would submit its report by 15th July, 2006.

x) Cross Disciplinary Technology Areas

Composition

1. Dr. Baldev Raj, Director, IGCAR, Kalpakkam and Prof. M.S. Ananth, Director,IIT, Madras — Co-Chairmen
2. Dr. P.S. Goel, Secretary, DOD, New Delhi — Member
3. Dr. P. Venkatrangan, VC, Amrita Vidyapeeth, Coimbatore — Member
4. Dr. S. Sivaram, Director, NCL, Pune — Member
5. Prof. Ashok Jhunjhunwala, IIT, Madras — Member
6. Dr. P.K. Tiwari, Head, Desalination Division, BARC, Mumbai — Member
7. Dr. G.S. Bhubaneswar, Sree Chitra Tirunal Institute for Medical Science & Technology, Thiruvanthapuram — Member

8.	Dr. V. Prakash, Director, CFTRI, Mysore	Member
9.	Dr. Indira Nath, Blue Peter Research Centre, LEPRA Society Hyderabad.	Member
10.	Shri K.V.S.S. Prasad Rao, Chairman, NTRO, New Delhi	Member
11.	Sh. B.N. Suresh, Director, Vikram Sarabhai Space Centre, Trivandrum	Member
12.	Dr. P.S. Dhekne, Head, Computer Division, BARC, Mumbai	Member
13.	Dr. C.S. Sunder, Head, MSL, IGCAR, Kalpakkam	Member Secretary

Terms of Reference

1. To identify important cross disciplinary technology sectors which should be focused upon.
2. To evolve a road map for research, development and delivery in important cross-disciplinary areas during the next 5 years.
3. To consider any other important and relevant item.
4. To indicate approximate financial outlay for implementation of the recommendations.
5. The Co-Chairmen may co-opt other members, if required.
6. The expenditure on TA/DA in connection with the meetings of the Working Group in respect of the official members will be borne by their respective Ministry/ Department. However, in the case of non-official members, they will be entitled for TA/DA as admissible to Grade-I Officials of the Government of India and the expenditure in this regard would be met by the Planning Commission.
7. The Working Group would submit its report by 15th July, 2006.

xi) Leveraging International Collaboration Inputs

Composition

1.	Prof. V.S. Ramamurthy, Formerly Secretary, DST, New Delhi	Chairman
2.	Dr. S. Natesh, Sr. Advisor, Deptt.of Bio-technology, New Delhi	Member
3.	Dr. S. Kailas, Associate Director, Physics Group, BARC, Mumbai	Member
4.	Dr. Rajeev Lochan, Assistant Scientific Secretary, ISRO, Bangalore	Member
5.	Shri S.K. Das, Adviser, Deptt. of Ocean Development, New Delhi	Member
6.	Dr. Naresh Kumar, Head R&D Planning Division, CSIR, New Delhi	Member
7.	Prof. Ashok Mishra, Director, IIT, Bombay	Member
8.	Prof. Akhilesh Tyagi, Delhi University, Delhi	Member
9.	Dr. Y.P. Kumar, Adviser, DST, New Delhi	Member Secretary

Terms of Reference

1. To identify important areas of international S&T collaboration/ cooperation consistent with ongoing national research and development efforts.
2. To suggest measures for greater and more effective use of major international facilities abroad.
3. To establish synergy between different institutions/ departments having international collaborative programmes.
4. To consider any other important and relevant item.
5. To indicate approximate financial outlay for implementation of the recommendations.
6. The Chairman may co-opt other members, if required.
7. The expenditure on TA/DA in connection with the meetings of the Working Group in respect of the official members will be borne by their respective Ministry/ Department. However, in the case of non-official members, they will be entitled for TA/DA as admissible to Grade-I Officials of the Government of India and the expenditure in this regard would be met by the Planning Commission.
8. The Working Group would submit its report by 15th July, 2006.

xii) Strengthening Academia Industry Interface (including Public Private Partnership

Composition

1.	Dr. R.A. Mashelkar, DG, CSIR, New Delhi	Chairman
2.	Shri R. Seshasayee, President CII, Chennai	Member
3.	Dr. V. Sumantran, Consultant Advisor, Chennai.	Member
4.	Prof. S. Mohan, C.E.O., SID, IISc., Bangalore	Member
5.	Dr. J.B. Joshi, Director, University Department of Chemical Technology, University of Bombay, Mumbai	Member
6.	Dr. G. Sundararajan, Director, International Advanced Research Centre for Powder Metallurgy and New Materials (ARC-I), Hyderabad	Member
7.	Dr. S.A.Bhardwaj, Director (Technical), NPCIL, Mumbai	Member
8.	Prof. Damodar Acharya, Chairman, AICTE, New Delhi	Member
9.	Prof. S.G. Dhande, Director, IIT Kanpur	Member
10.	Prof. Ashok Jhunjhunwala, IIT, Madras	Member
11.	Dr. Satish Kaura, CMD, Samtel, New Delhi	Member
12.	Prof. Anand Patwardhan, ED, TIFAC, New Delhi	Member Secretary

Terms of Reference

1. To suggest a suitable mechanism for increased participation of industry in scientific research and technological development.

2. To evolve a strategy for strengthening the interface between industry, R&D institutions and the academia for need based research.

3. To identify key sectors in which such participation could be possible in the next 5 years and also identify, wherever possible, partners who can be involved in such collaborative programmes.

4. To suggest methods to increase the spending by industry on R&D.

5. To suggest a mechanism for sharing equitably the IPR of such research outputs between the academia / research laboratories and the industry.

6. To consider any other important and relevant item.

7. To indicate approximate financial outlay for implementation of the recommendations.

8. The Chairman may co-opt other members, if required.

9. The expenditure on TA / DA in connection with the meetings of the Working Group in respect of the official members will be borne by their respective Ministry / Department. However, in the case of non-official members, they will be entitled for TA / DA as admissible to Grade-I Officials of the Government of India and the expenditure in this regard would be met by the Planning Commission

10. The Working Group would submit its report by 15th July, 2006.

xiii) Science & Technology for SMEs

Composition

1.	Dr. P. Rodriguez, Ex-Director, IGCAR, Kalpakkam	Chairman
2.	Shri Anupam Dasgupta, Secretary, Small & Medium Industries, New Delhi or his nominee	Member
3.	Prof. Anand Patwardhan, ED, TIFAC, New Delhi	Member
4.	Shri H.K.Mittal, Adviser, DST, New Delhi	Member
5.	Dr. Sarita Nagpal, Adviser, CII, Gurgaon	Member
6.	Dr. T. Karunakaran, Vice Chancellor, Gandhigram University	Member
7.	Shri Neeraj Saxena, Scientist 'D', TIFAC, New Delhi	Member Secretary

Terms of Reference

1. To suggest effective methods to promote innovation in the sector of SMEs.
2. To suggest a system for providing institutional support for encouraging innovation and successful commercialization thereafter.
3 To suggest a system for providing special support, both technical and financial to innovators to set up enterprises.
4. To consider any other important and relevant item.
5. To indicate approximate financial outlay for implementation of the recommendations.
6. The Chairman may co-opt other members, if required.
7. The expenditure on TA/DA in connection with the meetings of the Working Group in respect of the official members will be borne by their respective Ministry/ Department. However, in the case of non-official members, they will be entitled for TA/DA as admissible to Grade-I Officials of the Government of India and the expenditure in this regard would be met by the Planning Commission
8. The Working Group would submit its report by 15th July, 2006.

xiv) Effective Rural Technology Delivery (including partnership with Voluntary Organizations)

Composition

1.	Dr. R. Chidambaram, PSA	Chairman
2.	Dr. Anil P. Joshi, HESCO, Dehradun	Member
3.	Shri M.R. Rajagopalan, Gandhigram Trust, Gandhigram	Member
4.	Shri D. Raghunandan, CTD, New Delhi	Member
5.	Shri P.M. Tripathi, President, AVARD, New Delhi	Member
6.	Dr. Panjab Singh, VC, BHU, Varanasi	Member
7.	Dr. T. Ramasami, Secretary, DST, New Delhi.	Member
8.	Dr. Mihir Shah, Samaj Pragati Sahayog, Dewas,Madhya Pradesh	Member
9.	Prof. Dayanand Dongaonkar, Secretary-General, Association of Delhi University, New Delhi	Member
10.	Shri S. Chatterjee, Adviser, Office of PSA to GOI	Member Secretary

Terms of Reference

1. To suggest effective modes of technology delivery from R&D laboratories/ S&T institutions to rural areas.
2. To suggest a standard mechanism/ system for providing institutional support to the voluntary organizations for demand driven technology up-gradation.

3. To identify special programmes for application of S&T for improving the quality of life of the rural people, particularly of the weaker sections and women in the rural population.

4. To suggest possible methods for accelerating the process of rural industrialization involving S&T institutions as technology providers and also for providing technology back up.

5. To suggest a mechanism for mobilizing resources from various line function Government Departments/ Ministries for such large-scale replication.

6. To consider any other important and relevant item.

7. To indicate approximate financial outlay for implementation of the recommendations.

8. The Chairman may co-opt other members, if required.

9. The expenditure on TA/DA in connection with the meetings of the Working Group in respect of the official members will be borne by their respective Ministry/ Department. However, in the case of non-official members, they will be entitled for TA/DA as admissible to Grade-I Officials of the Government of India and the expenditure in this regard would be met by the Planning Commission

10. The Working Group would submit its report by 15th July, 2006.

xv) S&T in Socio-Economic Ministries/ Departments and State S&T Councils

Composition

1.	Dr. R.A. Mashelkar, DG, CSIR, New Delhi (and Chairman STAC)	Chairman
2.	Dr. T. Ramasami, Secretary DST and Chairman IS-STAC, New Delhi	Member
3.	Dr. A.E. Muthunayagam, Chairman State S&T Council, Kerala	Member
4.	Chairman, State S&T Council, Punjab	Member
5.	Dr. H.R. Bhojwani, Adviser to Minister (Science & Technology & O.D)	Member
6.	Shri H.C. Gupta (Secretary, Deptt. of Coal), Chairman, STAC, Ministry of Coal and Mines.	Member
7.	Dr. Mano Ranjan, Secretary, Ministry of Steel and Chairman, STAC	Member
8.	Shri A.K.D. Jadhav, Secretary, Ministry of Mines and Chairman, STAC	Member
9.	Dr. P. Rama Rao, Formerly Secretary, DST, New Delhi	Member
10.	Dr. P. Ramachandra Rao, Formerly Vice Chancellor BHU and Director, Inst. of Armament Technology, Ministry of Defence DRDO, Pune	Member
11.	Dr. (Mrs.) Malti Goel, Adviser and Head, STAC, DST	Member Secretary

Terms of Reference

1. To consider and suggest measures for better integration of S&T in government development programmes;

2. To suggest ways of implementation of National S&T Policy recommendation that the Socio-Economic Ministries would spend 2% of their budget on S&T appropriate to their needs;

3. To suggest measures to enhance support, physical and financial, to State S&T Councils, to enhance their reach for S&T to the people;

4. To indicate approximate financial outlay for implementation of recommendations;

5. The Chairman may co-opt other members, if required.

6. The expenditure on TA/DA in connection with the meetings of the Working Group in respect of the official members will be borne by their respective Ministry/ Department. However, in the case of non-official members, they will be entitled for TA/DA as admissible to Grade-I Officials of the Government of India and the expenditure in this regard would be met by the Planning Commission.

7. The Working Group would submit its report by 15th July, 2006.

xvi) Policies, Administrative Changes for Improvement in S&T Research Environment and Resources

Composition

1.	Dr. R. Chidambaram, PSA to GOI	Chairman
2.	Prof. P. Rama Rao, Ex-Secretary, Deptt.of Science & Technology, Ex-Vice Chancellor, Hyderabad University	Member
3.	Dr. T. Ramasami, Secretary, DST, New Delhi	Member
4.	Shri L.K. Joshi, Secretary, DOPT, New Delhi	Member
5.	Dr. Sanjiv Misra,Secretary, Department of Expenditure, New Delhi	Member
6.	Dr. Sukhadeo Thorat, Chairman, UGC, New Delhi	Member
7.	Dr. Mahtab S. Bamji, Emeritus Scientist, Dangoria Charitable Trust, Hyderabad	Member
8.	Prof. Prabuddha Ganguli, IPR Specialist and Adjunct Prof. School of Humanities, IIT, Mumbai	Member
9.	Dr. V. Rao Aiyagari, Adviser & Head (SERC), DST, New Delhi.	Member Secretary

Terms of Reference

1. To identify the organizational and administrative hurdles in the Government which prevent optimal use of public R&D resources. (SAC-C report on organizational and administrative changes for optimal use of S&T resources and the recent SAC-PM initiative in this context may be the starting point for discussions).

2. To suggest measures to strengthen the S&T infrastructure and inter institutional linkages to help India become a knowledge based economy.

3. To consider any other important and relevant item.

4. The Chairman may co-opt other members, if required.

5. The expenditure on TA/DA in connection with the meetings of the Working Group in respect of the official members will be borne by their respective Ministry/ Department. However, in the case of non-official members, they will be entitled for TA/DA as admissible to Grade-I Officials of the Government of India and the expenditure in this regard would be met by the Planning Commission.

6. The Working Group would submit its report by 15th July, 2006.

xvii) Resources for the S&T Sector

Composition

1.	Dr. R. Chidambaram, PSA	Chairman
2.	Dr. T. Ramasami, Secretary, DST, New Delhi.	Member
3.	Dr. M. K. Bhan, Secretary, Department of Biotechnology, New Delhi.	Member
4.	Dr. P.S. Goel, Secretary, Department of Ocean Development, N. Delhi	Member
5.	Dr. Anil Kakodkar,Secretary, Department of Atomic Energy, Mumbai	Member
6.	Dr. G. Madhavan Nair, Secretary, Department of Space, Bangalore	Member
7.	Dr. R.A. Mashelkar, Secretary, Deptt. of Scientific and Industrial Research & DG-CSIR, New Delhi	Member
8.	Shri S. Chatterjee, Adviser, O/o Principal Scientific Adviser to the GOI, New Delhi	Member Secretary

Terms of Reference

1. To examine the proposed outlay of each S&T Department against the projected programmes.

2. To recommend resource outlay for the XIth Five Year Plan for the S&T sector.

3. The Chairman may co-opt other members, if required.

4. The expenditure on TA/DA in connection with the meetings of the Working Group in respect of the official members will be borne by their respective Ministry/ Department. However, in the case of non-official members, they will be entitled for TA/DA as admissible to Grade-I Officials of the Government of India and the expenditure in this regard would be met by the Planning Commission.

5. The Working Group would submit its report by 21st August, 2006.