Report of Steering Committee of

Science &Technology Departments/Agencies

for the Tenth Five Year Plan (2002-2007)

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EXECUTIVE SUMMARY

A Steering Committee on Science & Technology was constituted in November 2000 by the Planning Commission (Annexure 1) to evolve an Approach on S&T for the 10th Five year Plan and to suggest plans and programmes of various S&T sectors on the basis of an assessment of the progress made by them during the 9th Five Year Plan. It consisted of eminent scientists, technologists, educationists and social scientists representing various scientific agencies, professional bodies and industry. During its deliberations, the Steering Committee constituted 12 Working Groups, 6 of which are for the Central S&T Departments/Agencies and the remaining 6 for the areas, viz., Approach, Policy and Inter-se-priority; R&D–Academia-Industry Interface; International Cooperation in S&T; Science & Society; S&T Manpower Development and Review of the 9th Plan S&T Programmes. In preparing this report of the Steering Committee, recommendations of all the 12 Working Groups have been taken into consideration. The discussions have brought a clear focus that the emphasis for the S&T during the Tenth Plan Period should be much more on delivery of benefits to society and economy. Therefore specific core programmes, mission mode projects and special action programmes have been identified. The implementation of these programmes and projects will be on a multi institutional basis along with synergies with users and industries. The technological developments required for such an approach have been identified and briefly given in the relevant chapters of this report.

A number of milestones were achieved during the 9th Plan. The first successful flight of GSLV-D1, operationalisation of PSLV with the successful flight of PSLV-C1, the launches of IRS–1D, P4 (Oceansat) and TES, INSAT-2E and INSAT-3B are some of the significant achievements under space programme. Several areas related to nuclear energy and its applications were undertaken for the benefit of the society. The nuclear power programme has reached an advanced stage of implementation and R&D in this area has resulted in India mastering all aspects of this difficult technology. A number of new initiatives were taken up under biotechnology research with a view to harness the biological wealth for societal and economic benefit of the country. A programme on drug development was initiated as a collaborative R&D effort involving national laboratories, industries and academic institutions. Technology Development programmes were pursued through TDB, TIFAC, and Advanced Research Centre. In response to the new WTO regime, patent awareness was created by setting up a Patent Facilitating Centre in. The industrial production catalyzed by the National

Laboratories crossed Rs.17000 crores. This has been built up over a period of several years and represents the present cumulative value. The number of Indian and foreign patents filed by the National Laboratories are around 1400 and 650 respectively. A number of incentive programmes were initiated to attract the young talent to scientific research. As a result of reorientation and revamping of the ocean-related activities undertaken for the sustainable and environment friendly exploration and utilization of marine living and non-living resources, several socio-economic benefits accrued to the country. Nevertheless in several areas of scientific services and societal science, much more effort still needs to be mounted. The S&T efforts in industry, education and societal development were still lesser than what were needed. During the 10th Plan special measures should be taken in such areas and the efforts made during the 9th Plan whose results are promising intensified.

An important aspect which should be recognized during the 10th Plan is the emergence of a new situation in which comparative advantage in the globally integrated knowledge based world economy is shifting to those with brain power to observe, assimilate and adopt the spectacular developments in S&T and harness them for national growth. Accordingly, the S&T approach for the 10th Five Year Plan has to give a special thrust to S&T by leveraging on the strong infrastructural /institutional S&T framework built in India so far upto 9th Plan and put significant inputs of S&T during the 10th Plan on the delivery of technology for knowledge, economy and society in such a way that India could achieve competitive position in the new global economy through value addition to the indigenous resources. With this focus, efforts will be oriented to promote basic research, technology development and commercialisation through user driven missions/projects; generation of right kind of S&T manpower; and adoption of Zero based budgeting throughout the 10th Plan period. The ultimate objective of this Approach is to produce products and services which are competitive in the domestic and global markets vis-à-vis generation of wealth, achievement of speedier economic growth and giving quality of life to common man.

Within the framework of this S&T Approach, Indian industry has to play more important role than hitherto. This is all the more necessary from the point of view of R&D expenditure as a percentage of GNP reaching the target of 2% at the end of the 10th Plan. Fortunately today the Indian industry and S&T sector are favourably inclined towards each other. Industry should take advantage of this situation and by maintaining perpetual interface with

the academia, continuously upgrade its technologies quickly responding to market demands. To accelerate the velocity of R&D, certain industry sectors like : forestry based natural resources, pharma/biotechnology products, health care products etc. should be given priority.

Improving quality of life is one of the objectives of S&T during 10th Plan. For this, there is an urgent need to generate appropriate research output for the benefit of the society, especially the weaker sections and women and for the development of rural areas. To make an assessment as to whether the research output is leading towards progress and the desirable shift, constitution of Research Audit Cells comprising specialists, environmentalists, economists and representatives of the people and setting up of Common Facility Centres with self help groups and facilitators from government departments are advocated.

It has been estimated that India would need around 50,000 S&T work force during 10th Plan. In this context the important aspects that need special attention are : imparting of high quality science education; introducing appropriate incentives to attract the students to science stream; creation of a conducive atmosphere for the personnel to take science as a career; devising strategies to retain the best in active science; and involving corporate sector in science education and R&D.

In view of rapid globalization, fast depleting material resources, raising economic competition between nations and the growing need to protect intellectual property, it is essential to find cost effective approaches in international scientific collaborations through intensification of established mechanism, contacts and collaborative tie ups. Some new initiatives that may be suggested are : establishment of Centres of Excellence/international class facilities; intensification of cooperation with developing countries; formulation of programmes for attracting Indian researchers settled abroad to work in India; catalyzing technology development through establishment of joint R&D centres; ensuring the linkages for international collaboration with the national programmes etc.

In fulfilling the above obligations vis-à-vis R&D expenditure achieving the target of 2% of GNP, the Scientific Departments/Agencies will play a bigger role than in the previous plans. With the formidable built up in the past, DAE will move towards the goal of delivering 20,000 Mwe by around 2020 by, inter alia, taking up successful Fast Reactor Programme and an efficient Thorium Utilization Programme. With the broad vision to develop India as a major Space Faring Nation, DOS aims at acquiring new capabilities for Space Communications,

maintaining leadership in Earth Observation Systems, vis-à-vis supporting National Natural Resources Management System (NNRMS), Disaster Management System and strengthening Space Science Enterprise. The thrust of the programmes of DST will continue to be on the Basic Research, Technology Development, S&T Manpower Development, providing Scientific Services to the community and on those relevant to Societal needs. CSIR, through its network of 39 laboratories and 80 field centres will continue to provide a variety of scientific industrial research services in the areas such as : Aerospace, Biotechnology, Chemicals, Health Care, Housing etc. It seeks to partner strategically with Indian industry for innovative research, development of technology and its commercialisation.

For the developments in Biotechnology area, the underlying principle is that the biotechnology will have the greatest impact on human kind for their food, nutrition, health, environment and livelihood security. Besides research on Polar Science and continuing Antarctica Expeditions, DOD coordinates S&T programmes for the exploration of living, non-living and energy resources of the sea and protection and preservation of ocean environment.

As a part fulfillment of their broad mandate for the Scientific Agencies described above, they are expected to undertake the Mission Mode programmes in specific areas of S&T identified by the Steering Committee during its deliberations. The Mission mode concept which is multi-disciplinary and multi-institutional in nature includes active involvement of development departments wherever needed so that the results of such missions could be straightaway applied in the development process by the concerned departments.

In the implementation of the programmes to be undertaken during 10^{th} Plan, the S&T Departments, socio-economic Ministries and State Governments should work together to achieve the targets. On the basis of an assessment of the 10^{th} Plan requirements, Steering Committee has made recommendations on the investments and these should be made available during 10^{th} Plan, if S&T were to show its contribution in the socio-economic development of the country.

CHAPTER 1

APPROACH AND THRUST OF S&T DURING TENTH FIVE YEAR PLAN

1.1 Eventhough there have been shortfalls, limitations, and missed opportunities, India has made substantial progress in a number of areas - reasonably high rates of economic growth, considerable food security, substantially high average life expectancy, growing literacy rates, success in higher education etc. In bringing about these socio-economic changes, the S & T policy and approach which have been formulated in various Five Year Plans by taking guidance from the Scientific Policy Resolution of the year 1958 and the Technology Policy Statement of 1983 have played a considerable role. The Ninth Plan has taken note of the changing global environment, vis-a-vis, the emerging needs of the country and formulated the strategy for the S& T development in the country. The broad features of the strategy during the Ninth Plan, inter alia, included the following :

- continuance of efforts to build and maintain a strong science base by utilising the expertise and infrastructure available in various disciplines of S&T in planning and development of S&T programmes,
- to lay emphasis of the research programmes on mission mode projects rather than discipline mode, with carefully identified end goals,
- to dispense with hierarchical bureaucracy in the R&D institutions so that the activities pertaining to scientific management, promotion and development are performed by scientists and technologists and all necessary steps are taken to raise the morale of working level scientists and technologists,
- establishment of strong linkages between the research institutions/national laboratories and industries both for development and marketing of technology by encouraging and strengthening interaction among R &D institutions and the users through networking,
- laying emphasis on quality and timeliness of S&T outputs instead of quantitative evaluation in terms of number of projects or expenditure incurred,
- preparation of long term (decade) S&T profiles with short-term commitments with the ultimate objective of integrating S&T with targets of productivity and efficiency envisaged in each socio-economic sector,

- to see that S&T plays a dominant role in improving the existing infrastructure in several socio-economic sectors so as to accelerate economic growth and to derive maximum societal benefits,
- to lay greater emphasis on clean technologies in the coming years,
- encouragement to the mobility of the S&T personnel among various R&D organizations, academic institutions and industries so that younger scientists would be attracted to scientific and technological research careers by providing imaginative incentives and improvement in the functioning environment,
- scientific and technical education and development of creative skills and innovative capabilities through S&T education so that S&T manpower could be given greater responsibilities to develop new energy efficient and environment- friendly processes in addition to fiscal and material resources,
- to activate and intensify science and technology activities in the states and union territories in such a way that they will be able to take up location specific R&D programmes for providing S&T inputs in the key sectors of socio-economic development,
- for coordination at the national level, to have an Apex level S&T advisory mechanism,
- to generate maximum possible resources for R&D from the production and service sectors.

1.2 While the broad features of S&T approach adopted during the Ninth Plan would be continued during the Tenth Five Year Plan as well, the approach in the later case has to take into account a new situation that has emerged for our industries, academic institutions and R&D laboratories which are heading for a strong competitive atmosphere. This new situation has also been articulated in the Approach Paper for the Tenth Plan, wherein it was recognized that the comparative advantage in the globally integrated knowledge based economy today is shifting to those with brain power to absorb, assimilate and adopt the spectacular developments in S&T and harness them for national growth and that the Tenth Five Year Plan should give a special thrust to S&T by leveraging on the strong institutional S&T framework built so far. Further, the approach to technology will have several new features. Significant inputs will be put in those areas where India can emerge as a global leader and where benefits of S&T will

accrue to all those who have been excluded so far. With a view to preserve, protect and add value to India's indigenous resources, vis-à-viz, to meet Indian needs, an appropriate mix of innovative technologies will be generated. The situation of Indian exports deriving their comparative advantage through resources and labour will be changed to the one where technology led hi-tech products derive comparative advantage. On the whole the approach towards S&T will be towards enabling delivery of products and services and the thrust, therefore, will be more on delivery and use the S&T infrastructure on which investments have been done over the past nine plans.

1.3 Another new thrust in the development of technologies will be towards finding solutions in health services; population management; natural hazard mitigation; sustainable development of natural resources etc. Such imaginative and innovative programme will be supported which gain increasing popularity of science and create willingness to take science as a carrier among the youth, vis-a-vis to enhance the intake of young scientists. The basic research which is vital for the development of all such technologies will be promoted through intensive support to relevant universities/ institutions. Strong support will be provided to agriculture and agro-based industries and infrastrucutral areas like energy, transportation, communication and housing while simultaneously supporting the emerging areas of information technology and biotechnology where India has a comparative advantage. For undertaking all such measures of S&T stated above, various policies and programmes will be suitably articulated during 10^{th} Plan by making the concerned socio-economic ministries the real stakeholders of S&T.

1.4 Another area of focus for S&T during Tenth Five Year Plan should be to enhance result-oriented interaction and partnership between the industry, R&D and the academia by setting up appropriate institutionalized linkages and mechanisms in various disciplines and in various regions across the country. The efforts should be oriented to promote basic research, technology development and its commercialization and the approach should be to produce products and services which are competitive in the domestic and global markets. There are a lot of expectations from the Government regarding contribution of S&T to wealth generation and for speedier economic growth. Also the common man looks at S&T to give him good life fast and in a cost effective way. Some ways and means are required to fulfil these expectations during the Tenth Plan.

1.5 This may be made possible for example by substantially increasing Indian participation in the herbal based medical sector where there is an international trade of tens of billions of US dollars and through utilization of natural resources like bamboo having a significant potential market. During the process of development of technologies, adapting an approach to achieve energy security simultaneously taking care of environment aspects and developing S&T based disaster management would be other areas of thrust.

1.6 The departments which are mainly concerned with the S&T are : Department of Atomic Energy (DAE), Department of Space (DOS), Department of Science and Technology (DST), Department of Scientific and Industrial Research (DSIR), Department of Biotechnology (DBT), and Department of Ocean Development (DOD). The items for priority and approach for these six departments have been spelt out in the following paras.

1.7 While general support to basic research and technology development and institutional support are important, it is essential that focus should be on specific end uses of the economy and user driven missions/projects keeping in view the competitive environment in which the Indian industries have to compete even in the domestic market with imported products. The strategy should not only to protect the domestic market but should also aim at international markets. Each department may focus on a few missions in this direction.

1.8 All the departments should critically examine the organizational structures of institutions which are under them and those being supported by them financially. The idea should be to focus all of them to a result oriented approach with speedy actions required for working with industries. Towards this end each of the departments may create one new entity, which will be equal to and better in quality and standards to the user driven and commercially oriented R&D centers being set up by MNCs. This is to be done preferably with multi-institutional approach and with consortium of industries. This entity should be managed by industrial groups and should become a model for new methods of working and also to produce first grade intellectual products from India.

1.9 A great deal of attention should be given to generation of the right kind of scientific and technical manpower whether it is technicians for operational levels or higher levels of postgraduate education including Ph.Ds., in order to maintain indigenous technology base. The conventional methods of courses for

undergraduate, postgraduate and Ph.Ds may have to be much more responsive to the needs of the economy and also in terms of global excellence. To implement the programmes on a large scale, each of the department might create a special set up in which the laboratories/universities can coexist in the same campaign along with industry participation. Each department may evolve its own system and include in the plan. These centers could become examples for others. Such systems could also invite private sector contributions, participation and management.

1.10 Zero based budgeting approach may be used throughout the 10^{th} Plan period in order to weed out the projects which are going on for a long time or which have not fructified with good results or which have become redundant in view of the new situations including market conditions of new technologies. Principles of zero based budgeting will reprioritize research activities under allocation of resources. The emphasis on technology development for applications may not duplicate among various S&T fields but bring in complementarities in efforts. The idea of such a zero-based approach is not necessarily to reduce the budget but to concentrate the funds on priority items and to step up those which can be accelerated with additional resources.

1.11 All the S&T programmes may indicate the user groups for which the programme is targeted for the expected results within the plan period and the parameters which can be used to measure success and failure.

1.12 A great deal of attention need to be given to focus and channelise the applied research to the market stages which may include even marketing to other government departments / agencies. In this context, some of the existing procedures in the Government Departments/Ministries need to be restructured and special encouragement given to industries producing products and services with reasonable content of indigenous technologies by ordering on them. Such measures will help create not only the initial market for products and services from Indian R&D but even to reach large scales.

1.13 Applications of S&T to rural areas and small scale industries are important. These should be done keeping in view the affordability and sound principles of economic sustainability after initial demonstration projects are completed.

1.14 User driven testing and instrumentation facilities may be set up by S&T departments to help Small and Medium Enterprise (SME) to be competitive. Again the principle of economic sustainability of the centers after their establishment is crucial and user contributions/fees are important.

1.15 S&T must play a more dominant role than hitherto in improving the existing infrastructure in several socio-economic sectors so as to accelerate the economic growth and to derive maximum societal benefits. It is important in this connection to induce and encourage socio-economic ministries to utilize the indigenous technologies to the maximum extent possible.

1.16 In the States and Union Territories, S&T activities must be geared to take up location specific R &D programmes for providing S&T inputs in the key sectors of socio-economic development.

CHAPTER 2

REVIEW AND ASSESSMENT OF THE NINTH FIVE YEAR PLAN PROGRAMMES OF THE CENTRAL S&T DEPARTMENTS/ AGENCIES

2.1 The broad features vis-à-vis the objectives and thrusts in the S&T during the Ninth Five Year Plan have already been spelt out in the previous chapter (vide para1.1).To achieve these 9th Plan objectives, a number of measures /initiatives have been taken in the past which include the following.

- Strengthening of R&D activities through creation of new research facilities, introduction of concept of basic research missions, enhancement of fellowships etc.
- Attracting young Scientists by awarding Swarnajayanti Fellowship for research, BOYSCAST Fellowships, Kishore Vigyanik Protsahan Yojana, National Bioresource Awards and Promotion of Youth Leadership in Science for school students.
- Strengthening S&T infrastructure in the universities & academic institutions through FIST programme.
- Promotion of indigenous technology using STAC and IS-STAC mechanisms and also through the programmes of PATSER, TDB, Homegrown Technologies etc. Individual innovators have also been supported under newly instituted Technoprenure promotion programme.
- Number of Science and Society related programmes were implemented to demonstrate application of S&T for improving quality of life by creating productive jobs, reducing drudgery, improving health and environment in the areas of blacksmithy, carp breed hatchery, low cost preservation and processing of horticulture products, food irradiation, application of radio-isotope and laser for the diagnosis and treatment of various diseases, use of PFZ maps for fishing activities using GIS coastal management etc.
- Creation of awareness on intellectual property rights and diverse aspects of patents.
- International S&T cooperation with 50 countries in selected areas of mutual interest to facilitate interaction to scientific research, to develop

advance technologies and to take mutual advantages of complementary scientific and technological capabilities among the participating countries.

- The funding of the S&T programmes remained mainly through the budgetary support by the Scientific Departments/Agencies of the Central Government. The financial contribution of the industry sector in R&D is about 28% of total R&D expenditure

Some of the significant achievements made by the Central S&T Departments/ Agencies during the Ninth Five Year Plan are given below :

Department of Space

2.2 The major thrust of the space programme during the 9th Five Year Plan has been towards strengthening the space based services for socio-economic development of the country. The development of Geosynchronous Satellite Launch Vehicle (GSLV) towards achieving self reliance in launching INSAT type of satellites is one of the major targets set for 9th Plan in the launch vehicle area. The Earth observation systems during the 9th Plan is oriented towards building state-of-the-art satellite systems configured for applications related to land and ocean addressing both emerging national needs as well as global service requirements. In the area of satellite communication and meteorology, the efforts during the 9th Plan are directed towards augmenting the INSAT system with additional capacity and newer services through development and launch of third generation INSAT satellites based on the demands indicated by the users. A number of studies and experiments are also planned in the areas of Space science and environment. Besides these, significant progress in industry participation, policy initiatives, international co-operation, commercialisation of the space capabilities and human resource development are also targeted during the 9th Plan period.

2.3 The operationalisation of PSLV with the successful flight of PSLV-C1 on 29th September 1997 is a major milestone in the Indian Launch Vehicle programme and it has established the self reliance in launching IRS type of satellites. The successful launching of PSLV-C3 on 22-10-2001 placing three satellites in orbit

has further strengthened India's capability to tap the vast global potential that exists for launching satellites. The successful launch of the first development flight GSLV D1 carrying GSAT satellite on 18th April, 2001 is a major land mark in Indian Space programme. The launch of IRS-P4 (Oceansat) on 26th May 1999 has opened-up new vistas for ocean development and coastal studies. The launch of INSAT-2E, the most advanced communication satellite India has made so far, in April 1999 and launch of INSAT-3B, the first in the third generation INSAT satellites, in March 2000 are significant achievements which have enhanced the INSAT space segment capacity for developmental and other applications.

2.4 The schemewise salient features of Space Programmes are indicated below : The launch vehicle programme is directed towards development of cost-effective launch vehicles to achieve self-reliance in launching Indian Remote Sensing and Communication satellites. The first operational flight of PSLV-C1 on 29th September 1997 successfully carrying IRS-1D into orbit has been a major milestone in the Indian Space Programme during the 9th Plan. This has established self-reliance in launching IRS type satellites. Following this, the subsequent flight PSLV-C2 on 26th May 1999 has placed three satellites in orbit viz. Indian IRS-P4 (Oceansat) and two auxiliary foreign satellites TUBSAT and KITSAT. The third operational flight PSLV-C3 which took place on 22nd October, 2001 has successfully placed in orbit the Technology Experiment Satellite(TES) in addition to two foreign piggyback satellites like BIRD of Germany. The PSLV C2 & C3 have established the multiple satellite multiple orbit launching capability of PSLV, besides being commercial flights. The PSLV has now been productionised with substantial industry participation. The first development flight GSLV D1 is successfully launched on 18th April 2001. The GSLV project with complex developments involving cryogenic stage which is first of its kind to ISRO, is a major step towards achieving self-reliance in launching 2T INSAT type of Satellite.

2.5 The Earth Observation programme is oriented towards building state-of-art remote sensing satellites along with necessary data reception, processing and interpretation systems as a part of the National Natural Resource Management System (NNRMS) of the country. While IRS-1D provided the continuity of space based remote sensing data for the user community in India and abroad, IRS-P4 has

provided vital data for ocean and coastal studies. The data from IRS-P4 has been used for potential fishing zone forecasts, ocean state forecast, medium range weather forecasting and other applications of national importance. Further, a Technology Experiment Satellite (TES), taken up to demonstrate advanced technologies for future high resolution imaging systems, has been successfully launched on 22.10.2001 on board PSLV-C3. The work on IRS-P6 (Resourcesat) for resource management applications and IRS-P5 (Cartosat) for urban and rural applications is in progress and the launch is targeted in 2002-2003 onboard PSLV.

2.6 The remote sensing applications have grown over the years to cover diverse themes as a part of National Natural Resources Management System (NNRMS) for which Department of Space is the nodal agency. The data from IRS satellites have played a vital role in implementing several national missions in key areas of social development. The network of international ground stations receiving the IRS data has been expanded with addition of 7 ground stations during 9^{th} Plan. Important applications of IRS data are in waste land development; generation of developmental action plans for sustainable development in specific areas from selected 175 problem districts; characterization of the bio-diversity at landscape level in bio rich areas of North Eastern Himalayas, Western Himalayas, Western Ghats and A & N islands; land slide risk zonation using satellite maps along the important tourist and pilgrim routes in Himalayas of Uttaranchal and Himachal Pradesh; national mission on drinking water; seasonal snowmelt runoff estimation; operationalisation of satellite remote sensing based Crop Acreage and Production Estimation (CAPE); Coastal Regulation Zone (CRZ) mapping, Environment Impact Analysis, Wetland Mapping, Grassland Mapping; disaster management support; forest cover mapping; drought monitoring; and flood monitoring, land use/land cover mapping; mineral targeting etc.

2.7 The Indian National Satellite System (INSAT) established in 1983 with launch of INSAT-1B is providing operational space services in the areas of telecommunication, TV broadcasting and meteorology. INSAT-2E heralded new capabilities such as global beams and capacity lease to international telecommunication organization. (INTELSAT). INSAT-2E is the most advanced satellite in INSAT-2 series and is a fore-runner in technology for the forthcoming

INSAT-3 series. Another significant achievement of the 9th Plan period is the successful launching of INSAT-3B on 22nd March 2000 which is providing Fixed Satellite Services (FSS) in extended C-band and Ku-bands and mobile satellite services in S-band. The INSAT-3B has augmented the private VSAT networks and the NICNET services. One of the transponders in the satellite is also used for setting up Education and Training Network in Andhra Pradesh. The INSAT-3C satellite is now ready for launch while the work on INSAT 3A, 3E and 3D are in progress. With the growth in INSAT system, the application services have also been expanded to include additional DD channels/ regional services, expansion of the VSAT networks for remote rural communication and business communications, educational channels, several news gathering services of DD, communication services in strategic applications, developmental communication networks in different States, Mobile satellite services, internet services, Search and Rescue services, VSAT services using C band and Ext-C band, meteorological services and host of other services. One of the important applications of INSAT system has been the satellite based interactive network for rural development. Towards this, a pilot project undertaken in Jhabua, a tribal district of Madhya Pradesh to demonstrate the developmental communications and training for rural development, has been successfully completed. Other services introduced in the INSAT system relate to the tele-health to make available expert medical expertise to remote and rural areas; and Flood forecasting through 100 real time hydrometeorological data collection platforms.

2.8 Another important initiative of the 9th Plan is setting up of a North-Eastern Space Applications Centre (NE-SAC) at Shillong as an autonomous body under DOS to provide access to high technology space infrastructure for focussed development activities of North Eastern States.

2.9 In the area of International co-operation DOS has acquired a significant role as a result of other countries recognizing India's achievements in the areas of satellite technology, space applications and the operational capability to launch satellites. India's contribution to international and regional bodies dealing with technical and policy matters related to space has also been significant. India hosting the second ministerial conference in New Delhi in 1999 on Space applications for sustainable development on behalf of the United Nations Economic & Social

Commission for Asia & the Pacific (UN-ESCAP) was a significant event in this area and the resolution of the conference known as "Delhi declaration" was issued by the Ministers launching the second phase of ESCAPs regional space applications programme identifying common denominator projects under minimum common programme of the region. At the initiative of UN, India has also established a Centre for Space Science and Technology Education for Asia and the Pacific (CSSTE-AP) with a view to provide capacity building opportunities in space science and technology for the countries in Asia and Pacific region.

2.10 There has been significant progress in marketing of the space capabilities developed through the space programme. Two important achievements in this direction are the leasing of eleven 36Mhz transponders onboard INSAT-2E to International Telecommunication Organization (INTELSAT) and launching of four foreign satellites of Belgium, Korea and Germany onboard India's Polar Satellite Launch Vehicle (PSLV-C2/C3). Several other export contracts for providing space services and supply of space hardware have also been executed during the plan period.

2.11 A number of policy initiatives have also been taken by DOS. A policy framework for satellite communication in India including provisions for use of INSAT capacity by non-governmental parties and also provisions for Indian satellite systems to be established by private sectors has been evolved and approved by the cabinet. A remote sensing data policy taking cognisance of the role and issues relating to availability of high resolution data for development purposes has also been evolved. The Department is also working on the adoption of a map information policy with reference to the usage and digitisation of Survey of India toposheet. A National Spatial Data Infrastructure is also being conceptualised with a co-ordinated approach to provide access for the map information of the country in computerised digital GIS format to facilitate developmental planning and decision making.

Department of Atomic Energy (R&D Sector)

2.12 The projects being pursued under the R&D sector of the Department of Atomic Energy (DAE) envisage comprehensive research on several areas related to nuclear energy and its applications for the benefit of the society. The programmes are being pursued by a dozen constituent units and aided institutions.

This sector provides much needed research support to the peaceful applications of nuclear energy for the improvement of the living standard of the citizens of the country. Review of the progress made in various areas of R&D sector are highlighted below.

2.13 Nuclear power programme involves a long-term strategy for exploiting the indigenous nuclear fuel resources in the country. It consists of setting up of Pressurised Heavy Water Reactors (PHWRs) in the first stage, Fast Breeder Reactors (FBRs) in the second stage and Thorium Based Reactors in the third stage. The first stage is already in commercial domain with demonstrated excellence in performance standards. However, sustained R&D support to continually upgrade technology for safe operation at high capacity factors, life extension and further improvement of economic viability will be a regular ongoing programme. Investments made in R&D in this area have resulted in India mastering all aspects of this difficult technology and the power reactors and fuel cycle facilities are operating well. So far161 billion units of eco-friendly electricity have been produced from the power plants with 49 billion units being added during the IX plan period.

2.14 All the technology objectives for Fast Breeder Test Reactor have been realized and the reactor is operating very satisfactorily with its advanced Plutonium-Uranium Carbide fuel, far exceeding its originally stipulated performance standards. Design of 500 MWe Prototype Fast Breeder Reactor (PFBR) is progressing well. Construction of PFBR is planned by December 2001.

2.15 Bhabha Atomic Research Centre (BARC) has made good progress towards the design and development of AHWR, which aims to utilise the vast thorium reserves in the country. The design of this reactor incorporates advanced safety features such as negative void coefficient, pumpless primary circulation, passive decay heat removal, large heat sink allowing 3 days grace period, passive containment cooling and passive containment isolation. Various activities are being pursued to ensure completion of the detailed project design report on schedule by March 2002. As a part of setting up of a critical facility for AHWR and 500 MWe PHWRs, detailed design of various systems has been completed and preliminary safety analysis report has been prepared. Tenders for Civil construction activities have been floated. Process design and detailed engineering for the Advanced Reactor

Experimental Facility have been completed. Tender for Civil construction activities has been floated. Ordering of major / important equipments is done and fabrication of the equipment is being followed-up with the suppliers.

2.16 Under the nuclear Fuels and Materials Development Programme, progressive introduction of mixed fuel (MOX) in Tarapur is going ahead and performance of the fuel in the reactor has been as per design. Construction of a new shielded hot cell facility for post irradiation examination, revamping and augmentation of fuel fabrication facilities, development of PFBR fuel, development of prototype High Speed Rotors, development of plutonium based fuels and their characterisation, augmentation of MOX fuel fabrication facility at Tarapur, development of telerobots, telemanipulators, and related projects being pursued have made very good progress and are expected to be completed by March 2002.

2.17 BARC contributed significantly towards the development of several control and instrumentation systems for the nuclear power plants being set up by Nuclear Power Corporation of India Limited (NPCIL). Systems developed by BARC include programmable digital comparator system, dual processor hot stand-by process control system, dual processor hot stand by reactor regulating system, channel temperature monitoring system, on-power fuelling control system, supervisory control and data acquisition system (SCADA) and several others. BARC has handed over three channel inspection systems (BARCIS) to NPCIL for their field use and operators from the sites have been trained to operate the system. ANUPUM Supercomputer developed by BARC is being continuously upgraded.

2.18 In the area of technology Development for Nuclear Recycling a facility for the separation of Uranium-233 from thoria and thorium targets irradiated in Dhruva and Cirus reactors has been completed and is undergoing commissioning trials. Procurement of bulk material for the new Fuel Reprocessing Plants at Tarapur and Kalpakkam is in progress. Waste immobilization plant at Trombay for the treatment and immobilization of high level waste from the reprocessing plant at Trombay is expected to be commissioned by March 2001. The revamping and refurbishing of Waste Management Facilities at Trombay, Tarapur and Kalpakkam has made significant progress and will be completed by March 2002.

2.19 Indigenous effort for the design and development of turbo-expanders, helium compressor, cryo-heat-exchangers and simulation rigs, which are critical equipment for decontamination and upgradaing of heavy water are in various stages of progress. Construction of a desalination plant at Kalpakkam to demonstrate the feasibility of coupling a desalination plant with nuclear reactor is progressing well and is expected to be completed by March 2002.

2.20 BARC continued to work on the development of safety related technologies for PHWRs. For the environment surveillance and monitoring in and around all nuclear facilities, environment surveillance laboratories are being upgraded. Procurement, installation and calibration of mini SODAR (Sound Detection and Ranging), RASS (Radio Acoustic Sounding System) and other tower stations have made good progress and are to be completed by March 2002.

2.21 The Radiation Technology Applications include health care, agriculture, food preservation, industry and research. Important programmes under health care include: setting up of a Radiation Medicine Centre (RMC) at BARC in Mumbai, which has become the nucleus for the growth of nuclear medicine in the country; comprehensive treatment for cancer and allied diseases at TMC; a regional radiation medicine center at Kolkata as a part of Variable Energy Cyclotron Centre (VECC); radiation detection interface and software to estimate the percentage of labeling of radiopharmaceuticals at RMC; upgradation/modernisation of major equipment like MRI, X-ray machines, mammography, orthopatograph and ultrasonography machines.

2.22 Application of radiation to agriculture has resulted in the release of 22 improved varieties of seeds; of them blackgram (urid) accounts for 95% of the cultivation of this pulse in the State of Maharashtra. On a conservative estimate, these varieties contribute over Rs 1000 crores in a year to the GDP. One spice irradiator is already operating at Navi Mumbai to treat items requiring high doses. Poton irradiator at Lasalgaon, near Nasik is being set up by BARC and will be completed in the year 2001. It will be used to treat items requiring low doses.

2.23 Applications of radiation technology for industry span a wide range including radiography, water hydrology, gamma scanning of process equipment, use of tracers to study sediment transport at ports and harbours, flow measurements, pigging of buried pipelines etc. On a conservative estimate, savings to the nation due to isotope application related services like Gamma scanning, Blockage & Leakage detection, RTD studies and sediment transport studies account for over Rs 2000 crores per year. More than 6000 technicians have been trained in the use of radiography and they have found employment in India as well as abroad. To enhance the analytical capabilities of isotope hydrology laboratory, computer aided tomography facilities for advanced industrial NDT applications, isotope processing facilities and shielded lead cell set up for development of radio-pharmaceuticals, sophisticated instruments are being procured. Procurement, installation and respective commissioning will be completed by March 2002.

2.24 The areas that are receiving attention under technology development are lasers and accelerators. Besides the Synchrotron Radiation Source (SRS) Indus-1 at CAT, the second SRS namely 2.2 GeV Indus-2 is expected to start by the middle of 2002. The other machines under development at CAT are : a 750 keV, 20 kW DC accelerator which can be used for radiation processing of paper pulp, surface modifications, paint and resin curing and other industrial applications; a radiotherapy machine; two types of accelerators for radiation processing of agricultural products and sterilization of the medical products; an Electron Beam (EB) Centre at Kharghar, Navi Mumbai in collaboration with SAMEER which is being set up for further enhancement of facilities for commercial application of EB irradiation etc. The heavy ion accelerator program and the radioactive ion beam programme is also progressing well at VECC. The Laser Programme which has industrial and medical applications developed a surgical CO_2 laser system and a dozen of them have been supplied to various hospitals. Other developments in this area include : designing a high repetition rate pulse TEA laser which gives peak power of more than 1 MW at 500 Hz repetition rate and several types of Nd : YAG laser suitable for R&D and medical applications.

2.25 Important technologies transferred to other Agencies are: development of finite element based software package specially tailored to rotor dynamic analysis

of turbo-pumps required for indigenous development of cryo-engines and Nickel-Titanium shape memory sleeves for the lightening insulator assembly for LCA; constricted arc plasma generator for testing strategic thermal protection systems for rocket motors and re-entry simulator devices; development of a pipe inspection gauge for monitoring the health of cross-country oil pipelines for Indian Oil Corporation etc.

2.26 Some of the programmes under basic research pertain to setting up of TACTIC array at Mt. Abu; the design and development of MACE, BEST, MYSTIQUE telescope facilities which are in progress; Seismic monitoring and data processing facilities; up-gradation of KALI-5000 system to produce intense particle beam; technologies on plasma nitriding equipment and medical waste pyrolysis units which have already been passed on to the industrial partners; work on SST project, the ADITYA experiment and a number of basic plasma experiments etc. Efforts have also been made to establish a synergy between the national laboratory system and the university system. Through Board of Research in Nuclear Sciences, research projects have been funded in the universities as well as national laboratories besides setting up of major centres in the academic institutions.

Department of Biotechnology

2.27 The main thrust of the Biotechnology programme during the 9th Plan was on research support on long and short term basis leading towards excellence, new products or processes, large scale demonstrations, validation of R&D leads, involvement of user agencies and industries, technology development and transfer, innovations for patenting purpose and high quality research publications. Emphasis was also laid on establishing new centres of excellence, facilities, programme support in priority areas, expansion of bioinformatics network and human resource development. Efforts were made to ensure that biotechnology tools are utilized to harness the biological wealth for societal and economic benefit of the country on an environmentally sound basis. Some of the new initiatives in bio-technology research include : establishment of National Bioresource Development Board; setting up of New Autonomous Institutes and Facilities such as National Brain Research Centre and National Centre for Plant Genome Research at New Delhi; National facility for Virus Diagnosis and Quality Control of Tissue Culture raised plants etc. Programme on Genomics; network programme on Bioprospecting of Biological wealth; setting up

of a Women's Biotechnology Park at Chennai; setting up of a Biovillage at Mocha, Porbunder etc; setting up of a Patent facilitating cell etc. The activities on the genomic research, tissue culture for plants and embrio transfer techniques in animals being done in the field of agriculture will also be reviewed and programmes in bio-technology formulated accordingly.

2.28 Product and Process oriented biotechnological research and development for application in agriculture, health sector and industry for the benefit of society have been given a major thrust. Basic research was supported through R&D projects to develop expertise and understand basic biological processes for further applications in protein engineering, drug and molecular design, identified potential molecules for development of vaccines and diagnostics for infectious diseases. Some of the achievements in plant biotechnology are : joining the International Rice Genome Sequencing programme with a commitment to sequence 10 Mb of chromosome 11 in a period of five years; development of markers for high quality protein content and cloning/modification of triticin gene with enhanced lysine content in wheat, development of molecular methods for hybrid seed mustard, production of transgenic plants of tobacco with viral resistance etc.

2.29 Biofertilizers programme consisted of transfer of technologies to four industries producing mycorrhizal and rhizobial biofertilizers for mass multiplication and distribution. Biopesticide formulation technologies have been transferred to the industry under the integrated pest management programme.

2.30 In animal sciences, embryo transfer technique in camel was standardized and a new protocol for camel superovulation was developed for the first time; seven different types of transgenic mice carrying antibiotic markers, Hepatitis-B antigens, inter-leukin genes and other markers have been developed and a new rabies vaccine for animals has been produced and is being tested for technology transfer.

2.31 Under Plant Tissue Culture, molecular diagnostic kit has been developed for detection of Bunchy Top Virus in Banana. The Micropropagation Technology Parks are serving as a platform for transfer of proven technologies and training in tissue culture. So far 6.5 million plants have been produced and planted in 7500 hectares in 17 states. Technologies for 10 species have been transferred to the

industry. A satellite park has been setup in North-East for popularization of technology and production of planting material for the region.

2.32 Considerable progress was made in the areas of Bioprospecting and Molecular taxonomy; seri biotechnology; medical and aromatic plants; biodiversity conservation; medical and food biotechnology. Fourteen genetic clinics were established for providing molecular diagnosis and counselling for the common genetic disorders such as beta-thalassemia, Duchenne Muscular Dystrophy (DMD) and other haemoglobionpathies prevalent in the country to the affected families. About 13,845 affected families so far have been benefited from these units for genetic diagnosis including prenatal diagnosis and counselling for major genetic disorders. In the programme on functional genomics, powerful computational capability for handling large scale human genome sequence data, robotic methodologies for genotyping and PCR based diagnostics for common genetic disorders have been developed.

2.33 During the 9th Plan four Jai Vigyan National S&T Missions in the areas of development of new generation vaccines, biotechnology for herbal product development, coffee improvement and establishment of mirror sites for genomics were launched and the targets set for the programmes in accordance with the objectives envisaged have been accomplished. About 25 technologies have been transferred to different industries. These include, diagnostic kits for HIV, Hepatisis, Dengue, assessment of reproductive hormones, Japanese Encephalitis, Vaccines for leprosy, drug formulation for septic shock, plant tissue culture protocols, formulation of biofertilisers, high protein gene from *Amaranthus* and bioremediation technology for mine spoiled dumps and crude oil spillage.

2.34 Fifty five centres set up under the BTIS net and six Interactive Computer Graphic Facilities have continued to disseminate information to the researchers under the Bioinformatics programme. The main focus of HRD has been to generate in large numbers highly trained scientists/students through consolidation of 38 PG/PD/one year diploma courses and 19 additional courses including one time support for strengthening PG programmes. About 800 students were trained so far and five bioscience career development awards and three women bioscientist awards given to

eminent scientists during 1999-2000. For the year 2000-2001, six bioscience career development awards have been announced.

2.35 Some significant contributions were made by the Autonomous Institutes in basic research and development of new products and technologies. At NII, New Delhi, one Australian, two American and one Canadian patents were granted and a biosafety level-3 facility has been established. A number of studies conducted at NCSS on cell culture, tissue banking and engineering have resulted into the development of biocompatible synthetic matrices suitable for controlled drug release ad immuno isolation of islets and dermal equivalents for transplantation for burn patients. Centre for DNA Finger-printing and Diagnostics (CDFD), Hyderabad started a new born screening program for diagnosing in born errors of metabolism under which every child born in 4 government hospitals in the city is screened for metabolic errors. National Brain Research Centre (NBRC), New Delhi was established in 1999 with the main aim to undertake, aid, promote, guide and coordinate research of high calibre in basic and clinical neuroscience. At the National Centre for Plant Genome Research (NCPGR), New Delhi which started functioning from 1st April, 1998 a novel gene, AmA1 from *Amaranthus hyprochondriacus* has been used for generating transgenic plants of agronomic importance. Transgenic potato with high nutritional quality has been developed with the introduction of *AmA1* gene. The relevant technology has been transferred to Cadila Pharmaceuticals for industrial production of animal feed supplement.

2.36 During the 9th Plan National Bioresource Development Board (NBDB) was set up under the Chairmanship of the Minister of Science & Technology with the main objective of developing a policy framework for effective application of biotechnological and related scientific approaches for research & development and sustainable utilization of bioresources especially for the development of new products and processes. DBT has been collaborating with various State Governments to establish Biotechnology parks and to implement other biotechnology related activities. Thus the programmes undertaken by DBT has resulted in a wide variety of societal benefits to the former in terms of developing transgenic crops, biofertilizers, biopesticides; vaccines for certain diseases, low cost nutritious food, genetic diagnosis cum counseling units etc.

Department of Science & Technology

2.37 The activities of the Department of Science & technology are primarily focussed towards Scientific Research, Technology Development, Socio-economic Development, Scientific services, International cooperation and Supporting Autonomous S&T Institutions. The achievements are briefly indicated below :

2.38 Efforts to strengthen R&D infrastructure and encourage research in diverse areas of Science & Technology were continued. Some of the major R&D programmes supported include : sub-Himalayan Cenozoic sediment studies using FT dating techniques, macromolecular crystallography, bioorganic chemistry, Raman spectroscopy study on strongly correlated systems and fullerness, laser application in high resolution molecular spectroscopy, non-accelerated particle physics, photo-chemistry in jet-cooled clustera etc. Some of the major Research facilities/centres of excellence and Programmes established are : National Centre for Computational Fluid Dynamics at IIT-Chennai; Facility for Technical Acoustics at IISc, Bangalore; Facility for Laser Scanning Confocal Microscope at BHU-Varanasi; X-Ray facility for Structural Biology at IISc-Bangalore (with DBT); National Single Crystal X-Ray Diffractometer Facility at University of Hyderabad; cross flow turbine technology for microhydel application etc.

2.39 The Monsoon and Tropical Climate (MONTCLIM), Indian Climate Research Programme (ICRP), Bay of Bengal and Monsoon Experiment (BOBMEX) were taken up under Earth System Sciences. A programme on drug development was initiated for promoting collaborative R&D in drugs and pharmaceuticals involving national laboratories, industries and academic institutions and 30 research projects relating to new chemical entities/ formulations to treat diseases like cancer, arthritis, diarrhoea, gastritis, pancreatitis, tuberculosis, hepatititis-B, rabis and inflammation were funded. This funding has further resulted in establishing 4 national facilities for identification of immunomodulating potential of herbal products and extracts of natural origin, pharmacological testing, characterization of crystals, medium throughput screening in different national laboratories.

2.40 Efforts to encourage young scientists include : launching of Swarnajayanti Fellowships; Kishore Vaigyanik Prothasahan Yojana with active support from IISc-Bangalore, IIT-Mumbai and AIIMS-New Delhi, fulfilling the need of sophisticated

analytical instruments such as ICP, WMR, EPR Mass Spectrometer XRD, TEM, SEM etc to the Scientists in the country from academic and R&D institutes and users from industries etc.

2.41 Technology Development Programmes have been pursued through the Technology Development Board, TIFAC, and Advanced Research Centre. The Technology Vission 2020 reports brought out by TIEAC have documented for the first time in comprehensive series on S&T in India covering 12 science departments besides releasing 31 reports on frontier technologies like transgenic seeds, recombinant DNA products, bio-degradable plastics etc. and TIFAC's networking of high performance computing facilities at 7 engineering/research institutions has been launched for taking up selected technology demonstration projects in different fields. This benefitted a large number of scientists, engineers and students and also forming the basis for Technology Mission Mode projects in the areas of sugar technologies, fly ash utilization, advanced composites and New Millennium Technology Mission project.

2.42 In response to the new WTO regime, a Patent Facilitating Centre (PFC) was set up which has helped in making patent awareness in the country. Under Technopreneur Promotion Programme (TePP) started jointly by DST, DSIR, TIFAC, several projects relating to Zeolite based Catalytic Converter, Next Generation Membrane Oxygenerator etc. were supported.

2.43 Through the IS-STAC mechanism twelve Joint Technology Projects have been taken up in the areas of Column Flotation Technology for Ore Benefaction and Pilot Enrichment Plant for Helium from Hydrothermal sources etc. As a measure of promoting S&T for Socio-Economic Development, Rural Technology Parks have been set up in North-Eastern Region; a number of need based S&T projects were supported in several places including hilly reasons in farm and non-farm sector in a number of areas like inland aquaculture, sustainable agriculture, solar/bio-mass based energy devices/systems, post harvest technologies, land-based activities, women's health, income generation activities and Drudgery removal, Rural engineering etc. Three women Technology Parks were also set up at Dehradun, Manipal and Barmer. A major breakthrough was achieved in the form of a project on food security by installing fish aggregation device in Andaman Island for primitive tribal group. Some

new programmes initiated during the Ninth Plan include : Technical Human Resources Development skill upgradation through vocational training in association with UNDP; National Facility for Science & Technology Based Entrepreneurial Innovation (Innovation Centre), National Project for International Business Information & Research (International Business Centre) and Technology, Innovation and Management Information Services (TIME IS), a complete web-site for techno-preneurs.

2.44 Project mode support to tackle State specific problems was provided to the State Councils which include high mortality of layer and broiler birds at Namakkal, Chennai; drying of large cardamom at Sikkim; documentation of medicinal plants at Rajasthan (Thar) and Madhya Pradesh; documentation of traditional fishing crafts and gears at Manipur; cultivation of Ginseng by tissue culture technique at Manipur and use of hydrams for irrigation purpose in Himachal Pradesh; demonstration plants for Cupola furnace in Bihar; solar passive housing technology in Manipur etc.

2.45 As a part of S&T Communication and Popularisation Programme, National Children's Science Congress (NCSC) were organised 4 times; a television serial 'Kudratnama' was telecast; and Telecast of video programmes on different scientific topics were made. Vigyan Prasar continued its efforts to promote and propagate scientific and rational outlook in the society through S&T communication. As part of NRDMS Programmes, 15 GIS Database Centers were set up planning Atlas for some districts of Gujarat were prepared; and Coordinated programmes in the areas of SAR Interferometer ground water modeling, coastal zone management and conservation and Bio-geo database and ecological modeling initiated.

2.46 As a nodal department for international S&T cooperation, the programmes undertaken by DST include : setting up of an Indo-US S&T Forum; launching of DST-NSF programme; supporting technology oriented projects on surface engineering of components; steel for automobiles; special plastics processing and pharmaceuticals development under Indo German programme; DST-DAAD Project based Personnel exchange Programme; taking up of several joint projects in the fields of Advanced Materials & Manufacturing Technologies; Information Technology; promoting S&T Cooperation among SAARC & BIMSTEC countries;

etc. Agreements were also concluded with Third World Academy of Sciences (TWAS) & International Centre for Theoretical Physics (ICTP).

2.47 Scientific services in the areas of meteorology, survey and mapping have been provided to the user agencies through the India Meteorological Department (IMD), Survey of India (SOI), National Atlas and Thematic Mapping Organisation (NATMO) and National Centre for Medium Range Weather Forecasting (NCMRWF). Significant achievements of IMD are : the commissioning of two Doppler Radars at Chennai and Calcutta; installation of 10 High Wind Speed Recorder; Cyclone Warning Dissemination System; Current weather Instrument System at Ahmedabad & Guwahati airports; new instrument for measurement of Runway Visual Range at New Delhi and Kolkata; upgradation of its seismological network through establishment of National Seismological Data Centre at New Delhi which has been connected online to Global Seismological Network; and installation of a new computer, which may be commissioned by the middle of 2001. In view of modern technologies and multi-disciplinary approach being adopted in planning process, Survey of India (SOI) is expected to supply multifarious scientific data and large scale maps at frequent intervals. It introduced digital cartography techniques in its circles and units to create Digital Cartographic Data Bases (DCDBs) from the topographical maps.

2.48 Thirteen DST aided autonomous institutions continued their research activities and transfer of technologies to industries. Significant achievement of these institutions include : a folion spray beneficial to crop yield; development of a laboratory-scale process for microbial detoxification of cyanide and metal-cyanide complexes; Nanostructred Semiconductor and CMR Materials and Devices by IACS; establishment of the world's highest observatory for optical astronomy in the Himalayas etc. Professional Science Academies continued their efforts in promoting Scientific activities such as publication and communication programmes in S&T areas and promotion of Engineering Education and Research in the Country.

Department of Scientific and Industrial Research (DSIR) including CSIR

2.49 Important achievements of DSIR include : recognitition of 249 newly announced R&D units in industry and 104 new non-commercial Scientific and Industrial Research Organisations (SIROs); publication of 50 quarterly news letters;

organisation of Annual National Conference on in-house R&D in industry; completion of 35 technology development and demonstration projects in the areas of digested organic supplement from agriculture waste, earth moving machinery, cold rolling mill, ginger oil based on green ginger, upgradation of technology for solar photovoltaic cells, interactive voice response system, nuclear based moisture and density gauge etc; under PATSER scheme resulting in commercialisation of products and processes and also leading to filing of 20 patents; supporting of 30 projects under the Technopreneurer Promotion Programme (TePP) jointly with DST; continuation of National Research Development Corporation (NRDC) effort on development and transfer of indigenous technology through invention promotion programme particularly biodegradable plastic, rice husk particle board, glucose bio-sensor, spirulina algae, glycol based anti-freeze coolant, manufacture of shrimp food etc. development of various technology by Central Electronics Ltd. (CEL) like SPV technology, high through put aluminium metallisation of UHE solar cells, switched mode power plant, new ferrite technology etc. and further strengthening of National Information System for Science & Technology (NISSAT) through sectoral information Centres on food, drugs & Pharmaceuticals, chemicals, textiles; setting up of Value Added Patent Information System (VAPIS), launching of 100 short term courses on information science & technology.

Council of Scientific & Industrial Research (CSIR)

2.50 CSIR, as a premier national R&D organization, continued to provide through its 40 Laboratories and 80 field centres scientific and industrial R&D of value not only for India's sustained development but for meeting its strategic needs as well. Implementation of programmes in CSIR was done in accordance with a white paper on 2001 vision and CSIR's mission statement that seeks to provide scientific industrial R&D that maximizes the economic, environmental and societal benefits for the people of India. The important organizational reforms envisaged by CSIR are : re-engineering of the organizational structure to enable CSIR to be more customer & market responsive; linking R&D to market place through alliances, networking & leveraging; stimulating intellectual property management in the CSIR & externally; investing in select high quality science; and refurbishing the ageing human capital.

2.51 The broad achievements of CSIR include : the total external cash-flow for the four year period 1997-2001 to cross Rs.1000crore and industrial production catalyzed is of the order of over Rs.17, 000crore; the number of Indian patents filed to be around 1400 and the foreign patents filed to be 650 in this period with the impact factor per paper increasing from 1.26 to 1.552.

2.52 Implementation of the Ninth Five Year Plan programmes/activities of CSIR was done in sixteen broad sectors viz. Aerospace; Biology & Biotechnology; Chemicals; Drugs & Pharmaceuticals; Earth Resources & Natural Hazards Mitigation; Ecology & Environment; Electronics & Instrumentation; Energy; Food & Food Processing; Housing & Construction; Information Products; Leather; Machinery & Equipment; Minerals, Metals & Materials; Rural Development; and Exports of R&D and Services. CSIR's significant acheivements in these sectors are as follows :

2.53 Under Aerospace sector the design fabrication and air worthiness testing of a 9-14 seater light transport aircraft was initiated and the first flight of the prototype is expected in the year 2001 itself; certification of the two-seater trainer aircraft – HANSA-3 designed and built by NAL, has been obtained and commercial production of the aircraft has commenced; R&D programmes include : a versatile universal polymer support developed by CBT; an efficient method to isolate and prepare in the pure form, large quantities of RNasin from discarded human placenta, developed by CCMB; Himalaya, a promising genotype of Mentha arvensis, developed by CIMAP through cross pollination of Gomti and Kalka (varieties earlier developed by CIMAP) released for commercial cultivation; a new strain of Withania (Ashwagandha), which is an important Indian Medicinal plant which yields about 14 quintals of dry roots/hectare against 8 quintals obtained from the check plant; a 30,000 TPA plant of Food Grade Hexane commissioned by M/s HPCL, Mumbai based on IIP technology; a process for catalyst free esterification and transesterification of vegetable oils for the preparation of lubricants, developed by IICT; mini refineries with capacities varying from 0.5 to 2.0 MTPA and self contained, skid mounted, low cost and low maintenance units congenial for installation in any location designed by IIP; mounting of a major coordinated drugs and pharmaceutical programme on the development and commercialisation of

bioactive molecules helping to put in place state-of-art expertise and facilities for new drug design a new antimalarial drug (EMAL) introduced in India for the first time developed by CIMAP & CDRI as an optimal epimeric mixture of α:β isomer Arteether (30:70 ratio); a new drug, Ablaquin for treatment of recurring malaria developed by CDRI, Lucknow now being manufactured and marketed by Nicholas Piramal India Ltd., Mumbai; Chamber Ventillation Technique developed by CMRI, Dhanbad using injection of high-pressure, high stable nitrogen foam for the control of fires in the long wall panels in mines which was successfully used in putting out the fires in the Jhanjra colliery, Bihar, and saving a permanent damage to the costly underground equipments; a technology called Cokeless Cupola developed by NML to replace coke by natural gas fuel in foundries, reducing the emissions of polluting gases; a process for the treatment of the paper mill effluent water to separate the lignin developed by NCL; fluorescence based prototype kit for detection of adulteration developed by ITRC; a high quality synthesis system developed by CEERI, useful for the visually handicapped persons as a `reading' machine as well as for information retrieval in railways/airlines/tourism industry and toys with voice synthesis developed by CEERI; a technology for display of vital flight parameters at about the pilot's eye level developed by CSIO, Chandigarh; an eco-friendly mining method known as wide stall mining without stowing developed by CMRI for optimal recovery of coal; a simple retrofit technology for conversion of two stroke engines of petrol/diesel run three wheelers to CNG operable engines developed by IIP; pre-harvest and post-harvest technologies for export of Mango, Litchi, Strawberry, Guava and Grapes; controlled/modified atmosphere storage of fruits and vegetables; a process for extraction of ginger oil directly from fresh ginger by RRL,Trivandrum; development of alternate building materials which utilise wastes and economise on energy and are eco-friendly; development by CRRI an Interlocking Concrete Block (ICB) pavement technique for special locations such as bus or container terminals, industrial roads, snow bound regions as well as for rehabilitation of old concrete surfacing; a Centralised Unit for R&D on Information Products to convert the dispersed and non-digital databases of CSIR to merchandisable information products; setting up of an technology proving of an economically viable fallen carcass recovery unit and a pilot demonstration plant commissioned at Melvisharam with support from

NBB/MNE/UNIDO and CLRI/LTM in leather sector; development and fabrication of a 1 TPD expeller by CMRI; fabrication of a powder x-ray diffractometer at NPL; development of an environment friendly process for manufacture of synthetic Rutile development by NPL; a high homogeneity superconducting magnet with superconducting shims for radial and axial field corrections suitable for NMR spectrometer application; development of a low cost online water purification system by ITRC which quickly makes water free from bacteria as well as removes toxic metals like iron, chromium, lead, zinc and nickel to safe levels useful for small hospitals, clinics, schools and community centers; etc .

2.54 One of the important cotributions made by CSIR under S&T-HRD scheme is to foster, sustain and upgrade the stock of the highly specialized scientists, engineers & technologists required for R&D, in diverse disciplines of S&T in the country. The scheme has provided support to the academic community for research schemes, award of fellowships/scholarships and scientists' pool placement. Other important scheme being implemented by CSIR pertain to modernization of CSIR labs; manipulation and management of IPR and technology management for corporate advantage, revamping and reengineering of CSIR Headquarters and the establishment of a communication network between Headquarters and CSIR labs. Through construction of resudential buildings and aminities, housing satisfaction of about 50% is expected to be achieved.

Department of Ocean Development (DOD)

2.55 The programmes and activities undertaken by the Department of Ocean Development which have been reoriented and revamped during the 9th Five Year Plan period relate to sustainable and environment friendly exploration and utilisation of marine living and non-living resources for the socio-economic benefit of the country. Some of the acheivements of DOD are highlighted below :

2.56 With a view to promote polar science and as a treaty obligation, scientific expeditions to Antarctica were undertaken on annual basis and various activities were carried out which include : commissioning of three component seismometer which recorded 360 seismic events, trial test of PFMC fuel cells and wind energy audit for application studies, establishing permanent GPS station, permanent analog VLF

monitoring station, permanent environmental lab at Maitri, Albedo and radiation budget estimation on one year round basis, mapping of seasonal variation of geomagnetic field and total magnetic field intensity, installation of two remote Automatic Weather Stations with DCP which recorded various surface energy flux etc.

2.57 Under the program on Drugs from Sea 6 organisms possessing anti-diabetic/ anti-diarrhoeal, anti-hyperlipidaemic, anti-anxiety, anti-cholesterol, anti-bacterial and larvicidal activities were identified and 84 compounds having interesting biological activity and novel chemical structure, isolated. Marine living resources programme includes : acquisition of benchmark data on marine benthos in the shelf waters of India to undertake studies on impact of bottom trawling on marine benthos. Systematic collection of environment and productivity data of the Exclusive Economic Zone for summer, winter and inter-monsoon periods for possible correlations with fluctuations in abundance and distribution of living resources.

2.58 Survey & Exploration in the CIOB mine site was continued for revalidation of relative concentration and quality characteristic of polymetallic nodules in different pre-determined blocks. As a part of the obligation as a pioneer investor, the Department relinquished 30% of the allocated 1,50,000 sq. km. area to the International Sea Bed Authority (ISBA). Environmental Impact Assessment study was carried out at CIOB and the impact of disturbance in the test and reference site is being monitored periodically to know the recolonisation effect of the benthic organism on the basis of the benthic disturbance report prepared.

2.59 As apart of technology development for mining, a demonstration of shallow bed mining technology at a depth of 420 m in open sea off Tuticorin in March, 2000 was carried out wherein it pumped slurry and an improved ROV system is ready for test in Indian Water upto 250 meters depth which is capable of inspection of under water structures, pipelines, sampling etc. As a part of technology development for extrctive metallurgy, a demonstration pilot plant of 500 kg /day capacity is scheduled for commissioning at the end of first quarter of 2001. In order to revalidate the laboratory scale process package, demonstration campaigns were carried out at RRL (B) and BARC, Mumbai.

2.60 Coastal and Marine Area management was undertaken by processing of data at National Marine Data Centre on Marine Pollution at Regional Centre, National Institute of Oceanography, Mumbai and disseminating the same to the Pollution Control Boards whenever necessary. Under the Integrated Coastal and Marine Area Management (ICMAM) programme, GIS based critical habitat information system was developed for Pichavaram mangroves, Gulf of Mannar, and Kadamat, Malvan and Gahirmata (Lakshadweep) and EIA guidelines were formulated for major coastal developmental activities and processes like construction of ports and harbours, assimilative capacity was determined for Tapi estuary(Gujarat) and Ennore creek (Chennai).

2.61 Ocean Observation and Information Services were carried out by deploying the moored buoys, drifting buoys, current meter arrays and XBTs for undertaking oceanographic processes and validation of satellite data. An autonomous centre called "Indian National Centre for Ocean Information Services" was established at Hyderabad, to cater towards generating and disseminating quality data and data products.

2.62 The Coastal Community Programmes (Societal Programmes) taken up by DOD relate to distribution of 50 units of Integrated Fish Finder cum Navigation Guidance System (IFFNGS) for locating fishing shoals and the position of fishing vessels in the sea in the states of West Bengal, Orissa, Maharashtra, Pondicherry, A&N Islands, Gujarat and Lakshadweep. The Potential Fishing Zone (PFZ) advisories for generated and disseminated for the benefit of fishermen on biweekly basis.

2.63 Significant programmes on island development are the project on shrimp culture which was completed; a pilot scale technology development for fattening of spiny lobster *Panulirus homarus* using live feeds (clams and mussel); and setting up of an seafront laboratory and a marine animal grow out system near Chennai and a laboratory at Port Blair to carry out studies on marine living resources, coastal environment, ocean observation and related areas in Ocean Science and Technology.

2.64 As a part of Marine Research and Capacity Building, DOD has been assisting the institutions, universities to create infrastructure facilities, taking up research and building up a skilled human resource base in Marine Sciences.

2.65 National Institute of Ocean Technology (NIOT) completed the testing of a pilot plant of capacity of 1 MW, under took the work on design and manufacture of underwater thruster of 800 W power rating and 140mm diameter for operations at 1000m depth and underwater connector suitable for operations at 1000 metre water depth in coastal and environmental engineering; and taking up indigenous development of instruments/hardware for marine and oceanographic use. To create Ocean Awareness among public, DOD participated in a number of fairs/exhibitions and funded various seminars, conferences, workshops etc.

2.66 Several activities were undertaken to promote/fulfil International Cooperation & Obligation. India continued to participate in the meetings of International Seabed Authority, Antarctic Treaty Consultative Committee, the programmes of Commission on Conservation of Antarctic Marine Living Resources, Scientific Committee on Antarctic Research, International Oceanographic Commission (JGOFS & GOOS), Regional Seas and Independent World Commission on Oceans and signed MOUs with a number of bilateral organization for undertaking joint ocean related programmes. DODs efforts lead to International Seabed Authority finally approving India's application for plan of work for exploration of polymetallic nodules in the pioneer area.

Specific Issues of Scientific Departments

- Since the INSAT programme has attained the operational/commercial capability, it would be appropriate to segregate the same from the S&T sector and include it in a development sector like Communication.
- Space services should be provided to the users on cost sharing basis so that the INSAT system could be made self sustaining.
- In the areas of remote sensing, there should be greater application of the remote sensing data/information by the development departments for designing, implementing and monitoring various developmental programmes.
- While providing R&D back up by the research institutions under DAE, efforts need to be accelerated for use of thorium.
- DAE may tie up these technology development programmes with the societal development programmes of the concerned departments/ agencies so that the technologies/capabilities developed in the areas of nuclear science for societal benefits are harnessed optimally.

- To bridge the gap between converting the important results of basic research into technology development, there is need to highlight as to how far various R&D projects supported so far have led to technology development and their commercialization.
- Science and society related programmes need to be more closely tied up with the programmes of the development sectors, so that the programmes relating to poverty alleviation, employment generation etc. could be strengthened with S&T inputs and large scale applications of the new technologies could be explored.
- In respect of modernization and upgradation of autonomous scientific institutions under DST, a phased programme for modernization requires to be evolved.
- To combat the menace of gregarious flowering of bamboos due to excessive green house gases there is a need to start a bamboo mission programme by DST so that the problem could be managed effectively.
- In respect of the R&D in drug industry being implemented by DST, DBT, CSIR and DOD there is a need to adopt a focused integrated approach by these departments through interaction so that duplication in terms of programme and investment are obviated. In the case of efforts relating to attracting young talent to science career, similar integrated approach is necessary.
- While funding R&D programmes one has to work for more interface with industry so that dependence on budgetary support could be minimized.
- Instead of several Departments like DSIR/DST/TIFAC and TDB taking up technology development programmes, to avoid duplication, they could be brought under one mechanism.
- Similarly in regard to biotechnology programmes and modernization/ upgradation of the facilities in terms of equipment being undertaken by various S&T departments/agencies in their institutions, more interaction among various departments undertaking them is necessary. This would help in optimal utilization of any facility and avoid repeated investment of scarce resources.
- Greater emphasis is needed on the critical tasks of consolidation of research results for technology development, demonstration and transfer, and taking up R&D programmes which have potential for market oriented technology development, in order that the benefits of these efforts are fully realized.
- It is necessary to ensure that the data on ocean observations are put to use in policy formulation, development programmes particularly in the areas of control of coastal pollution, marine fisheries, marine bio-diversity etc.
- The two long term programmes viz., Antarctic Research and PMN programmes are needed to be critically examined in the light of the experience and results obtained so far, and necessary mid-course corrections initiated accordingly so that only the need based activities are continued with optimum utilization of scarce resources.

General Issues

- The national apex level S&T mechanisms have been constituted, which should play an active role in formulating the over all S&T policy and provide implementation guidance in an integrated manner for harnessing the benefits derived from the Science and Technology for development of the various sectors of economy.
- To make basic research comparable to international standards in terms of publications, winning of awards and sophisticated facilities with specific indication of

areas etc. It would be desirable to compare the past and present Scientific Citation Index (SCI) so that standard of basic research could be assessed and gap areas identified and bridged.

- For implementing the thrust area research programmes in various disciplines, a single window mechanism may be evolved. Greater involvement and linkages are also required to promote basic research in the universities and academic institutions and specially around the outstanding scientists with a focus on strengthening of infrastructural facilities.
- Most of the research programmes, irrespective of discipline, must be/ required to be demand driven and based on market force so that the sophisticated research facilities and vast scientific and technological expertise could be utilized optimally for improving the quality and productivity of the goods and services.
- For integrating S&T with the socio-economic development, Science and Technology Advisory Committees (STACs) set up in various Ministries/ Departments need to be encouraged to take up an active role in providing the technology inputs necessary for the concerned sector.
- With regard to patents, indication of exploitation of patent along with the filing in various countries and obtaining of patents would be quite informative to assess our technological capability particularly for commercialization of research.
- So far as funding of the S&T programmes are concerned, contributions by industry and government are 28% and 72% respectively. In order to attract greater industry funding, national R&D institutions and laboratories should orient themselves in a greater measure to address the needs of the industries and take up industry specific problem solving programmes.
- In order to deal with the challenges posed by WTO, the S&T thrust need to be focused on (a) strengthening of intellectual property awareness, information, generation & exploitation mechanisms; (b) aligning of Quality Assurance Systems for S&T to international norms; (c) widening the innovation base through supporting non-formal and grass-root level innovation; (d) intensifying the funding of knowledge/ innovation based industries; (e) exploring and initiating the export of S&T based services; (f) and deepening & strengthening linkages among and between different players in the innovation chain.
- In the areas of patent and protection of intellectual property rights, efforts have to be made on providing the information relating to the aspects of exploitation of patent along with the filing and obtaining of patents to assess our technological capability particularly for commercialization of research.
- The science departments must interface with their science and society related programme with the major development programmes like IRDP, TRYSEM etc. so that innovative S&T based programme could be enmeshed for better performance and higher return.
- The popularization of science and inculcating scientific temper amongst the society were continuing for quite some time by all the S&T Departments/ Agencies. An assessment could be made as to the extent of achievement made in this regard particularly application of science in daily life and also understanding of scientific phenomenon in various spheres of life. Various programmes implemented by the Central S&T Departments may be reviewed on the basis of such an assessment.

- There is a large scale migration of students from India to other countries or from one career option to another resulting in non-availability of specialized and trained manpower in the field of S&T. There is a need to evolve an integrated scientific manpower development programme to curb such an outflow as well as to suit the national requirements.
- There are also some strategic concerns particularly relating to industries. While the resources are limited, there exists a need to continuously evaluate strategies of optimal utilization and conservation of resources to deal with likely shortages in future. New technologies relating to materials and processing need to be continuously addressed. There also exists a need to assess requirements of equipments, products and services which fall under the category of strategic needs particularly technologies for the extraction of new energy sources and raw materials from diverse sources including the sea-bed.
- Efforts made in some specific areas like combating cyclone, flood, landslide, earthquake etc. with S&T inputs need to be assessed particularly in the areas of research and its application in mitigation of natural disasters.
- The concept of zero based budgeting need to be introduced in planning and implementation of various S&T programmes.This facilitates identification of schemes that would be continued, converge/integrate with other schemes of the same department or related schemes of other departments, and the schemes that need to be discontinued/weeded out due to non-relevance.

Chapter 3

Industry Participation and Strengthening the Interface between Industry, R&D Institutions and Academia for S&T

Industry Participation in S&T so far

3.1 S&T is a key resource for development having enormous significance for the growth of national economy at macro level and for building business competitiveness at the micro level for the business firms. Today globalization and liberalisation have thrown up immense opportunities and some challenges for S&T too.

3.2 The R&D sector in India has so far been predominantly supported through Government funds. Traditionally, Indian industry has been seeking technology (mostly know-how rather than know-why) from foreign sources through license production. However, in the 1990s industry has obtained and successfully used technology developed by indigenous sources. In fact Indian academic and research institutions also have very good capabilities and have developed state-of-the-art technologies in many areas. Gradually, the interface between industry-R&D-academia has been gaining strength in terms of: acquiring new technology, availability of well trained scientific and technical manpower, gaining experience relevant to the country, development of sector specific capability etc. There have been weaknesses too such as : lack of forums for regular need-based interaction; low sensitivity to urgency; deliverability and end-use orientation; insufficient motivation for continuous improvement & innovation; lack of proper mechanisms for technology transfer and absorption; lack of level playing field; inadequate mechanisms for accountability and rewards etc.

3.3 During the last few years, however the Indian industry has become more conscious of the S&T sector as knowledge generator e.g. pharmaceuticals, biotechnology and information technology. The approach of the S&T sector towards industry has also undergone a welcome orientation. It has been increasingly recognized that greater coordination and cooperation between industry on the one hand and R&D/academic institutions on the other is called for. Moreover in the post GATT liberalized and competitive environment, Indian industry needs support of indigenous S&T in a big way so as to compete effectively with multi-national corporations in the domestic as well as international markets. For this, there is a need to set a target for the development of S&T during Tenth Plan. As suggested by Prime Minister the target

for the R&D investments could be to reach 2 % of GDP by the end of the Tenth Plan from the present level of about 1%. And in order to be able to utilize this level of R&D investments, it is essential and timely to take serious efforts to enhance and strengthen the meaningful interaction between industry, R&D and academia. As most of the S&T development in the country is being carried out by Government supported institutions, the Industry looks forward to the Government to play a significant role for strengthening the industry – R&D linkage through appropriate policy framework, fiscal incentives and by setting up institutionalized linkages and mechanisms to facilitate effective interaction between the industry and the S&T developers.

Technology Requirements of the Industry

3.4 At macro level, S&T management should focus on meeting the needs of the nation, including the industry, and encompass a wide spectrum of activities, namely basic research, applied research, technology transfer, design, development, fabrication, tests & trials, manufacturing, marketing, maintenance and product support during the life cycle. At the micro level, R&D institutions and the academia should not limit their efforts in developing technologies on laboratory scale. They must carry out further work for extending the 'R&D' to 'R&D and Engg' so that the indigenous technology can meet the specific requirements of the industry for setting up the manufacturing facilities.

3.5 Technology always changes rapidly. But, what is required of any technology is its capability to convert the related R & D outputs to economic value. The main contributing factor in this process is the overall technology climate in the country. Other dominant factors are: national policies for facilitating the evolution and application of R&D supporting infrastrucutral facilities like technological information sources; intellectual property protection regime; standards and productivity structures; engineering and design capabilities; equipment manufacturers; technology brokers/licensors; venture and risk capital instruments; and intra-institutional factors such as managerial practices; staff remuneration and motivation and project identification and management.

3.6 In the present liberalized environment, industry should pay much more attention to the external sources and upgrade its technology through radical technology jumps. It should anticipate technological changes and take advantage of the same, acquire appropriate new technology depending on its business strategy and commercially exploit it to develop and

produce new products for the competitive markets. Customers' subsequent experiences with the products may project new needs and stimulate requirements for newer technologies. Technology management for industry can be viewed as a continuous and cyclic process. A model for the technology requirement of a business firm is presented below.

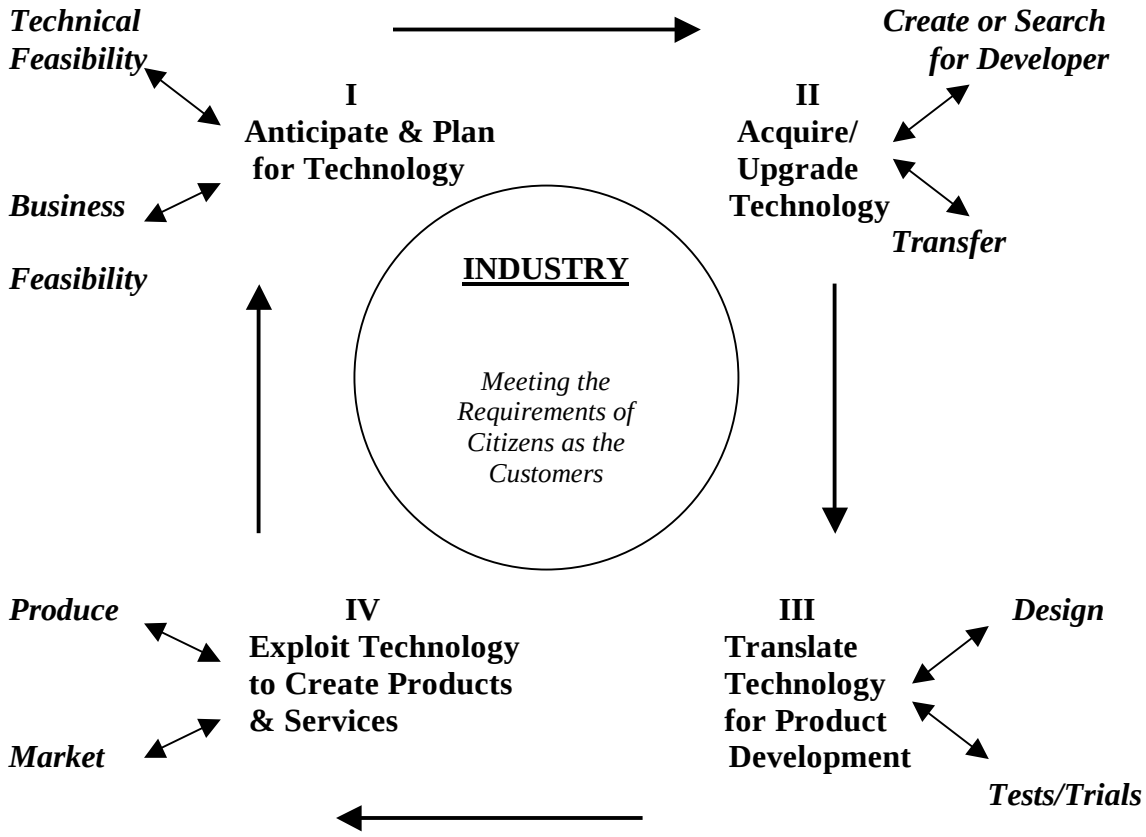

Fig: Technology Requirement Model for a Business Firm

3.7 This four stage model indicates the cyclic process through which industry should be geared to meet the requirements of customers by timely upgradation of technology. This model is rather an indicative one than a prescriptive one. Within one particular stage, there may be multiple levels depending on the market environment (comprising of technology, newer products and new competitors), technology & business strategies adopted by the competitors, opportunities and risks identified and prioritized by the firm, internal capabilities/competencies, management vision, management practices and many more factors. Further, industry firms may

also have certain specific short-term or medium-term requirements for upgraded/improved technology, where they may need support from R&D/academic institutions. The interaction between industry-R&D-academia has to be on a continuous basis, rather than being a one-time activity. This requires strong interfaces of permanent nature, where a kind of 'forum' may be there to facilitate the permanent need based interactions and some kinds of 'bridges' may facilitate reaching out.

Strengthening Industry-R&D-Academia interaction

3.8 To strengthen the interface between Industry-R&D-Academia and to enhance the level of industry participation, there is a strong need for appropriate steps to be taken at various levels by all concerned, i.e. Government, industry associations, R&D organizations, universities, research institutions and the industry. These measures may seem to be of general nature but should be implemented in area-specific manner, depending upon the sectoral uniqueness and requirements**.**

(a) Measures for increased awareness of mutual strengths and requirements

i. R&D/academic institutions and industry associations should facilitate organization of workshops, seminars and exhibitions to enhance/strengthen working level interaction between industry and R&D/academic personnel, and to enhance awareness about the scientific expertise available at the institutions and the problems faced by the industry. Sandwich programmes (attachment of a student to an industry after completing two years in a college to make the student understand the needs of the industry) may be introduced in select engineering institutions.

ii. There should be one-to-one linkages between the R&D/academic institutions and the industry firm(s) located in a local region, for continuous and sustained interaction.

iii. There is an urgent need for setting up of accurate, up-to-date, reliable, realistic and user-friendly data base(s) on indigenous technological expertise / infrastructure, S&T personnel, institutions, research programmes, technological breakthroughs & innovations, technologies available for transfer, venture capital for indigenous technology, and test & validation facilities available in the country and also those being established.

(b) Mobility of personnel and human resource development

iv. Qualified and experienced personnel from the industry firms and in R&D laboratories should be able to take up adjunct faculty positions in the academic institutions. Similarly, S&T

personnel from institutions should be facilitated to take up adjunct appointments in the industry.

v. Government and the Industry should facilitate easy mobility/exchange of personnel between industry and institutions on short/medium term basis, particularly at the time of technology transfer. The persons associated with technology development may be permitted to permanently move over to the technology licensee industry.

vi. Universities and academic institutions should organize appropriate training and continuing education programmes for the industry personnel to cater to the specific requirements of the industry.

(c) Reforms and changes in policy, procedures and systems

vii. The Government should introduce appropriate reforms and policy/procedural changes in the university set-up for allowing and encouraging the faculty to accept contract/collaborative research for the industry.

viii. R&D/academic institutions should simplify their terms & conditions including the IPR issues for technology-transfer to the industry.

ix. Government should permit technology-provider institutions to participate in the equity in lieu of full or part of the technology-transfer fee. This will enhance confidence of the industry in indigenous technology and also facilitate continued long-term association of technology-provider agency with the industry-venture being established.

(d) Technology transfer to the industry

x. R&D/academic institutions should give appropriate importance to design & product-engineering aspects, usability and upgradability aspects of the technology to be transferred to the industry.

xi. Interaction with the industry should not end at technology transfer. Technology provider agency should support the licensee industry continuously for problem solving, technology absorption, and improvement/upgradation of the technology.

xii. R&D/academic institutions should accept the commitment for undertaking further R&D work to upgrade the technology to meet the requirements of the industry. The licensee industry should be kept informed/posted of the subsequent improvements/ upgradation of technology.

xiii. Facilitate establishment of pilot plant facilities at selected R&D/academic institutions to

upgrade the bench-scale technologies developed through innovations.

xiv. R&D/academic institutions should take professional steps to facilitate smooth transfer of indigenous technology to the industry. For this purpose, Government should set up Technology Transfer Cells at the leading R&D/academic institutions.

xv. Government and industry associations should work towards establishment of independent test facilities for reliable quality-checks, calibration and also for technology validation.

(e) Institutionalized mechanisms to strengthen the interface

xvi. Government and industry associations should work towards setting up of 'Industry S&T Interface Institutions (ISTI)' in regions where there is a concentration of institutions and industry firms. These institutions should have technology management centres with qualified personnel, who may provide interface between industry and the technology teams working at the R&D/academic institutions. Such institutions should be autonomous and self-sustaining in nature, and should network with other similar institutions.

xvii. S&T Entrepreneurship Parks should be established at the academic institutions to motivate the faculty and entrepreneurs to establish industrial ventures on the basis of indigenous technology, using the technical infrastructure available at the institute(s).

xviii. The Government should provide financial support to R&D/academic institutions for establishing 'Technology Business Incubators', where indigenous technology could be nurtured further and demonstrated as a viable business proposition. Such centres would reduce cost of business-feasibility studies through shared physical infrastructure and facilitate reduction of gestation period for setting up the industry.

xix. Industry firms should cooperate with their industry associations to form consortiums to upgrade their infrastructure for R&D, to set up common facilities and to award contract research to R&D/academic institutions on issues of common interests.

xx. Government and industry should work together to establish local and region based Industry-Institution Interaction Forum(s) to discuss the problem issues and to assist the industry in generating appropriate solutions for the specific problems and to work as self sustaining profit centres.

(f) Incentives/support measures by the Government

xxi. There should be a mechanism to promote purchase of products developed through indigenous technologies. User Departments in the Government should give preference to the products

based on indigenous technology, which can compete on quality and price, without insisting on 'completion of prescribed years of experience in marketing of product' before becoming eligible to submit offer/tender.

xii. The Government should bring out comprehensive incentive scheme, applicable on medium term basis, for industry firms adapting indigenous technology as also for those investing in R&D.

Encouragement to specific industries

3.9 Certain industry sectors, both at low-end and at high end of technology, need encouragement and policy support from the Government to accelerate the velocity of R&D and to enhance the pace of utilization of indigenous technology.

3.10 For example India's forest based natural resources are fast depleting and greater attention is required to be given in the Tenth Five-year plan period to the forestry sector. The existing linkages between the industry and forest research organizations should be appropriately strengthened. Further, over last few years, there has been a tremendous opportunity for India to invest in pharma/biotechnology products, health-care products, agriculture, diagnostic-kits, and bio-informatics etc. These areas deserve a special attention in the Tenth Five-year plan period. Some of the important issues needing attention are as under: -

- Encourage higher productivity and attractive remuneration to producers.
- Better marketing support to the indigenous produce.
- Increased research support to the small and medium scale industries.
- Enhanced investment in development of industrial infrastructure, which would also help the new industries.
- Higher customs duties on import of finished products, atleast equal to the excise duty levied on the similar products when locally manufactured in India.
- Enhanced tax holiday period depending on the adapted based on indigenous technologies and their impact on long term R&D investment.
- Excise duty concessions for mass-consumed products manufactured on the basis of indigenous technology (including generic and ayurvedic drugs).
- Reduction of duties/taxes for industries investing substantial funds in their in-house R&D.

Chapter 4

APPLICATION OF SCIENCE & TECHNOLOGY FOR THE SOCIETY

4.1 Though India is reckoned as one of the leading nations in the area of Science and Technology with the largest S&T manpower base, the progress made has not made significant impact on the society, because the progress has not been in proportion to "technologies developed" and "technologies applied" and most of the knowledge remained either unutilized or under-utilized. All the research efforts were not applied to development of new technologies and all the new technologies were not necessarily immediately applicable. Therefore there is an urgent need to make all out efforts to ensure that appropriate research output which can be put to use for the benefit of the society is generated.

4.2 In other words, the need is to evolve mechanisms and identify programmes for application of S&T in improving the quality of life of the people, particularly, the weaker sections and women, and for the development of rural areas for reducing regional imbalances and inculcating scientific awareness. It is recommended that during the first year of the Tenth Plan itself a specific mechanism is evolved and instituted through which every year the Scientific institutions/departments can assess as to what results have been achieved through the cumulative efforts of the work done during the earlier years. Such results should be specific in terms of industrial products and change of life styles in rural areas.

4.3 The quality of life of a population, in the simplest terms, could be assessed on the basis of its health and nutritional status, purchasing power potential and knowledge and empowerment. The first two parameters are directly related to economic aspects and the third one to the sociological. In social terms, a good quality of life would mean availability of choices to an individual and right to choose the most earnest path of living.

4.4 So long as the activities of life are devoted to fulfillment of basic needs alone (which is the case for nearly 70% of the population of this country), the main role of science & technology could be to make such necessary interventions, which may blend with the life styles of the people rather than trying to change it (the life style). These interventions must aim at providing simple affordable scientific solutions, which help the individual, save on time and energy for the same life routine,

thus creating opportunities for additional works in the non-traditional areas and augmenting income. At this stage the science & technology can play a critical role as a provider of options and knowledge to the people. Introduction of new technologies could pave way for desirable shift in life styles and consequent improvement in quality of life.

4.5 Having identified the roles that the science can play in improving the quality of life, comes the next step in the mandate: "Implement it for the society specially with reference to the weaker sections and women." The weaker sections could be either dependent on some natural resource which they own or those having no access or rights to such natural resources.

4.6 In the case of the first category, a very wide spectrum of activities may be advocated. The immense diversity of our county's natural resources and various prevalent local situations suggest that location specific interventions would be required. This calls for evolving S&T on "participatory basis". The kinds of technologies to be provided should be what people want rather than what we want the people to adopt. This approach would not only ensure acceptability of the technological innovations but would also help people to look up to research agencies for solutions to their day-to-day activity. This would also help in generating scientific temper amongst the masses. The S&T have an extremely important role to play in the second category. There is an immense scope of creating awareness in this category for generating employment through expansion of science sector in the remotest parts of the country. Technologies which aim at value addition in the cottage/small scale industry products can play a vital role. Women could be involved in location specific production programmes. Access to non-formal education can pave way for gradual increase in employment in non-traditional sectors in the villages. Sectors like information technology, health & nutritional programmes, forestry programmes especially nursery raising and biodiversity conservation have a huge scope of involving people. These efforts can lead to economic upliftment and employment of women and other weaker sections. Thus, eventhough there is a vast potential for making a significant impact on the socio-economic conditions of the society through S&T interventions, due to weak science delivery system, the success in this regard is not very encouraging.

4.7 Application of Science & Technology for society has two important aspects. First, our society, be it weaker sections or others, is not a uniform group, but consists of a host of identifiable groups with entirely different life styles, different requirements and, therefore, no unified approach could be effective for all such groups taken together. Secondly, for the same identifiable group there could be many aspects where S&T could play an effective role. The organization endeavoring to direct its R&D towards societal needs must, therefore, narrow down to clearly defined section of the society (to its lowest level of organization) and then spell out which societal needs are likely to be addressed through a particular endeavor.

4.8 In this context, there are also other aspects that should be kept in mind. The first is the areas where S&T can play important roles. Broadly speaking, they are: proliferation of information technology to the remotest parts of the country and delinking formal education and computer literacy and giving more emphasis to the later, independent of the former. The second is the method of connecting the 'Problem Population' into 'Human Resource'. It can be done through: activity oriented training and skill up-gradation, developing entrepreneurship, and facilitating self-employment by using new technologies as test or demonstration. For this it is important to involve people working on scientific and research-based solutions for their long term problems like: drought, fodder crisis, epidemics, drinking water shortage, nutrition, sanitation, health, housing etc. and day to day problems like: value addition to the products, improved technology for routine works, improved dietary habits, shift towards non conventional energy sources, product packaging etc. The third is to find the ways of making the people cultivate the habit of using the natural resources (specially wood, bamboo, medicinal plants and other non-wood forest products) more judiciously through the application of environmentally clean technologies.

4.9 In a country like India which is rich in natural resources the simple ways through which society can progress are by: increasing productivity of economic activities; keeping focus on environmentally benign and cost effective technologies essaying sustainability; and by developing human resource through non-formal education. A method should also be devised to measure this progress from time to time.

4.10 In order to measure the success of the endeavor, i.e.; whether the expected outcome will have acceptability and would lead to a 'desirable' shift, Research Audit Cells (RAC) may be advocated comprising of socialists, environmentalists, economists and representatives of people, who could not only judge the merit of the R&D endeavors but also weigh the claims of agencies. The reports of the RAC could help bring in a much-focused approach for the agency concerned and could also form a basis for fund allocations.

4.11 In order that the impact of research could be increased many fold, there is a need to have a net-working amongst various agencies involved in R&D. Such a networking would help in bringing in synergy in the research efforts, focusing the approach for problem based research, avoiding duplication of efforts, providing proper extension of technologies and taking economical and competitive research. But such a networking itself is not enough. People should have not only easy access to the information on useful technologies, but also the financial strength and aptitude to use the technologies. To achieve this, self help groups with the help of facilitators of government departments could take up this task through a set up which may be termed as Common Facility Centres (CFC) with the following mandate :

- Perceive peoples' need, identify the S&T department which can fulfil that need and associate that department concerned for undertaking the job. Here comes the necessity of Networking of R&D Agencies / Departments each of which have attained certain level of progress in developing appropriate technologies for the benefit of society including weaker sections, women, tribals etc.
- Filter useful information generated by these S&T departments and make it available to local people.
- Motivate people to use these information/technologies for their benefit.
- Provide all necessary assistance (financial/otherwise) to the user groups for taking up new technologies.
- Provide insurance to the user against risks of failures in implementation of these technologies.

4.12 The CFCs are expected to maintain both forward & backward linkages; provide a communication link between the users and S&T agencies; help in exploiting potentials of all useful information; facilitate financial assistance,

programme, convergence for the end-user & marketing of their products and play a vital role in improving marketability of the products & services of entrepreneurs.

4.13 The CFCs should be located close to the user group as permanent service institutions. Non-government Organizations, Educational Institutions (Community Polytechnic etc.), Industries having social outreach programme will be needed to create these institutions with proper representation from the administrative, panchayati and community based organizations. Expansion of Information Management Technology by imparting appropriate training to local people could be a key area for correcting regional imbalances. Generation of employment and access to information at the remotest parts of the country would lead to improvement of quality of life.

CHAPTER 5
INTERNATIONAL COOPERATION IN S&T

5.1 International cooperation is expected to be a natural extension of the ongoing national programmes, or alternatively, national activities can be developed based on the results of the international collaboration.

5.2 International cooperation in science & technology is essentially a mechanism: (a) to provide the possibility of interaction between scientific researchers to update and refine their knowledge base for accelerating the pace of investigation as also to fill up any gaps in the available information, (b) to develop advanced technologies, high tech equipment and new generation required for the economic growth of the participating countries, and (c) to take mutual advantage of complementary scientific & technological capabilities amongst participating country teams.

5.3 International S&T programmes aid in the creation of national S&T assets through optimum utilization of available resources. They aim at capability building in terms of upgrading the skills, modernization of the facilities for undertaking scientific R&D activities and exchange of S&T information for mutual benefit. While science and technology has been universally acclaimed as a vehicle for economic growth, there are other factors besides the mutuality of interests in science & technology, such as foreign policy, which play a significant role in deciding the bilateral / multilateral ties in science and technology.

5.4 International S&T programmes may be classified into three categories, namely, bilateral cooperation, regional cooperation, and multilateral programmes. Considering the relative scientific, technical and financial strengths of the partner countries, the bilateral programmes may be further classified into cooperation with (i) developed countries; (ii) developing countries; and (iii) CIS Republics (erstwhile Soviet Union)

5.5 The accent in cooperation with developed countries is more towards strengthening knowledge base through exposure to latest trends / techniques

/ technologies in frontier areas; development of infrastructure facilities, including the human resources development; and evolving mechanisms / methodologies for catalyzing technology transfer.

5.6 The focus in respect of developing countries is more towards providing, as well as setting up, of advanced facilities, supplementing indigenous R&D activities, offering consultancy services, providing training opportunities / facilities, sourcing human resources through fellowships, carrying out state-of-the-art surveys, and finally, having S&T interventions for socio-economic development on a case-to-case basis.

5.7 Collaboration with CIS countries assumes greater significance in view of the special status each of them had in technological advancements in the erstwhile Soviet Union. Each country has its own expertise in specific areas, including technologies, highly trained manpower and facilities. There are potential technologies on which joint work can be taken up for commercialization and mutual sharing of the benefits. However, due to financial constraints in the CIS countries, a different approach is taken in developing joint activities. This includes the requirement of often sharing the financial burden by supplementing funds in their R&D institutions for mutually beneficial R&D.

5.8 While these tie-ups with various countries are important in the context of developing national programmes, an appropriate coordination mechanism is an essential factor for a fruitful cooperation. These aspects apart, it needs political goodwill, wherewithal and monetary resources, as well as efforts from all the participating countries to make a collaboration successful. For this, availability of stable funding and quick disbursal is an important factor.

5.9 At the regional level, the cooperation modes have generally been more inclined to organization of joint seminars and workshops, group training and preparation of state-of-the-art reports, rather than on joint R&D. Cooperation in multilateral mode includes our participation in country programmes under UNDP auspices; UNESCO related activities pertaining to S&T through Indian National Commission; and participation in activities of the NAM S&T Center.

Present status of international S&T cooperation

5.10 Department of Science & Technology (DST) has been entrusted, in close cooperation with the Ministry of External Affairs, with the responsibility to negotiate and implement international S&T cooperation agreements, coordinate S&T aspects of activities of international organizations and appoint Indian scientific attaches abroad. Department of Biotechnology (DBT) serves as the inter-ministerial and inter-agency nodal point for all specific international bilateral and multilateral R&D collaboration and agreements in the area of Biotechnology and work related to the International Center for Genetic Engineering and Biotechnology (ICGEB). Department of Scientific & Industrial Research (DSIR) is responsible for maintaining the national register for foreign collaborations. Other scientific departments have been entrusted to deal directly on international relations in matters connected with their respective sectors and on arrangements with universities, educational and research oriented institutions abroad in connection with foreign scholarships and the training of Indian scientists.

International S&T Programmes of Cooperation by Scientific Agencies

5.11 DST has coordinated the signing of inter-governmental S&T agreements with 56 countries so far and suitable mechanisms were established for implementation of programmes of cooperation with 36 countries. Some of the important among them are: DST coordinated/collaborated programmes like Indo-US S&T forum; advanced training in Super Photon Ring of 8GEV of Japan; International Advanced Research Centre for Powder Metallurgy (ARC-I); INDUS-I and INDUS-II synchrotron radiation sources etc. In the activities of NAM-S&T Center, 36 countries have been participating. Some of the areas of collaboration on new technologies include: laser ultrasonics; gas-phase mirage spectroscopy; MANAS chip development etc. Major collaboration activities of DBT are in the areas of contraceptive and re-productive health and plant and medical biotechnology. DOD's international cooperation mainly relate to UN convention on

the Law of the Sea, Antarctic Treaty system, South Asia Regional Seas Programme etc.

5.12 In the field of Atomic Energy, the International Atomic Energy Agency (IAEA) recognizes India as a " developed state". India is also a member of several IAEA committees. As a donor, DAE has been imparting training to other members of the Technical Cooperation Programme. DOS cooperates with several foreign countries and space agencies. Antrix Corporation markets ISRO's products and services outside India. Some important areas of S&T Cooperation of DOS include: Megha Tropiques; earth and atmospheric sciences; remotesensing and GIS applications etc.

5.13 Through various protocols, CSIR implemented collaborative projects and workshops with agencies in 27 countries. Important new areas of research and facilities set up in CSIR laboratories through external assistance include: Creep testing, Turbo machinery, coal gasification, tower testing etc. Every year 80-100 scientists from other developing countries are being provided training in CSIR laboratories. ICMR coordinates international S&T programmes in biomedical sciences pertaining to: heart diseases, RF/RHD, Cancer, re-productive biology and TB, AIDS etc. Some of the typical collaborations are: ICMR-INSERM (France) MOU and Indo-Russian Working Group.

5.14 During 10^{th} Plan, from various considerations, international collaboration has become a dire necessity. However, in view of rapid globalization, shrinking government funding, fast depleting material resources, rising economic competition between nations and the growing need to protect intellectual property, it is essential to find cost-effective approaches in international scientific collaborations. At the same time, best use of the established mechanisms, contacts and collaborative tie-ups could be made only if the scope of government's financial support is suitably enhanced on an urgent basis to meet the present day ground realities and challenges. This will result in higher level of interest among the scientific community as well and result in extended range of collaboration, which will bring more focus, comprehensiveness and visibility to the international programmes. Various

mechanisms of implementing international cooperation during 10th plan have been suggested below.

Access / Participation in Major International Facilities and Programmes

5.15 An existing mechanism, which needs to be intensified relates to participation of Indian scientists and laboratories in the setting up of major facilities abroad in cash or kind during the establishment of such facilities thus helps not only in giving our scientists a better access in these facilities, but also in upgrading the skills for setting up similar facilities in the country. Concerted effort therefore needs to be put in identifying such activities internationally and an exclusive fund should be allocated to enable such participation with national priorities in mind. Further, India should conscientiously strive to enter into appropriate bilateral arrangement with the world class facilities abroad for use of these facilities by our scientists and participation in their programmes in cases where there are no plans to create similar facilities within India in the near future. Government funding to Indian scientists should be enhanced to fund totally the visit of the scientists as well as buying the facility time, if required. Separate allocation needs to be made to take up sub-contracts in upcoming international facilities.

Establishment of Centers of Excellence/International Class Facilities in India

5.16 A new initiative suggested is the establishment of international class facilities within the country, which would help in attracting Non Resident Indians (NRI) back home, as well as induce the foreign scientists, including Persons of Indian Origin (PIO), to work in these institutions, who would be able to contribute to the Indian Science. Better Work Ethics and Environment would further accelerate the growth of science in India. Choosing such areas where India has certain natural advantages like: Biodiversity, Geographical location, S&T manpower, will attract collaborations more readily. This may be sought to be achieved either by identification and upgrading of some national centers to international standards in which there is a proven excellence in allied areas, or by establishment of international class facilities in frontier areas. Some of the centres which may be considered in the first category are: National Center for Medium Range Weather

Forecasting (NCMRWF); establishment of the Indian Astronomical Observatory at Mt. Saraswati, Hanle, Ladkh; National Core facility for Genomics and Proteomics; a facility of 'Bio-Solver' – massively parallel computer (in the line of Flow Solver of NAL) for obtaining a synergistic fusion between modern biotechnology research and information technology. Some suggested areas in which the world class facilities may be created could be: Biological Containment; Tissue Engineering, Earthquake Engineering, Bio-Materials / Polymers, Electronic grade materials, nano-size particles, thin films, nano-tubes, Fuel cell technology, Ceramics, Surface Engineering, etc.

Intensification of Cooperation with Developing Countries

5.17 The socio-economic problems being similar with the developing countries, common S&T interventions and pooling of resources should be aimed at. Emphasis should be on receiving people from developing countries by offering fellowships to S&T personnel to work and receive training in India.

Fellowships / Training for Post Doctoral Level Scientists

5.18 Another new initiative suggested is to obtain specific number of slots by negotiating with the foreign foundations offering such fellowships, which may be centrally operated in India. Mobility of young scientists among developing (as well as developed) countries could be increased. Necessary schemes to attract talent from outside should be put in place.

Programme for attracting researchers to work in India

5.19 This again is a new initiative. Talented young Indian researchers working abroad should be encouraged to come back to India by offering competitive career awards to work in Indian institutions of their choice in nationally important programmes. This could be along the lines of Welcome Trust Grant or Swarnajayanthi Fellowship. Further, foreign scientists too should be invited to do their research activities in Indian institutions of excellence and for utilizing Indian international class facilities like the Giant Meterwave Radio Telescope (GMRT) in Pune and Telescope Facility at Hanley in Ladakh.

Catalyzing Technology Development

5.20 Some of the measures that may be suggested for catalysing technology development are: establishment of Joint R&D Centers for Pre-commercial Technology Development; participation of Indian laboratories in ongoing technology development programmes of a few premier laboratories located in the developed countries also by way of sharing the cost associated with technology development; making appropriate provisions in the S&T Programmes to include industrial participation as far as possible; by expanding the bilateral cooperation agreements to include the state-of-the-art technological facilities as demonstration centers with foreign institutions providing the technology at a discounted price etc.

Showcasing Indian expertise / technologies through exhibitions

5.21 If laboratories have to sell their technology worldwide, their participation in industrial exhibitions is essential. In this context the need for Chamber of Commerce & Industries to interact actively with scientific departments like DST, DSIR, DBT etc. and research laboratories may be advocated. Technology expositions jointly by the Government and these institutions on a cost-sharing basis and facilitating future follow-up until successful technology transfer could be attempted through bilateral S&T arrangements.

Integration with major national programmes

5.22 There is a need to ensure linkages of international collaborations with large national programmes like: Natural Disaster Mitigation, AIDS / Cancer, Superconductivity, Alternate Energy, Clean Technology, programmes under Technology Missions, etc. For this, a focused exercise to identify gaps to be filled for successful implementation of the programme through international inputs could be taken up and special programmes with suitable countries with necessary expertise formulated.

Intellectual Property Rights

5.23 Intellectual property rights arising from 'joint research / co-

operative projects' will need to be shared jointly and regulated in accordance with respective national legislations of participant countries /scientists / institutions / organizations through an agreement.

Coordination of international S&T cooperation / management of database

5.24 Since international S&T programmes are implemented by various Ministries / Departments / agencies / organizations, there is a necessity to create an appropriate mechanism (such as a National Steering Committee), to enable a strategic, integrated and cohesive approach to specific programmes and also a suitable database/ information system.

Enhancing S&T Representation in Indian missions abroad

5.25 Currently we have scientific attaché only in Germany, Japan, Russia and USA. There is an emergent need to create scientific attaché positions in other appropriate countries, like China, UK, Latin Americas and Asian region for intensifying the collaborative efforts.

Reallocation of External Technical Assistance Funds to Scientific Agencies

5.26 Presently external aid under the aegis of ODA, GTZ, AUSAID etc (including some fellowships / training opportunities) of which S&T is a part is being coordinated by the Department of Economic Affairs (DEA) leading to undesirable delays. To introduce efficiency in the S&T component of such programmes, it is suggested that the management of funds for international S&T activities may be directly handled by the concerned scientific agencies.

5.27 Some suggested S&T areas for international Cooperation in the 10th plan which are based on our national programmes as well as partner countries' capabilities are:

Basic Sciences, High Performance Ceramics, High Performance, Polymers, Nano-Materials, Nano-technology & Nano-electronics, Sensors, Manufacturing Technology, Bionics, Development of NWP models on massively parallel computer systems, Development of coupled atmosphere-ocean models for extended range prediction/Climate

Prediction, Global networking for Natural Disaster Management, Functional Genomics & Proteomics, Diagnostics & Vaccine research, Plant and Agricultural biotechnology, Technologies for Exploration and Exploitation of Ocean Resources, training of Scientists/Technologists in particular Coastal Zone Studies from Developing Countries in India, Research in the Ocean Atmosphere coupled models with Advanced Countries. Science Popularization / Communication (Establishment of a Chair) etc.

CHAPTER 6

HUMAN RESOURCE DEVELOPMENT IN S&T

6.1 In the process of bringing about technological innovations as well as during the implementation of new technologies developed as a result of such innovations and finding solutions to the new problems which arise during the process of modernizing and developing a society, human resource / manpower development in S&T assumes a special significance. It is also an indirect measurement of the strength of the country as it contributes to socio-economic development through participation in S&T activities.

6.2 Development of S&T manpower depends on the quality as well as need based and S&T related higher education. The 8th and the 9th Five Year Plans have laid considerable emphasis on scientific and technological inputs in various programmes of socio-economic sectors and aimed at improving the quality of S&T education. With the current restructuring of the economy, adoption of economic liberalisation policies and emphasis on the implementation of the scientific policy resolution, it is clear that scientific and technical manpower will be required in considerable strength to meet the objectives of economic development. India's enormous manpower resources can become an asset only when it is appropriately trained and educated. Against this background, it is relevant to examine the present status of science education in the country.

Status of Undergraduate Science Education

6.3 There had been a phenomenal growth in the number of universities and colleges imparting science education and in the students enrolling in the science stream. Student enrolment in the science stream at undergraduate level was a mere 1.25 lakh in 1950 which increased five-fold by 1985 and is today estimated to be over ten-fold of the number 50 years ago. Despite this impressive growth in numbers, the percentage of school students opting for science has consistently declined over the years. While in 1950, around 32% of the students who passed the higher secondary examination

enrolled in the science stream, this percentage declined to around 20% in 1986 and is now estimated to be around 15% only i.e. less than half the figure 50 years ago.

6.4 Also there is a marked shift downwards in the quality of the students taking to science stream. This is evidenced from the comparatively lower range of marks needed for admission to science stream as compared to other streams. It is the distilled "left over residue" which forms the major input to our undergraduate science education programmes. As a result the level attained by Indian science graduates today is considered to be much inferior to that of a science graduate from western countries. Those few who pursue post-graduate education in science generally lack curiosity, are devoid of creativity and innovativeness and are unmotivated. It is becoming increasingly difficult to find adequate numbers of motivated and competent students to take to science education and R&D. This is evident from the high drop-out rate of NET qualified research fellows. There is near saturation in the out-turn of post-graduates and doctorates in science over the last decade. If the trend continues, even sectors like Space, Biotechnology, Defence and Atomic Energy will find it difficult to recruit young scientists of high caliber needed for the national programmes. What is at stake is not only the future of science and technology in India, but the very foundation of its long term industrial and economic growth, national security and social welfare.

6.5 Several reasons contribute to the quality deterioration in science education. A large number, around 90% of undergraduate science students, is educated in affiliated colleges, most of which are overcrowded, under equipped in laboratory and library facilities, and poorly staffed. Undergraduate science education programme has now become entirely chalk-talk-rote routine without any emphasis on understanding of the basic concepts and the unity of the subject. Classroom demonstrations and open ended experimentation have all but disappeared from the undergraduate programmes (although science is truly experiment based). This depressing environment curbs the inherent and natural excitement of doing science.The examination system has contributed further to

the deterioration of science education as it emphasizes on rote memory rather than on analytical ability and fresh thinking. The dropout and failure rate is quite high at around 40%. There are nonetheless an exceptional few institutions that offer science education comparable to that abroad. But they are confronted with outmoded curricula and rigidity of institutional set up of the universities and are thus unable to make any significant impact on the general scene.

6.6 However this is not the case with engineering and medicine which still continue to attract the top 10% of the school graduates. In regard to engineering education there has been a continual increase in the number of institutions and out-turn of engineering graduates. The number of institutions increased from around 340 in 1990 to 580 in the year 2000, corresponding figures for out-turn of engineering graduates being 42,000 and 72,000. The IITs, Regional Engineering Colleges and a few other technical institutes have been able to maintain tenable level of engineering education and infrastructure. But the science education needs a closer and detailed look.

Choice of Science as a Career

6.7 As already pointed out earlier, the talented students are generally not prone to opt for a job in science because they do not see it as a rewarding and satisfying career. Even those who take up science as a career are getting discouraged by the unsatisfactory work of our scientists who are not gaining prominence either nationally or internationally. The contribution of Indian scientists to global knowledge has also stagnated for over two decades at mere average of 12,000 scientific papers per year despite the increase in the number of the active scientists.

6.8 The job opportunity pattern has undergone a sea-change in the past five years. The share of government and government supported organizations in the overall job market has considerably declined. There is also an interse shift between the primary, secondary and tertiary sectors of the economy for creation of new jobs creation, the balance shifting heavily in favour of the services sector-basically the IT, communication, banking & financial services. Added to the above is the universalisation of the job market and the

recognition of Indian skilled and trained human resources in the services sector as among the best in the world. This has created a lure and pull on our youth from abroad.

6.9 Even then, in view of the tasks involved as a consequence of the targets set for the 10th plan, there is a need to produce a sizeable number of personnel by talent search, incentives and through infrastructure development in the 10th plan. For example, the S&T expenditure as a percentage of GNP is targeted to be raised from the present level of 1% to 2% by the end of the 10th Plan and about 300 companies from abroad had set up R & D centers in India and more are expected to follow. Due to this and on several grounds, it has been estimated that India would need around 50,000 S&T work force over the plan period.

6.10 Further, it is estimated that knowledge led business contributed around 12% of the global GDP in the year 2000 but its contribution in just a decade is set to exceed 25%. India can participate beneficially in this new factor of economic growth based on its large pool of scientific and technical manpower being innovative and globally competitive in their knowledge base. Thus there is a need for India to maintain a viable base of scientific manpower which would arise from the more talented and bright amongst our youth taking to science and to make requisite investments in improving the quality of its science education and nurturing a cadre of the most brilliant and gifted youth to take up science as a career.

Future Strategy

6.11 To achieve the above targets, a five pronged strategy indicated below could be considered.

i. to selectively nurture excellence in science education;

ii. to identify, motivate and attract the talented to pursue science as a career;

iii. to provide avenues and opportunities for those engaged in science to refurbish and enlarge upon their knowledge and skills base;

iv. to devise strategies to retain the best in active science; and

v. to involve the corporate sector in science education and R&D.

6.12 The following measures may be suggested for implementing the above strategy:

- To set up on par with IITs and IIMs specialized science institutes as centers of excellence in various parts of the Country and in every institute to train every year a selected band of 1000 students in science education programmes leading to an M.Sc., Degree. To attract the cream of the lot, a suitable stipend may be offered to them. The rules governing the faculty in the Institutes may be suitably amended to permit them co-appointments and honorariums on consultancy. The institutes could be managed by establishing an autonomous council and financing from 1% of the Plan allocation of the scientific agencies.
- To proliferate excellence in science around the country, each national laboratory (under the Science Departments/Agencies) adopt at least one school and one undergraduate college for raising the level of quality of their science education.
- To attract highly talented students to R&D, the Assured Career Opportunity Scheme in science, proposed by DST, which provides appropriate scholarships during their education and assured employment with a career profile may be supported.
- To upgrade the knowledge base of the teachers, 'floating academies' might be organized on regional basis where science teachers are imparted in a crash time frame (during vacations) knowledge on new emerging areas like genomics, bio-informatics, conducting polymers etc. Successful participants may be offered an honorarium/incentives.
- To retain the best talent, some of the benefits like liberalisation of travel grants for conferences/seminars abroad, co-joint appointments with universities abroad, allowance for unlimited honoraria for consultancy and permitting working scientists to set up their own science enterprises etc.may be provided.
- Involvement of corporate sector in science education and R&D can be in two ways: first by sponsoring chairs in their corporate names in the

specialized institutes referred to above and second by adopting a school or college to develop student and faculty excellence. Besides, more science oriented corporates in the pharma, biotech, communication and information sectors could share part of the responsibility of the Government in supporting centers of excellence in their concerned subjects of interest.

- As talented young men and women are not coming forward in the required members for R&D career in science and technology, appropriate schemes should be launched to *"catch them young*". Graduate level and Post Graduate level merit scholarships/fellowships may be launched from a central fund. Such scholars should be provided summer employment/training in leading S&T institutions and R&D organizations. Leading S&T organizations like DAE, ISRO, DRDO, IITs etc. should have special quotas and schemes to directly employ such students without long drawn recruitment processes. Selection/recruitment may be done in the final semester while the students are still in the College. In addition, there should be dedicated schemes in various S&T areas for continuous mid-career education and professional training in the emerging technology areas and disciplines.

Chapter 7

CORE AND MISSION MODE PROGRAMMES

7.1 Undeniably, science and technology component contributes in a major way to the improvement of standards of living and quality of life vis-à-vis raising the economic growth of a country. In India since independence the efforts made towards S&T have led to the creation of a large infra-structure for science and technology covering a wide spectrum of areas. These capabilities are of a quality, and on a scale, that they can make a significant contribution to rapid national development. What is needed are mechanisms that can ensure that these capabilities can be appropriately utilized to solve the national problems which are clearly defined on the basis of national objectives and needs. One of such mechanisms is a mission mode approach by identifying certain core programmes. With a special emphasis during the 10th Five Year Plan to use the S&T infrastructure built up during the nine five year plans towards actual delivery of products and services to the economy and people in an affordable and sustainable manner, it has become essential to focus on actions and outputs. Hence, the following core programmes, mission mode projects and special action programmes have been identified.

Core Programmes

7.2 Among the clearly defined programmes in any sector-scientific or otherwise –the most important of the lot which are indispensable and need all out efforts –both physical and financial–to implement them are considered as the core programmes. The essentiality of the projects included in such core programmes is so much that the favourable impact of their contribution on the society /quality of life in general and on the S&T development in particular is considerably high.

Mission Mode Programmes

7.3 The core programmes pertained to the areas and topics which are considered as significant by S&T personnel of the Departments themselves. This is correct when one is dealing with pure science, and fundamental techniques and processes of the future, including newly emerging high technology areas such as nuclear and space technologies, biotechnologies, microelectronics, information technologies etc. However, this is an inappropriate methodology if science and

technology has to have an impact on the functioning of the country through improvement and enlargement of a fairly large conventional base of its agriculture, industry and various infrastructure sectors; in these S&T has to relate ultimately to the objectives in these sectors, to the investments and economics involved, and to available materials and skills. For this, science and technology can be far more effective if it is closely responsive to the demands posed to it. Such a demand can arise through setting goals in major socio-economic sectors, identifying their science and technology components and instituting a number of science and technology missions to meet these goals. The projects identified by adopting such an approach are Mission mode projects.

7.4 A mission mode approach to technological development can have several major advantages. It would provide emphasis on getting a job done, using all possible resources, manpower and expertise, irrespective of the agency or organization they come from. Such tasks, when posed with cost and time constraints and other limitations (e.g., embargoes on import etc) provide challenges which will enhance the initial capability. This approach will foster relevance and provide motivation. It would automatically establish linkages which are live and working. It would bring meaning to the work of many by providing visible opportunities to contribute well defined goals. It would also introduce a sense of urgency and help to meet time targets.

7.5 The criteria for identifying a mission mode project are:

i) Socio-economic relevance/essentiality.
ii) Readiness for operationalisation
iii) Availability of skilled manpower
iii) End-user acceptability
iv) Requirements of equipment/production/procurement of technology
v) Training needs and
vi) Lead time for creation of adequate infrastructure.

7.6 There are two categories of mission mode projects-One devoted to subserving critical societal needs of nation-wide socio-economic relevance, and the other aimed at development of technological excellence and its application in

areas of national importance. In identifying the first category of projects, more emphasis may be laid on the criterion (i) and for the second category, emphasis will be on criterion (v).

7.7 Some of the S&T areas identified as Mission Mode Programmes during the 10th Plan are given below department wise:

Department of Atomic Energy

1. Advanced Heavy Water Reactor (AHWR) and development of technology for utilization of Thorium for third stage of nuclear power programme.
2. Technology demonstration and transfer of water desalination.
3. Nuclear medicine.
4. Application of irradiation technology of farm products.

Department of Space

1. Operationalisation of National Natural Resource Management System (NNRMS) for application of remote sensing technology in developmental programmes.
2. Technology development for future generation of launch vehicle/development of advanced launch vehicle technology.
3. Development of all weather remote sensing technology.
4. Application of space technology in education and health particularly distant education and telemedicine.

Department of Science & Technology

1. Technology for bamboo products.
2. Drugs & Pharmaceutical research.
3. Instrument development
4. Seismology
5. Nano science & technology
6. Technology Business Incubators

Department of Biotechnology

1. Genomics covering human plants animals and microbes with emphasis on drug targeting.
2. Development of new drugs and molecules from important medicinal plants.

3. Bioresources characterization and inventrisation and documentation of special ecosystem
4. Production demonstration and testing of biofuels
5. Development of New Generation vaccines
6. Food & Nutritional Security

Department of Ocean Development

1. Exploration and technology development of gas hydrates
2. Large scale technology demonstration of ocean thermal and energy convergence plant
3. Ocean information service.
4. Technology development and demonstration of drugs from sea.

CSIR/DSIR

1. Development of technology for control of Asthma caused due to pollution.
2. Leather technology
3. Design & development of civil air craft-stretched SARAS and HANSA.
4. Traditional knowledge digital library for bringing out comprehensive, information and document on traditional knowledge.
5. Exploration and exploitation of microbial wealth of India.
6. Molecular biology of selected pathogen for drug targeting
7. Study of Mesozoic sediments for hydrocarbon exploration in coordination with ocean development.
8. Herbal preparation, standardization, validation and introduction
9. Evolving pollution monitoring system/devices for air, water and solid waste.
10. Development of microwave tube technology for ultra high frequency communication for large scale application.

7.8 Apart from these, CSIR has identified 24 Mission Mode Programmes in the areas of : Development of Specilised Aerospace Materials; Photonics and Opto-Electronics; New Generation Fuels and Lubricants; Custom tailored special materials etc. and 21 Core

Programmes in the areas of developing and sustaining high S&T for National Aerospace Programme; Electronics for Societal purposes; Advanced facility for Safety Evaluation of Genetically modified/Engineered Drugs; advanced manufacturing technology etc. The details are at paras 12.29 and 12.30.

India Millennium Missions 2020

7.9 These are aimed at multi-institutional and multi-departmental efforts to deliver the benefits of science and technology to Socio-economic sectors typical set of missions identified include:

Electric Power, Energy and renewable energy sources; Surface transport; Food, Agriculture and Agro-food processing; Engineering Industries; Health care and Population; Services; Critical Technology; Information Security etc.

SPECIAL ACTION PROGRAMME

7.10 While the above mentioned core programmes and mission mode projects will receive thrust during the 10th Five Year Plan, it is also proposed to have a few programmes mounted on a special action mode to reach upto the final delivery stages. Some of the initially identified Special Action Programme (SAP) are :

- Bamboo products and associated bamboo cultivation
- Instrumentation for various sectors
- Disaster management
- Leather and leather products
- Herbal products
- Distant education and telemedicine

CHAPTER 8

Tenth Five Year Plan Programmes-Atomic Energy (R&D Sector)

8.1 DAE (R&D), as in the past, pursues its high-tech areas in such a way that basic science and technology development go synergistically and an organic linkage is established between the laboratory system and industry. DAE units have realised most of the goals set for the IX plan and the department is now ready for a steep take-off. While formulating the Tenth Plan, efforts have been made to take up further challenges particularly to pursue multi-agency programmes for delivery of science to specially identified target groups in the country. Every scheme is examined for technical feasibility and economic viability including analysis on the principles of Zero Based Budgeting at various levels viz., Constituent Units, Department and finally Atomic Energy Commission. DAE has built up a formidable base in the past and has been moving towards the goal of delivering 20,000 (Mwe) by, around 2020 by inter alia, taking up a successful fast reactor programme and an efficient thorium utilisation programme. In tune with the present globalisation and liberalisation era, DAE will participate in collaborative advanced basic research at the international level and develop advanced competitive nuclear technologies. In this process, it will continue to maintain close linkages with the education system as well as industry.

8.2 Realising that, from economic as well as strategic considerations, a long term energy security in India should be based mainly on indigenous resources and that the thorium based nuclear energy systems will have to be a major component of the Indian energy mix in the long-term and also the fact that India has to be in the lead as far as the development and deployment of thorium utilisation technologies are concerned, the future policy to be adopted by DAE will be to build a strong indigenous R&D infrastructure as well as to deploy in their future programmes the appropriately trained scientific and engineering manpower.

8.3 With regard to the nuclear power programme the policy will be to continue to pursue it in three stages finally envisaging a closed fuel cycle involving reprocessing of the spent fuel to separate the fissile fuel for recycling. Based on radiation technology applications, significant contributions will continue to be made in the areas of food, agriculture, health and industry. In the area of basic research, while contributing to

the knowledge pool in nuclear and related topics and thereby strengthening our technology development capability, the objective is to link it intimately with the development of cutting edge technologies so essential for pursuing basic research. Human resource development will also receive high priority during the 10th Plan by strengthening the linkages with academic system. Another important aspect of the policy is that the strategic technologies should be well guarded and that they should be developed both to meet defence requirements and to promote economic growth. Keeping in view these policy guidelines, DAE has formulated its Tenth Plan activities under a number of major programmes realising at the same time the necessity for DAE to cater to the national strategic needs. Broad highlights of the major programmes of DAE during 10th Plan are given below.

Nuclear Power Programme

8.4 It has been recognised that Nuclear Energy is a sustainable energy resource for our country. As already stated, the Nuclear Power Programme, based on a closed nuclear fuel cycle is being pursued in 3 stages. The first stage started with the indigenous development of nuclear power plants based on Uranium cycle in Pressurised Heavy Water Reactors (PHWRs). Enough R&D has already gone into it. The required R&D support for currently operating and future PHWRs will have to continue to ensure that : the technology does not become obsolete; safety and economic competitiveness of nuclear power is continually improved; and capacity utilisation is further maximised. In case of operating plants, continuing R&D will be deployed in some of the areas like ageing management, life extension, in-service-inspection, repair technologies which can carry all jobs remotely with minimum man-rem consumption and also in other programmes like progressive introduction of MOX fuel in the reactors at Tarapur. Technology for the front end and the back end of the fuel cycle also will be pursued hand in hand with the nuclear reactor technology.

8.5 The second stage started with the Fast Breeder Reactor Programme at IGCAR, Kalpakam utilising plutonium based fuel. Improvements and upgradation in the technology will be an important part of the programme in the coming years. For irradiation of fuel and structural materials to be used in the fast reactors, various projects to be pursued under the 10th Plan are in the areas of physics and shielding, chemistry,

materials, thermal hydraulics, structural mechanics, component development, fuel development, in-service-inspection, instrumentation and control and fuel cycle.

8.6 The third stage pertains to designing and developing advanced nuclear power systems which will utilise the precious plutonium resources in an optimum way to maximise conversion of thorium to ^{233}U, extract power in-situ from the thorium fuel, and recycle the bred ^{233}U in future reactors. This is the major work during the 10th Plan. The goals set for the Nuclear Power Programme in this stage are: utilization of thorium as fuel on a commercial scale; large scale deployment of nuclear power in the country; achieving a good economic performance as compared to alternate options for energy generation; utilising the proliferation resistant potential of thorium fuel cycle to the fullest extent; providing for adaptability to non-electrical applications, in particular, desalination and high temperature processing applications, including those for generation of non-fossil fluid fuels.

8.7 Keeping these goals and the current international trends in nuclear technology in view, a road map for the third stage of Indian nuclear power programme is drawn involving 4 steps viz., development of AHWR for specifically utilizing thorium for commercial power generation; design and development of High temperature reactor based power packs mainly for process heat and non grid based electricity generation applications; accelerator driven sub-critical systems (ADS) to produce several times more electrical energy than that required to run the accelerator; and accelerator driven system with a fast reactor sub-critical core together with a mainly thorium fuelled thermal core somewhat similar to that present in AHWR. Based on a Co-ordination Committee's report, the details of the accelerator technology to be developed for the ADS programme during 10th Plan have been worked out.

Radiation Technology Applications

8.8 Under Radiation technology application programme, the DAE will continue to develop research reactors, accelerators and lasers and other advanced technologies. One of the major programmes to be initiated during the 10th Plan is the setting up of a research reactor for isotope production and associated isotope processing facilities at a new campus to be set up for BARC. Development of technologies for desalination will be

given further impetus. Efforts to develop technologies for the production of the strategic materials in the country will be intensified. DAE will also initiate projects around all its installations for the deployment of technologies such as farming for the production of breeder seeds using mutant developed by BARC, setting up of laboratory facilities for the production of saplings by tissue culture techniques for distribution to farmers in the area, and any other technology which could provide improved means of livelihood to the people. For this purpose, land around nuclear installations will be utilised with the involvement of farmers in the neighbourhood with the DAE scientists

ce to specially identified target groups in the co[un]try. Every scheme is examined for technical feasibility and economic viability including analysis on the principles of Zero Based Budgeting at various levels viz., Constituent Units, Department and finally Atomic Energy Commission. DAE has built up a formidable base in the past and has been

moving towards the goal of delivering 20,000 (Mwe) by, around 2020 by inter alia,

successful fast reactor p existing infrastructure will be augmented and at certain locations new infrastructure set up.

Core and Mission Mode Programmes

8.11 The details of the Core Programmes and the Mission Mode Programmes are given below.

8.12 The Core Programmes of DAE are Nuclear Power Programme – Stages I, II & III ; Radiation Technology Applications ; Basic Research in mathematics, computer science, physics, chemistry, biology etc ; Research- Education linkage; and Infrastructure Development. These have already been discussed in the earlier pages.

Mission Mode Programmes are given below:

I. Advanced Heavy Water Reactor and Thorium Utilisation

8.13 This is a very important programme for providing long-term energy security for the country. It has 4 sub-programmes as indicated earlier. While the setting up of a 220 Mwe AHWR is proposed to be funded through the power sector, associated short term and long term development including that for other aspects of thorium utilisation in the long term would be covered under R&D sector. Accelerator development with the eventual aim of utilisation for energy technologies with focus on thorium utilisation needs special emphasis. Implementation during the 10^{th} Plan will be a part of this strategy with the projects designed to have specific deliverables, while the development will dovetail into the final objective. A complete report for this activity has already been prepared.

II. Water Desalination

8.14 BARC has been engaged in R&D on thermal and membrane desalination processes with an aim to develop indigenous technologies in the country for large scale desalination of seawater and fresh water into fresh potable water. A number of pilot plants based on Multistage Flash (MSF) and Reverse Osmosis (RO) processes were successfully fabricated and operated and useful design data collected in the last 10-15 years.

8.15 The desalination industry is witnessing numerous technological innovations aiming to reduce the cost of water produced, so that it is available to needy poor population in the water scarce areas. Based on the earlier experiences, a 6300 m^3/d

combined MSF-RO plant has been set up at MAPS, Kalpakkam in the 9th Plan. The operational experience of this plant will be useful for the design of large size plants of 50,000-m^3/d capacity required for augmenting the water resources in the water scarce coastal areas.

8.16 The related activities are planned to be taken up in a mission mode to supplement the activities on desalination already carried out and in hand. The successful completion of the project would lead to cost effective solution for meeting the drinking water needs in the coastal as well as inland areas of the country. Various activities in this mission mode programme include : multi-effect distillation vapour compression; setting up a low temperature evaporator with cooling tower; membrane based pretreatment system for SWRO desalination plant; continuous thin film composite (tfc) membrane casting assembly; desalination by centrifugal reverse osmosis; and barge mounted RO unit.

III. Nuclear Medicine

8.17 There has been a rapid progress in the use of radioisotopes in the health care programme in the last decade. This programme is the outcome of a vigorous effort made by DAE to expand its programme on making available a variety of radioisotopes for the diagnosis and treatment of many diseases which include cancer and endocrinal disorders. Associated with this is the training imparted to a number of doctors and technologists in the discipline of Nuclear Medicine. Newer isotopes with short and ultrashort half-lives which are produced in a hospital based cyclotron - a 9th plan project – will shortly be commissioned. This facility which is coming up at TMC-RMC (Tata Memorial Hospital - Radiation Medicine Centre, BARC) complex will be utilized for diagnosis of a variety of cancers, neurological diseases, cardiac diseases and others.

8.18 The benefits accrued from such a facility will be extended to the socially handicapped patients to a large extent. At the same time radioisotopes will be made available to Corporate Hospitals, so that the usage can be greatly extended. Training facilities for doctors and technologists in this new technology will be provided. Other activities envisaged include: use of isotopes for diagnosis “in vitro” development of newer technologies like nanotechnology which will greatly enhance the utilization of radioisotope applications not only for patient care, but even for other strategic

applications such as diagnosis of drug resistant tuberculosis; developing “hybridoma” techniques and nude mice models for treatment of cancers etc.

IV. Food and Agriculture

8.19 The objectives of the projects under this mission mode programme are as follows :

i) Development of technically feasible, economically viable and ecofriendly technologies through linkage with state agriculture universities, seed corporations, ICAR and other state and central agencies in respect of : development of crop varieties of pulses, cereals and oil seeds; soil, nutrient and pest management; biotechnological remediation of nuclear installation waste and pollutants; development of Biosensors; increased production of Bioactive compounds; edible vaccines in transgenic plants.

ii) R&D in radiation technology and other post-harvest techniques for food preservation and hygienisation : to promote commercial application of ionising radiation to food and agricultural commodities for extending shelf life, improving hygiene and for overcoming quarantine barriers in international trade; study of process parameters for commercial exploitation of accelerator based sources of ionising radiation; to develop methods for detection of radiation processed foods for the benefit of regulatory agencies; to promote use of radiation processing technology among entrepreneurs and enhance public awareness; operation maintenance and infrastructure development of POTON and design of multitasking radiation process facilities.

8.20 The attempt will be to ensure that technologies already developed are deployed and new technologies developed by using the land area around nuclear installations for deployment of such technologies and to transfer technologies to as many parties as possible.

CHAPTER 9

Tenth Five Year Plan Programmes – Space

9.1 The primary objective of the space programme has been to establish operational space services in a self-reliant manner in the thrust areas of satellite communications and satellite based information which assist in survey/management of natural resources and satellite meteorological applications. For achieving this objective, the guiding vision for the Indian Space Programme, set for itself by Department of Space (DOS), has been and will be the development of space technology and its applications to solve the real problems of society vis-à-vis strengthening indigenous capabilities in space. While finding solutions to societal problems, the appropriate role for space has been to become a strong enabler for social transformation, a catalyst for economic development, a tool for enhancing quality of human resources and a booster to strengthen national security. In this role, Technology Advancement which is essential to maintain competitive relevance will be one of the major thrusts for space endeavours in future. In the context of rapidly transforming India into an economically prosperous, socially secure and culturally rich nation, large scale applications of Space Technology in the areas of national priority will also be the future thrust.

9.2 Taking this objective, role and thrust of DOS into consideration, the overall direction of the Space Programme, as it transits to 10^{th} plan, formulated within the framework of a Ten Year Profile (2001-2010), will be to consolidate the gains of developments in the 9^{th} plan and to build upon its achievements. It is also recognised that the goals for the 10^{th} Plan will be conditioned by the changes in the environment both at the global and national level as also the emerging needs in the scientific/technical and application areas. With the broad vision to develop India as a major Space faring nation with multi-dimensional programs benefiting every citizen, major goals set by DOS for the 10^{th} Plan are : to acquire new capabilities for Space Communications by positioning Indian Satellite Systems – Gramsat and INSAT networks – for operational services; to maintain leadership in earth observations by positioning EO infrastructure to meet the national imaging demands and supporting National Natural Resources Management System (NNRMS), Disaster Management Support (DMS), Developmental activities and improved weather and ocean state forecasting; to give major thrust for space

transportation by productionising PSLV, operationalising GSLV, upgrading launch capabilities and undertaking major developments in technologies leading to future generation vehicles ; to encourage space

science enterprise by mobilising high quality scientific group for advanced space science endeavours; and to promote spin-offs in human resources, industry and international partnerships. The details of the individual space programmes envisaged in the 10th Plan are given below.

Satellite Communications & Meteorology

9.3 The major objective of the Satellite communications programme during the 10th plan is to develop a self sustaining satellite based communication network - GRAMSAT program - for developmental communications, e-governance, tele-medicine, tele-education and rural development with the involvement of state governments and NGOs. The projected demand for transponders during 10th Plan broadly cater to the requirements of public broadcast (DD/Prasara Bharathi), AIR, BSNL, VSNL, VSAT service providers association, Software Technology Park of India, GRAMSAT network, Educational networks including Vidya vahini, national security applications etc. The transponder requirement by 2006-07 as projected by users will be 120 transponders in C band, 45 in Ext-C band, 60 in Ku-band, 6 in Ka band, 4 in S band and 1 MSS transponder.

9.4 The INSAT system has four satellites viz., INSAT-2C, 2DT, 2E and 3B. But INSAT-2C and 2DT would be reaching the end of life in 2002. INSAT-3C and 3A are planned for launch in 2001-02 followed by INSAT-3E by Mid 2002. Thus, by 2002-03, the first year of the 10th plan, it is estimated that INSAT-2E, INSAT-3B, 3C, 3A and 3E will be in service and expected to remain operational throughout the 10th Five Year Plan period providing a total capacity of 116 transponders. The fourth generation INSAT-4 satellite series with a total transponder capacity of 142 has been planned to meet the capacity & service requirements projected for the Tenth five year plan. One of the primary considerations in configuring the INSAT-4 has been the planned availability of GSLV Mk II with a lift-off capability of 2T satellite by 2003-04. Various approaches and procedures towards making INSAT financially self-sustaining systems in a progressive manner are being worked out.

9.5 The Meteorological services provided by the INSAT system are planned to be substantially enhanced with improved/new payloads as well as through establishment of dedicated meteorological satellites, METSATs. To provide backup for the crucial meteorological segment of INSAT, the first satellite METSAT-1 carrying Very High Resolution Radiometer (VHRR) and Data Relay Transponder (DRT) is planned for launch onboard PSLV during the second quarter of 2002. The METSAT-2 satellite, carrying VHRR and DRT is planned for launch on PSLV during 2004-05 to serve the needs of weather forecasting. This will also eventually provide replacement for METSAT-1. To meet the DCP requirement of IMD, the Data Relay Transponder in INSAT-4 system is planned with additional bandwidth of 200 kHz to enable expansion of the network of Data collection platforms. The other communication satellites that are scheduled to be launched during 10th Plan are : GSAT-3, GSAT-4 and Advanced Communication Satellite. The INSAT- METSAT system is geared to meet the increased user demands in the most cost-effective way and provide enhanced services and benefits to the nation in terms of establishing communication network, technology demonstration system for aircraft navigation, mobile communications, data broadcast services etc.

Earth Observation Systems

9.6 Within the framework of the long term vision, the Indian Earth Observation (EO) Programme will continue to serve as the mainstay of the NNRMS. DOS has recently defined a 'Earth Observation :2025 strategic plan that outlines the way forward for furthering the Indian EO & NNRMS programme. With this in mind, the major goal set for the 10th Plan is to roll into action the EO-2025 Strategy which outlines the EO based NNRMS programme for : launching a variety of EO Missions; undertaking EO advanced technology programme and arial surveys etc.

9.7 A major activity relates to strengthening of the NNRMS and the State Natural Resource Management Systems (SNRMS) and bringing to front-end focus the State Remote Sensing Centres and enabling the systems emerge as the main source of natural resources information. Special efforts will be made to provide space based infrastructure and information support for development of NorthEastern states. Some of the new initiatives under NNRMS umbrella are : undertaking Natural Resources Census; building up National Spatial Data Infrastructure; Large Scale Base Mapping Programme;

supporting developmental programmes relating to : rural roads, environment, watershed development, etc. and undertaking oceanographic applications.

Disaster Management Support (DMS)

9.8 The IRS and INSAT satellites have been providing valuable services in Disaster Management of the country. For disaster management to be effective and efficient, the DMS has to address the gaps / constraints in the current system which include lack of centralized information on the climate, weather and man-made structures (roads, hospitals, boundaries, etc.), timely and reliable assessment of the location, area and extent of damage, a systematic spatial database through which the information can be analysed to make an assessment of the disaster. In order to appropriately address these gaps/constraints, a Disaster Management support Programme drawn up by ISRO/DOS in association with other organisations will be implemented during the 10th Plan. The programme with special focus on North Eastern region involves: mapping and monitoring support; creation of thematic and cartographic information database for flood-prone and cyclone-prone areas and ortho-photomaps of earthquake-prone areas; demonstration of the applicability of GIS based decision support system for disaster management; infrastructure including networking facilities; R& D support etc.

Launch Vehicle Systems

9.9 Based on the launch vehicle requirement scenario and the long term vision of the space transportation system, the programmatic targets have been set for the launch vehicle development. PSLV would remain as the work horse vehicle for Earth observation and space science and meteorology satellites for polar, inclined and GTO missions respectively with the current capability of 1200 kg for Polar and 950 kg for GTO. Further improvements in PSLV vis-à-vis the technology developments will continue. The development flights and operationalisation of GSLV (Mk I and II) with 2T GTO capability with indigenous cryo stage and the establishment of second launch pad at SHAR will be completed .The development of GSLV Mk III with 4T lift off capability to GTO will be an important thrust area of development. The development of critical technology base related to RLV and realization of the proto unit of RLV technology demonstrator are also targeted.

Space Science & Environment Research

9.10 In this area, the thrust will be towards investigations in the new, emerging and challenging areas of space science research including planetary science/exploration and micro gravity science. Besides this, the other areas of research include : modelling of climate/global change phenomena and its impact on regional and global scales; high energy astronomy and astrophysics with dedicated space mission; ionospheric/ thermospheric modelling; space weather related research etc. Some of the major missions that will be launched by DOS for undertaking this research are : Astrosat Satellite Mission (2006-07) onboard PSLV; a high spectral and temporal resolution Solar X-ray Spectrometer (SOX) onboard the GSAT satellites (2002-04) for developing very accurate ionospheric models required for Global Positioning System (GPS) related applications; and an ISRO-CNES (France) joint climatological mission called "Megha Tropiques" which will help predict tropical cyclones and forecasting of monsoons and tropical rain seasons.

International Cooperation

9.11 While multiple means to pursue international cooperation (Bilateral and Multilateral) will continue, major thrust will be on : space mission operations, meteorology, environment and humanitarian services such as Megha Tropiques; a cooperative satellite mission with Synthetic Aperture Radar; international charter on Space Disaster Management Support, Internal Global Observing Strategy, Global Precipitation Mission etc.

Industry Interface, Indigenisation and Commercialisation

9.12 The quantum of contracts to Indian Industry is expected to grow significantly in view of the expected growth in the magnitude of space activities during 10^{th} Plan. Antrix corporation would endeavour to expand its marketing base and increase its export turnover through concerted efforts towards: securing contracts for development and supply of complete satellite systems; maximising efforts to supply complete subsystems to leading international space agencies; marketing IRS satellites data; establishment of TTC stations in Ku/Ka band; providing ground support services and dedicated launch services using ISRO's workhorse PSLV; providing necessary consultancy services and intensifying the efforts on indigenisation of critical electronic components and materials required for Indian space programme.

Organisational Development and Human Resources

9.13 Major thrust areas where specific actions are being contemplated towards organisational development are : consolidation of core competences and enhanced outsourcing; reorientation of administrative systems and efficiency improvement; inducing motivation, morale and maintaining organisational health; succession planning for the perennial availability of technical personnel for replacement in case of any type of eventualities through induction of talents and their retention; learning and knowledge management etc.

Core/Mission Mode Programmes

9.14 In the case of DOS, 4 **Mission Mode Programmes** have been identified by the Steering Committee and the same are considered as the Core Programmes by the DOS. Their details are as follows :

I. Operationalisation of NNRMS through Application of Remote Sensing Technology in Developmental Programmes

9.15 The NNRMS, established by the Planning Commission in 1983, is an interagency programme, co-ordinated by the DOS through its various space related programmes. It is an effective virtual mechanism for operational utilisation of remote sensing technology in conjunction with the conventional methods for the management of natural resources for supporting developmental activities in the country. With the apex Planning Committee of NNRMS (PC-NNRMS) providing the overall policy guidelines, NNRMS has established high power Standing Committees headed by the concerned Secretaries of Government of India for effective coordination amongst various user agencies for identified thematic areas. Some of the major national projects carried out are: land use/land cover mapping, wastelands mapping, crop acreage and production estimation, forest mapping, coastal applications, land and water resources management,

command area development and watershed development, to name only a few. Due to these continuing efforts towards operationalising NNRMS over the years, India has achieved an unenviable position of having an end-to-end capability in remote sensing technology and its applications.

9.16 Operationalisation of NNRMS has been done by institutionalising the remote sensing applications as part of the user departments /agencies - central, state and private. With the expertise, thus developed over the years in the country through NNRMS, many user agencies in the country have been adopting the remote sensing and GIS techniques in their operational functioning. This programme will be implemented in a Mission mode to achieve the targets set for the 10th Plan by providing continuity of data services; promoting R&D activities in technology and applications; strengthening Government- Industry – Academy cooperation; conducting periodic natural resources census; supporting meteorological and oceanographic applications and studies related to global change etc.

II. Technology Development for Future Generation of Launch Vehicle / Development of Advanced Launch Vehicle Technology

9.17 The major objectives and scope of development of advanced launch vehicle technology are : to develop a satellite launch vehicle GSLV Mk III for placing 4T class INSAT satellites in Geosynchronous transfer orbit and also critical technologies required for future Reusable Launch Vehicles (RLV). As full-scale design and development of the vehicle is extremely complex with several developmental uncertainties, it is proposed to work on a smaller-scale technology demonstrator as a test bed during the 10th plan period. To achieve the targets, it is proposed to develop several technologies both for realising GSLV-MK-III and for RLV.

9.18 The mission will be implemented using the technology expertise and infrastructure base of Vikarm Sarabhai Space Centre, Liquid Propulsion Systems Centre, SHAR (Shriharikota) centre, ISRO Inertial Systems Unit and ISRO Satellite Centre and the national facilities available in other institutions like NAL. A major portion of the

infrastructure set up, fabrication work and production is planned to be farmed out to Industries.

9.19 The first developmental flight of GSLV Mk III is targeted for 2007-08. In respect of RLV, it is planned to complete the R&D work on air breathing propulsion technology and space capsule recovery experiment during the 10th plan period.

III. Application of Space Technology in Education and Health

a) Education

9.20 The objective of this project is to set up tele-education networks in all the states during the 10th plan covering high schools and professional colleges. DOS/ISRO will provide the required transponders from INSAT system for tele-education networks to be set up across the country and will partially fund the ground infrastructure. State governments through their education departments will be involved in promoting supplementary high school education. Agencies like NCERT may be able to provide support in curriculum planning and content design. It will be implemented through joint funding by Government and Non-Government sectors.

b) Health

9.21 The mission objective is to set up a tele-medicine network connecting about 600 district secondary health care hospitals to tertiary care centres in cities using VSAT technology. Tele-medicine technology provides the means for delivering quality health care to remote rural areas bypassing geographical constraints. Tele-medicine provides the services such as : remote consultation in clinical areas like cardiology, neurology, oncology, dermatology etc; second opinion in diagnosis and treatment; interpretation of X-ray and other scanned images; continuing education of practising doctors etc. Tele-medicine technology involves acquiring patient data in the form of text, images, video etc. and transmitting to remote specialists for interpretation and diagnosis as well as audio and video conferences between the specialist and remote doctor. The partners in this project are Government hospitals, Charity hospitals and private sector speciality hospitals. ISRO provides the satellite communication services for the tele-medicine network and also be a facilitator for the tele-medicine projects. The network will support data transfers and audio/video conferences and will be supported on INSAT transponders.

IV. Development of All-Weather Remote Sensing Technology

9.22 The major objective of this project is to develop a Radar Imaging Satellite (RISAT) with a multi-mode, multi-polarisation agile Synthetic Aperture Radar (SAR) payload operating in C band and providing 3-50 meters spatial resolution. Various modes such as ScanSAR, strip & spot modes are planned to provide images with coarse, fine and high spatial resolutions. It also envisages development of related algorithms and data products to serve the user community in many applications of relevance to the country.

9.23 The SAR payload with active phased array antenna for RISAT is a complex technology involving several new elements for Space segment & ground segment. Recognising this, ISRO/DOS has initiated developmental efforts in 1991 and realised C-band Airborne Synthetic Aperture Radar (ASAR). Besides this, ISRO has also developed certain key SAR related hardware technologies for satellite SAR payload under R&D programme. It has also expertise in developing SAR processor in-house. It is envisaged that RISAT mission could be realised in the time frame of around four years and the satellite is targeted for launch onboard India's Polar Satellite Launch Vehicle during 2005-06.

CHAPTER 10

Tenth Five Year Plan Programmes- Ocean Development

10.1 The plan programmes of DOD, established in 1981, have been mainly guided by the Ocean Policy Statement and certain International conventions and commitments. The responsibilities of the Department are : to formulate and implement programmes with long term economic and technological implications; to act as a nodal agency for technology development in areas relevant to the economic and social development of coastal population; and to act as an agency to formulate and coordinate scientific and technological projects for exploration of living, non-living and energy resources of the sea and for protection and preservation of ocean environment. Currently the activities of the Department are directed towards the development and use of Ocean Science and Technology with the active participation and support of national R&D laboratories, educational institutions and industries. The details of the programmes to be undertaken by DOD during the 10^{th} Plan are given below.

10.2 Polar Science & Antarctic Expeditions: The research on Polar Science and the annual expeditions to Antarctica will continue. The National Centre for Antarctic and Ocean Research (NCAOR) will expand its activities pertaining to in-house research on Polar Science covering remote sensing, global change, etc. So far the Indian activity has been confined to the Central Dronning Maudland (CDML) area of Antarctica. To have a more comprehensive database during the 10^{th} plan, all the activities preparatory to construction of a second Indian permanent station in Antarctica will be initiated. Research Programmes in Southern Ocean Oceanography and in Polar Environment and Ecology which are significant for global processes and some additional new programmes on biotechnological potential of Antarctica microbes and biodegradation of organic wastes will be taken up.

10.3 Marine Living Resources: The Centre for Marine Living Resources and Ecology (CMLRE) at Kochi will continue to implement the expanding activities connected with Indian EEZ and take up construction of its own building during 10^{th}Plan. The scientific programmes like environment and

productivity, benthic productivity, harmful algal blooms and others will also be continued. Drugs from Sea programme will emphasise on product development, commercialisation of the developed products and confirmation and optimization of new leads already developed. The new programmes are in the areas of near Shore Dynamics with special reference to Upwelling and Mud Banks, bioluminescence and its significance in the Eastern Arabian Sea, Survey of Marine Mammals of Indian EEZ, Climate and Marine Fisheries, Assessment of tuna resources of the Indian EEZ, and Basic Research on Marine Living Resources. Under Coastal Community Programmes, farming and pearl production in black lip pearl oyster in Andamans, ornamental fish production through culture in Lakshadweep, etc. would be taken up.

10.4 Marine Non-Living Resources: Under Polymetallic Nodules Programme, Survey and Exploration, EIA, Mining and Allied Technology Development, and Metallurgy will be continued. BENFAN programme will also be taken up during the 10^{th} Plan period, with emphasis on long coring of the sediments at selected locations. With a view to map the EEZ for identifying areas for future detailed surveys for the non-living resources exploration, comprehensive systematic EEZ topographic surveys using multibeam system (state of art) will be initiated and a strategy for comprehensive assessment of resource potential of the Indian EEZ including gas hydrates, cobalt crust, etc. evolved

10.5 Marine Environment and Coastal Zone: The existing stations for collection of near-shore samples identified under COMAPS programme will be more carefully planned to reflect the pollution load that is occurring close to the shore. The activities under ICMAM on capacity building programmes funded by World Bank, training to coastal States on use of GIS and on critical habitat information system using GIS for critical habitats, and zonation of coastal waters will continue. As a pre-requisite for Preparation of ICMAM Plans in selected areas by the coastal states/others, eco-system modelling studies which can be ideally used for management of the shoreline land, particularly to control erosion and accretion, will be conducted. Other R&D activities in this area include : Decision Support System (DSS) for management of small to large habitats, migratory patterns of

turtles, long-term monitoring of pollutants, development of online pollutant detection system using sensors for hotspot areas etc.

10.6 Ocean Observations, Science and Information Programme: INCOIS will continue to process and disseminate to user community the data and data products like fisheries, weather, climate, ports, shipping, etc. Development and management of a Web Site and Ocean Portal would be taken up. Under Ocean Observation Systems, the activities envisaged are : increase in the number of moored buoys to 40 with indigenisation of its prototypes, increasing the drifting buoys to about 150, adding a XBT line, increasing the tide gauges to 34 and deployment of 150 ARGO floats. In the context of newly planned Indian and foreign Satellite Missions such as Megha Tropiques, Oceansat-II etc., development of algorithms, models etc. will continue. Consolidation of the efforts that are ongoing under the Indian Ocean Modeling and Dynamics (INDOMOD) for operational applications will be continued on priority basis. A number of areas that require concerted and focussed research aimed at translating the information into operational applications during the 10^{th} plan are : Biological Productivity, Physical Processes (upper ocean), Sea level variability studies, Deep and Bottom Ocean circulation etc. For Ocean Data Assimilation, an Ocean Modeling Centre will be established. For better weather prediction, some new programmes such as setting up of automatic island weather stations will be taken up in consultation with IMD.

10.7 Ocean Engineering and Technology Development: Under Ocean Energy, modification of the 1 MW OTEC plant to function as a land based or shelf mounted OTEC plant for islands would be taken up. Deep Sea Technology activities include: technologies for direct applications to shallow and deepwater mining, and development of technology base for deepwater applications. The technology and necessary expertise for the exploration and recovery of Gas Hydrates will be developed. NIOT would endeavor to have institutional cooperation/collaboration for technology development with the reputed National and International Research Laboratories, Academic Institutions, International Organizations and Private R&D

Institutions. New initiatives include: development of wave powered data buoys for offshore applications and establishment of marine meteorology cell, and marine instrumentation & sensors calibration cell.

10.8 Marine Research and Capacity Building and Ocean Awareness: The already set up OSTCs on Marine Ecology, Marine Biology, Marine Microbiology, Marine Benthos, Coastal Marine Culture Systems, Marine Geology/Geophysics, Marine Placer Deposits, and Ocean Engineering & Underwater Robotics will be strengthened by providing adequate equipment. The ongoing programme of award of research fellowships to students for pursuing higher studies, participation in exhibitions and fairs to create awareness among the public on ocean and their usefulness to mankind and organization and conduct of seminars will continue. The new initiatives include : training programme for foreign students in India to develop a competency in the SAARC/Indian Ocean Rim Countries, taking ocean sciences to schools and to the common man through scientists, faculty members and students through illustrated talks, slide shows, video film shows, exhibitions, radio and TV programs, articles in newspapers, etc., building a museum on the lines of the one constructed by the USGS recently and modernization of the existing museums and marine aquaria.

10.9 International Cooperation & Programmes: DOD would continue to participate in the meetings of Law of the Sea, International Sea Bed Authority, Antarctic Treaty System, Intergovernmental Oceanographic Commission, and Regional Seas Programme and will also initiate bilateral scientific cooperation during the 10^{th}Plan period. Under Southern Ocean Marine Living Resources programme, two cruises will be conducted during the 10^{th}Plan for assessment of Krill and tooth fish in the Indian Ocean sector of Antarctic waters in collaboration with South Africa, Poland and Russia. Other initiatives relate to : Monitoring of Harmful Algal Blooms in the Indian Ocean sector; and R&D studies on Large Marine Ecosystem in Bay of Bengal in coordination with Bangladesh, Myanmar, Srilanka, Thailand, Malaysia and Indonesia.

10.10 **Research Vessels:** Two programmes are envisaged under this. The first is to upgrade/renovate the two research vessels of DOD- ORV Sagar Kanya and FORV Sagar Sampada- which are on the verge of becoming obsolete. The second is to acquire/construct a new multipurpose vessel for technology services and demonstration to serve as a platform for the programs envisaged in the 10^{th}Plan and also as a utility science vessel which will augment the capacity need of the marine living and non - living resources programmes of the Department. The National Institute of Ocean Technology (NIOT) would be the nodal agency to implement the second programme including the operation and maintenance of the vessel.

10.11 **Ocean Commission:** In view of the fact that the developments in ocean sector have national, regional and global implications and that the management of diversified programmes involving the Central and State Governments and their agencies is a complex task, an Apex Body viz., Ocean Commission in the lines of Space Commission and Atomic Energy Commission will be set up to look after the ocean related programmes.

Core and Mission Mode Programmes

10.12 The details of the Core Programmes identified by the DOD and the Mission Mode Programmes identified by the Steering Committee are given below.

10.13 The Core Programmes identified by the DOD are: Polar Science and Antarctic Expeditions; Marine Living Resources; Marine Non-Living Resources; Marine Environment and Coastal Zone; Ocean Observations, Science and Information Programme; Ocean Engineering and Technology Development; Marine Research and Capacity Building and Ocean Awareness; Research Vessels; International Cooperation and Programmes; and Ocean Commission. The details of these programmes have already been discussed in the previous pages. The details of the **Mission Mode Programmes** are given below.

I. Large Scale Technology Demonstration of Ocean Thermal Energy Conversion (OTEC) Plant

10.14 In tropical oceans within about 25^0 North South latitudes, a temperature difference of about $20\ ^0$ C exists between the surface of the ocean and water at a depth of 1000 meters. The Ocean Thermal Energy Conversion (OTEC)

process uses this temperature difference to operate a heat engine, which produces electric power. The OTEC plants of smaller ratings (below 40MW) have already proven the concept, however, commercialisation of such plants are economical only at higher ratings. There is enough evidence to show that at ratings of around 40-50 MW, floating OTEC plants are likely to be competitive with fossil-fuelled ones. The unit cost for a 100 MW OTEC plant in Indian conditions is calculated as Rs. 2.93 / KWh

10.15 The mission Mode programme aims at the establishment of 20MW shelf mounted OTEC plant to start with. The NIOT would design power module components, shelf mounted platform and other OTEC components, establish the plant and demonstrate the technology for large scale application. This plant is likely to be established in Andaman & Nicobar Islands and costs about Rs.450 crore. On the basis of the experience on the design and engineering of a 20 MW OTEC plant, studies towards realization of a 100MW plant can be taken up.

II. Studies on Exploration and Technology Development of Gas Hydrates

10.16 Gas hydrates with their abundant resource potential is turning out to be an ideal source of energy. National Gas Hydrate Programme (NGHP) was already initiated by Ministry of Petroleum and Natural Gas in Indian offshore regions.

10.17 Indian EEZ is a promising area for occurrence of gas hydrates due to highly favorable geologic conditions and well-developed cadre of geoscientists and engineers. So a comprehensive programme is under formulation to develop S&T in respect of exploration of gas hydrates and to recommend suitable sites for drilling and technology development for ground truth validation. So far, the only country to have produced gas hydrate is Russia and DOD has good links with the Russian Scientists in this regard under the ILTP.

10.18 The programme is planned to be implemented in three phases. First, multi-channel seismic gravity and magnetic data under Legal Continental Shelf (LCS) programme will be acquired in a grid of about 60 NM from the foot of the continental slope up to a distance of 350 NM. Special processing will be carried out and two most promising areas will be identified to carry out further detailed surveys.

Detailed multi-channel seismic surveys will be carried out in an area of 100 X 100 km in the next phase. In the third phase, the work pertains to : collection of in-situ samples (gravity coring, CTD measurements, water sampling); High Resolution Seismic Surveys (HRSS); Swath Bathymetry; and Heat flow measurements. Based on the analysis of samples and interpretation of geophysical and geochemical data, sites for ground truth validation would be finally selected. Concurrently, technology feasibility studies shall be carried out to produce gas hydrate on a Pilot Plant basis. This will be a joint programme between DOD, NGRI, NIO, NIOT & GAIL. This programme would provide a reasonable estimate of gas hydrates potential.

III. Ocean Information Service

10.19 Ocean information services are essentially a service-oriented programme aimed at generation, analysis, modeling, product development and dissemination of ocean data and data products to users. After successful completion of this mission mode project, the services that will be offered by Ocean information services are (i) Potential Fishing Zone (PFZ) Advisory services (ii) Ocean State Forecast (OSF) (iii) Ocean information Bank and Web based services and (iv) Marine Meteorological and Oceanographic Services (MMOS) to developmental sectors.

10.20 Improvement of PFZ advisory services is envisaged through generation and dissemination of Integrated PFZ advisories using SST and Chlorophyll obtained on the basis of the composite images received from IRS-P4 (OCM) and NOAA (AVHRR) satellites and species-wise and Demersal PFZ advisories, and by setting up of Information Kiosks in maritime states/islands.

10.21 The broad objective of OSF is to provide required impetus to indigenous development of modeling for ocean research and facilitating forecasts of 3-5 days in advance. Though other global centers are providing OSF, the Prediction models are not transparent and the parameters are not useful in accurate predictions. With the successful completion of Marine Satellite Information Service (MARSIS)

Phase I & II projects and the Launch of Oceansat-1, OSF in real time will be attempted in Indian Seas including coastal regions.

10.22 The online data sets provided under Ocean Information Service in real-time obtained on the basis of the data generated by Marine Data Centres (MDCs) and met-ocean parameters data will be validated and integrated by NIOT and NIO under the National Data Buoy Programme and Drifting Buoy Programme. These data sets will then be archived at INCOIS as a User-friendly Information Bank. Appropriate mechanisms would be instituted for ensuring data integrity, organizational identity and intellectual property rights. This Information Bank would provide access to large spectra of Users. Also, it would be used by INCOIS for generating Value-added services.

10.23 The objective of MMOS is to provide reliable and real-time meteorological ocean information to a wide range of users like fishermen, boat operators, Coast Guard, Ports and Harbors etc. The data from various satellites will be assimilated and integrated and delivered to the users through multi-media. A number of organizations like INCOIS, CMLRE, NIOT, IMD, NCMRWF etc. will participate in this Mission Mode project to be completed during the 10^{th} Plan.

IV. TECHNOLOGY DEVELOPMENT AND DEMONSTRATION OF DRUGS FROM SEA

10.24 The objective of the programme is to explore the drug sources from ocean and to obtain leads for development of bioactive molecules and drugs for the welfare of mankind. So far, from the exploratory work under this project, excellent leads (13 organisms) having interesting therapeutic potentials were identified. Bioactivity confirmations in repeat collections have been done. Regulatory pharmacology studies of products of interest will follow thereafter. This will be followed up by toxicity evaluation in rodents and primates. If safe, the active products, i.e., antidiabetic, antidiarrhoeal, and antihyperlipidaemic will be taken up for clinical trials and tie-up with pharmaceutical houses during the 10^{th} Plan.

10.25 A systematic exploration of marine organisms along the coast of India is done continuously to deliver new chemical entities with great therapeutic potential for future development of novel drugs of sea origin. The research work will

open newer advances in marine biology and chemistry with training of incumbents in ocean biotechnology, chemistry and pharmacology. This programme will be implemented in coordination with CDRI.

CHAPTER 11

TENTH FIVE YEAR PLAN PROGRAMMES - SCIENCE AND TECHNOLOGY

11.1 The thrust of the 10th Plan programmes of DST continue to be on the basic research, technology development, S&T manpower development, providing scientific services to the community and to undertake programmes relevant to societal needs. The elements of broad strategy to be adopted in DST are : priority to synergy among science and technology, public policy and organisation; focus on knowledge capital; reorganisation of technology transfer systems; raising our capability and excellence in S&T; orientation of S&T efforts towards finding solutions to poverty, employment, livelihood, environment etc.; doubling of government and private investments in research in the next five years; and acceleration of national, regional and international collaborations for technology generation, assessment and transfer.

11.2 Within the framework of this broad strategy and keeping in view the national needs and the recent developments in S&T, vis-à-vis, the globalization process, some new initiatives will be taken by DST such as : restructuring of SERC into a National Science & Engineering Board (NSEB), as an autonomous body, to provide directions to basic research in the country in all its aspects; building strengths in a few chosen emerging S&T areas like : System/Integrative Biology, Nano-technology, Synchrotron Facility, 6 to 8 M Optical Telescope, Molecular Electronics etc.; evolving a tripartite arrangement for the active involvement of the Scientific Agencies, National Laboratories/IITs and universities to prepare an Integrated Manpower Development Programme; providing a few industrial research fellowships to researchers to work jointly in industry and in University Departments for promoting interaction between industry and academic institutions; and as a measure of encouragement, formulating a different scheme for female scientists with a track record for either excellent scholastic record or good publications; promotion of India's capability to set up Centers of Excellence jointly with other countries through its bilateral S&T programmes by identifying a suitable laboratory or institution; encouraging talented young Indian researchers working abroad to come back to India by offering competitive career awards to work in Indian institutions of their choice in nationally important programmes; giving encouragement to higher

value addition activities and preservation of natural resources through the development and application of high technologies such as biotechnology, new materials, computers, telecommunications and information techniques and systems, micro-electronics, etc. Salient features of various individual programmes are briefly given below followed by more details on Mission Mode programmes.

11.3 SERC mechanism is a major programme under Research & Development schemes. Though it has gained reputation among the scientists, however, it was felt that, it requires a new system of governance, which ensures a greater freedom for choice of research areas, faster utilization of funds and quicker disbursement to investigators. SERC will, therefore, be restructured into a National Science & Engineering Board (NSEB), as an autonomous body to provide directions to basic research in the country. Under Intensification of Research in High Priority Areas (IRHPA), national facilities will be set up such as: Radioactive Ion Beam Facility, Crystal Growth Facility, Low Temperature and High Magnetic Fields Facilities, Biomedical Imaging and Spectroscopy Facilities, XRD and TEM facility. Research Centres will also be set up in the areas of : Non-linear and Integrated Optics, Molecular Manufacturing, Bio-Engineering, Tissue Engineering etc. The scheme on Fund for Improvement of S&T Infrastructure in academic and related Institutions (FIST) will be continued and about 1000 departments will receive support during 10^{th} Plan. Another continuing scheme is the Young Scientists Programme which includes : Kishore Vaigyanik Protsahan Yojana, Schemes for Young Scientists, Boyscast, Swarnajayanti Fellowship for Basic Research and the Fast Track proposals for the Young Scientists (FAST TRACK). The above three programmes relating to (a) IRHPA, (b) R&D Funding, (c) Young Scientist Programmes, and also (d) The scheme on Fund for Improvement of Infrastructure in S&T in academic institutions will be appropriately brought under NSEB.

11.4 Apart from those already mentioned at para 11.2 other new initiatives that will be taken by DST include : Patent Facilitation scheme to create an awareness and understanding of the latest information on patents; creation of NSEB Chair and Emeritus scientist position to superannuated scientists etc. Also flexibility in manpower deployment and enhancement of research fellowships will be introduced to attract more candidates to JRF/SRF/PDF. Other programmes pertain to : selective support to

professional bodies for quality based activities; encouragement to the senior and young scientists in scientific events/ seminars by providing internal/ international travel support; refurbishment of the RSICs to minimize obsolescence; expanding the scope of National S&T Management Information System (NSTMIS) to undertake some activities relating to : development of National level databases in selected S&T areas, e.g., R&D outputs leading to commercialization, outcomes of extramural sponsored research projects, scientific manpower, scientific equipments & instruments, etc; national level study on commercialization of Patents; preparation of National Manual on Measurement of S&T activities; development of S&T indicators in the new knowledge economy; etc. Under Seismicity programme also, in the light of new earthquake disasters at Latur, Jabalpur and Bhuj, some new initiatives will be taken.

11.5 Technology Development Programme will be given a boost by : developing new and innovative technologies through national as well as international programmes; funding in multi-disciplinary, multi-institutional type of technology feasibility/demo-type projects which include high, traditional and socially relevant technologies and mega projects on IR detector, image processing etc; evolving a more inter-active approach by creation of a DST-IS-STAC Forum with the Ministries and creating an independent website covering the various STACs, their R&D efforts, S&T related policy issues etc.; replication and extension of the existing activities of the Patent Facilitating Cell to more centres; etc.

11.6 Under drugs and pharmaceuticals research programme, besides the ongoing research projects, the new ones to be initiated relate to : nutritional deficiency and related diseases, e.g. iron and protein deficiency; herbal drugs for ailments prevalent in India; new drug delivery systems; etc. Efforts will also be made to set up New National Facilities for screening of anti-viral activity, combinatorial synthesis, high through-put screening, regulatory toxicology, clinical pharmacology etc.

11.7 The ongoing activities of Technology Information Forecasting Assessment Council (TIFAC) like preparation of TIFAC reports, Technology vision 2020 reports, Homegrown technology programme etc. will continue.

11.8 Taking into consideration the changing international scenario arising out of rapid globalization, and the growing need to protect intellectual property rights, DST,

in close collaboration with M/o External Affairs will give a new thrust to the Internal S&T cooperation by : encouraging participation of Indian scientists and the laboratories in the setting up of major facilities abroad; establishment of international class facilities within the country; intensification of cooperation with developing countries by offering fellowships etc.; encouraging young Indian researchers abroad to work in India by offering competitive career awards; showcasing Indian expertise/technologies through exhibitions; ensuring linkages of international collaborations with large programmes like natural disaster mitigation, AIDS/cancer, super conductivity, technology missions etc.; creating more scientific attache positions in the countries like China, UK, and a few important Asian regions and including in International programmes focussed national priority areas like : high performance ceramics, Nano materials, photonics, sensors, bionics, process engineering, exploitation of ocean resources etc.

11.9 The science and society programmes comprise of need based individual projects for technology development/modulation and demonstration where people's need for technology component and services will be given adequate attention focussing on farm & non-farm sector, horticulture and processing techniques, inland aquaculture, modern nursery, solar/biomass based energy devices/systems etc. Bamboo Farming will be undertaken in the form of a technology mission. The societal programmes will be implemented in selected locations in countryside through networking of people and S&T based field groups by linking them with S&T institutions.

11.10 The scheme on S&T for Women is aimed at empowerment of women through an input of S&T in the gap areas relating to technological needs of women. Keeping in view the socio economic reality of women, the focus of this scheme will be on increasing incomes and creating employment based on local resource; capacity building; inter linkages with R&D institutions for promoting and sourcing technology for women; non-traditional occupations etc. Some successful technology packages will be replicated in other locations as coordinated programmes through networking of local women, S&T based field groups and S&T institutions. A few multisectoral programmes also will be initiated in the hill, coastal, arid zones, and island communities to specifically address biomass utilization, income generation and health issues of women and disaster management in these remote areas. The programme on cultivation of medicinal plants

will be enlarged to include preparation of herbal formulations and quality control by women cooperatives. Women Technology Parks will be set up in all the agro climatic zones of the country.

11.11 The efforts under Tribal Sub-Plan will be continued to undertake RDD in the traditional vocations for socio-economic upliftment and improving the quality of life of scheduled tribes and the thrust will be on : sustainable agriculture; animal husbandry; bamboo based structural and other quality products; water, health, sanitation and genetic disorders; area specific S&T based development plan for tribal regions etc. The areas for research under special component plan meant for the development of SC are : co-ordinated programme on waste re-cycling and management; animal husbandry with reference to smaller animals; production on recycling material; quality product from bio-mass; etc.

11.12 The initiatives under NRDMS programme include : improvements in database management; development & adoption of new techniques for data generation & analysis and promoting NRDMS methodology for other areas like: land & water systems analysis; landslide studies; Coastal Zone Management & Conservation etc. NRDMS network will be expanded by setting up at least one district NRDMS center in all the states of India to expose the respective state governments to the methodology and train the administration in the adoption of the data-based approach for district level planning. Under Karnataka project on development of a laboratory for NRDMS Methodology, emphasis will be on providing information back up to the Zilla Panchayats in the two selected sectors of water management and energy budgeting.

11.13 Developments in the field of communication technology will be exploited to reach out with need-based science and technology to different groups – students, development workers of all types, teachers, industrial workforce, armed forces, scientists and other professionals. Other important communication related activities include: creation of centres for research in science and technology communication in the existing academic institutions and setting up of National Institute for Teaching and Research in S&T communication on the lines of inter-university centre of excellence.

11.14 While formulating the NSTEDB programmes also, the aspect of globalization process will be taken into consideration. Accordingly, the scope and

contents of the newly started scheme for the establishment of TBIs will be enlarged to help : development of knowledge intensive enterprises; new product development and innovative ideas. Besides this special training programs as well as awareness programs will be organized in the fields of Quality control, design, pollution and environmental control and IPRs; cluster approach adopted for modernization through technology and design inputs and the possibility of setting up new enterprises explored.

11.15 National Centre for Medium Range Weather Forecasting (NCMRWF) will be further strengthened, structured and pushed forward to meet the ever-growing demands through appropriate communication infrastructure for reaching out to the wider user community. In the India Meteorological Department (IMD), the thrust will continue to be on the major areas of Space Meteorology, Telecommunications, Cyclone Warning, Aviation services, seismology and observational organizations in terms of inducting latest technologies, particularly by providing cutting edge S&T in high value sectors. New programmes of IMD pertain to : starting a commercial cell; establishment of a satellite based network of 1000 stations for automatic collection of meteorological data from all parts of the country for assimilation in numerical models in near-real-time; and pursuance of scientific work to develop improved climate prediction models. Some of the important initiatives of Survey of India (SOI) include: introduction of dual series of topographical maps in SOI; upgradation of photogrammetric potential in SOI; establishment of National Geospacial Digital Infrastructure Centre; Airborne Laser Terrain Mapping Technology etc. In the National Atlas & Thematic Mapping Organization (NATMO) the ongoing schemes like: District Planning Maps; Economic Science and Technology Atlas; revision of Forest Atlas of India etc. will continue during 10^{th} Plan.

11.16 The autonomous institutions under DST will, besides pursuing fundamental and applied research in various concerned areas, produce high quality manpower in unique and frontline areas of science and engineering and initiate work on upgradation of facilities. They will be modernised to do research at par with developed countries. The network of State S&T Councils will be further strengthened by continuing the support to the Councils with focus on S&T manpower; suitable career advancement of S&T secretariats; identification, formulation and implementation of location specific and multi-sectoral programmes in the states; etc.

11.17 The details of the Core programmes identified by the DST and the Mission Mode programmes identified by Steering Committee are given below.

Core Programmes

11.18 The Core Programmes identified by DST are : Science and Engineering Research Council (SERC); Intensification of Research in High Priority Areas (IRHPA); Mega Science Projects; S&T Manpower Planning and Development; Fund For Improvement of S&T Infrastructure In Universities And Higher Educational Institutions (FIST) Programme; Regional Sophisticated instrumentation Centres (RSIC); Support to Professional Bodies; Travel Support to Seminars and Symposia; Co-ordinated Programmes on Earth & Atmospheric Sciences; Technology forecasting and Assessment; The Technopreneur Promotion programme (TePP); A National Accreditation Board for Testing and Calibration Laboratories (NABL); Technology Development Board (TDB);Instrument Development Programme; Joint Technology Programme; Patent Facilitating Cell (PFC); Research for Delivery of Competitive Technologies; International Co-operation; National S&T Management Information System (NSTMIS); Natural Resources Database Management System (NRDMS); Science and Society Programmes; National Council for S&T Communication; Science and Technology Entrepreneurship Development; Scientific Services of the institutions, viz., SOI, NCMRWF, IMD and NATMO; Autonomous Research Institutions under DST; State Councils for Science and Technology; and Management. All these programmes have already been discussed in the previous pages.

Mission Mode Programmes

I. Seismology

11.19 The objectives are: to improve the detection and location capabilities of earthquakes occurring anywhere in the country up to magnitude 3; and to improve upon

the national capacity, and capability building, to provide better earthquake related services. The proposal envisages strengthening of seismological network in the Himalaya and its contiguous region (Indo-Gangetic-Brahamputra plains) with state-of-the-art robust earthquake monitoring systems for fine scale mapping of the earthquake hazard and ascertaining the seismogenic sources. Another important component will be Human Resource Development by the help of some laboratories abroad in emerging analytical tools and approaches. The project will be implemented in a consortium mode by involving all the relevant agencies. An Apex Steering Committee assisted by a Project Implementation Committee will oversee the implementation.

II. Nano Science and Technology

11.20 One of the emerging fields in the area of materials science and engineering is Nanomaterials, which has tremendous applications in all the spheres of life. In recent times, emphasis is being laid on synthesis of new types of Nanomaterials which find interesting applications in areas like catalysts, advanced ceramics, optics, medicine, computers etc. Taking into account the recent developments in this area, a Mission Mode project on Nanomaterials S&T will be initiated in the 10^{th} Five Year Plan. A National Expert Committee is expected to evolve a strategy balancing both basic and applied aspects of R&D. The activities under this programme include : support to open ended fundamental Nano-science and engineering research on nanosized ceramics, water purification, drug delivery systems, energy devices etc. through university - national laboratories - industry participation by establishing Centres of Excellence for Nanotechnology Research and manpower development.

III.Technology for Bamboo products

11.21 Given its scope for generating sustainable livelihood and reducing pressure on the timber resources, the bamboo sector has been receiving very little support and is in need for a comprehensive programme for sectoral upgradation. A programme undertaken at the national level could impart a significant boost to the usage of bamboo, promote specialized products for commercialization and would generate good employment opportunities. The program will identify technology oriented business opportunities for processing raw bamboo into value-added products and expediting their economic & marketing feasibilities. It would be designed more in the development-

financing pattern while keeping the market acceptance, commercialization, and product branding as the ultimate objectives.

11.22 Important objectives of the mission are: development and promotion of bamboo based products; promotion of design capabilities, fabrication techniques & testing methodologies for specific applications (building & construction, architecture & decorative uses, industrial applications, marine operations etc.) through industry-lab linkages and empowerment of people at the grass-root level. This program is expected to create new awareness for eco-friendly use of bamboo while building a sustainable infrastructure for plant multiplication, propagation and cultivation and would be an ideal platform for demonstrating the 'technology with a human face'.

IV. Drugs & Pharmaceutical Research

11.23 The scheme aims at enhancing capabilities of the Indian drugs and pharmaceutical industry towards development of new drugs by synergising the strengths of publicly funded R&D institutions and the Indian Pharmaceutical drug industry for discovery and introduction of new drugs and practices in all the systems of medicine. Under this scheme financial support is provided to national labs and academic institutions for joint research programmes conceived by the industry and public funded R&D institutions.

11.24 During the 10^{th} Plan, it is planned to continue supporting collaborative research projects leading towards drug development in the areas covered before (in the last Plan), besides making efforts to generate and support projects leading to development of new drugs and practices for diseases not covered so far such as AIDS, Leprosy, Malaria, Kala Azar (Leishmaniasis), Amoebiosis, Skin disorders like Leucoderma, Gastrointestinal disorders like Diarrhoea, Cholera, Diabetes, Epilepsy, acute respiratory infections and Hypertension, veterinary diseases etc. The areas in which national facilities will be set up in the near future pertain to: screening of anti-viral activity; combinatorial chemistry facilities along with HTS attachment; peptide synthesis and peptide sequencing required for new drug development etc. At least two Clinical Research Organizations (CRO) will be established to satisfy the rising demand of the D&P industry.

V. Instrument Development

11.25 Instrumentation is one of the major areas of Science and Technology. It makes a great impact on vital sectors of national activities such as education, scientific research, industry, agriculture and health etc. An Expert Group on Instruments and the Science Advisory Committee to the Prime Minister (1988) have recommended initiation of focused programmes

in instrumentation using multi-institutional and multi-disciplinary approaches by involving R&D institutions and industries. Because of meager financial allocation, programmes in the 9^{th} Plan were confined to a few areas on project basis. Now, in the 10^{th} Plan, this Programme will be taken up in Mission Mode. The subprogrammes under this will include: Analytical/Scientific Instrumentation, Medical Instrumentation, Industrial Instrumentation, Imaging Techniques and Instrumentation, NMR Imaging System, Thermal Imaging System, development of Component, Sub-systems & Sensors.

VI. Technology Business Incubators

11.26 To enable SMEs to overcome their technological backwardness and to have easier access to new technologies, they need to be given a conducive environment, which, in the present context of globalization, calls for a human centered approach, with tacit knowledge playing a predominant role. This could be obtained by means of Incubators where potentials of new industries will be studied. Some of the major objectives of establishing TBIs are: technology commercialization; economic development; property venture; entrepreneurship development and R&D for Industry. In order to have an impact of the programme on the economic development of the country, 50 TBIs will be established in the first phase, spread throughout the country, within a period of five years.

CHAPTER 12
TENTH FIVE YEAR PLAN PROGRAMMES – SCIENTIFIC & INDUSTRIAL RESEARCH

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH (DSIR)

12.1 DSIR will continue to operate its programmes under 4 ongoing schemes and two Public Sector Undertakings (PSUs) during 10th Plan. The 4 schemes are : Research and Development by Industry (RDI); Programme Aimed at Technological Self Reliance (PATSER); SEETOT scheme renamed as Management and Trade of Technology and Related Services (MATTS); National Information System for S&T (NISSAT). The PSUs are National Research Development Corporation (NRDC) and Central Electronics Ltd (CEL). The schemewise and PSU wise programmes to be undertaken during 10th Plan are given below.

12.2 Under **RDI**, recognition will be given to about 500 new in-house R&D centres and 250 new SIROs; 5 annual national conferences will be conducted and awards presented to 50 new companies; approval will be accorded to 100 commercial R&D companies and 250 in-house R&D centres u/s 35(2AB). The new programmes to be undertaken relate to financial support to SIROs, award of fellowships to a selected meritorious research workers who opt to work in recognized R&D centres and assistance to small and large industrial units in entering into International R&D collaborations. Support under **PATSER** scheme will be for : 100 Technology Development Projects in various areas; 500 projects under Technopreneur Promotion Programme (TePP); 20 Workshops and Seminars; 10 Technology Evaluation Studies in important sectors/areas and marketing of technologies for completed PASTER projects. **MATTS** scheme comprises of three sub-schemes viz., Technology and Innovation Management Programme (TIMP), Transfer and Trading in Technology (TATT) and Promotion and Support to Consultancy Services (PSCS). **TIMP** programme will support 25 Technology Development Studies; suitably selected Studies on technology & innovation

management; 20 Case Studies on Technology Management; preparation of directories of Foreign Collaboration Approvals; 5 chairs in Technology & Innovation Management; and Awards for best Technology Management Practices/Papers. **TATT** programme will get the documentation of technology Export Performance and Capabilities done through newsletters and profiles on exportable technologies, organize publicity and awareness campaigns; support the activities of Technology exports Development organization, Technology Trade Facilitation Centres and Product Design Centres and will position Technology counselors in selected developing countries. **PSCS** will continue to promote and strengthen technical consultancy capabilities for domestic use and export requirements including support to Consultancy Development Centre (CDC). The annual institutional support to Asia and Pacific Centre for Transfer of Technology (**APCTT**) will be increased from US$ 100,000 to US$ 200,000 (around Rs.1crore) during the Tenth Five Year Plan to take care of the expansion of APCTT and increased costs of utilities. Various activities under **NISSAT** pertain to creation of : information centres/national websites/servers in a few sectors/subjects of national interest; data bases for basic knowledge elements on home medicines, explorations and harvesting techniques, weather forecasting etc.; preparation of Indian Digital Library of Electronic thesis, National Scientometric programme; phaseII of the Virtual Information centres, bibliographic application of computers through acquisition of UNESCO developed software packages like CDS/ISIS & IDAMS; Monitoring & coordination of S&T Information activities; documentation of grass root level technologies; development of information linkages for giving guidance to community; setting up open information archives in a few selected disciplines; and establishing a common facility for Scientometric Studies etc. DSIR needs a separate building for housing its officers and staff. A separate building for DSIR will therefore be constructed in the Technology Bhavan premises for which preliminary work was already initiated during the 9^{th} Plan.

12.3 **NRDC** will continue to undertake the projects under the two programmes, viz., Invention Promotion Programme (IPP) and Technology Promotion Programme (TPP). In addition to the awards, assistance to investors, publications etc, **IPP** envisages new programmes on organizing Inventors' Clubs and exhibitions, and restructuring their publications to cater to the needs of SSIs. Under **TPP** for the development and promotion

of rural technologies, a demonstration-cum-operating centre will be set up in and around Delhi for demonstration of rural and household technologies. To promote export of technologies, NRDC will participate in 15 International Exhibitions/seminars/trade fairs and bring out multimedia CD presentations of exportable technologies. Other measures under the TPP relate to : setting up a technology information related Portal covering information on indigenous and foreign technologies, IPR, R&D institutes and awards, training programmes etc.; interactive multimedia package on IPR; funding of technology development programmes in the areas of gene delivery system, digital fountain clock, slow release spray in pesticides etc. and providing loan/equity/convertible loan/grant to : licensees of NRDC technologies, Indian industry setting up projects abroad, joint venture companies etc. **CEL** will develop technology for use of around 250 micron thick silicon wafers for manufacturing solar cells; complete development of technology for manufacturing 125 mm and 150 mm pseudosquare multicrystalline solar cells and initiate R&D work on thin film solar cells; carry out D&D work for PV products for use as building materials; undertake development of strategic electronic equipment and systems so as to make this area of operation contribute to about 20-30% of the turnover; complete D&D work on the digital axle counter and carry out development of other signaling and safety systems for Indian Railways and export; develop hybrid remotely operated PV systems for microwave repeater stations, and applications of piezo electric elements for defence and automobiles. The programmes envisaged under **I&M component of CEL** are : commencement of regular production of 125mm pseudosquare cells & modules; expansion of production capacity for solar cells and modules to 10 MWp per annum; commencing production of multichannel PCM driver presently under development; taking-up production of SPV cells & modules using multicrystalline type silicon wafers upto size of 150mm pseudosquare; initiating pilot production of thin film solar cells and SPV modules in the form of construction material, commencing regular production of phased arrays, DF systems and IFF Systems for defence; and expanding range of signaling and safety systems for Railways.

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH (CSIR)

12.4 The guiding principle for CSIR in the formulation of 10^{th} Plan programmes continues to be to provide scientific industrial research and development

that maximizes the economic, environmental and societal benefits for the people of India. Besides, CSIR seeks to foster in the organizational values of : excellence in science; global competitiveness in technology based on high science; local relevance in tune with socio-cultural and economic ethos of the people; and innovation in all the spheres of activities ranging from science to technology management to financing. These principles coupled with SWOT analysis carried out in CSIR laboratories were taken into consideration in deriving the opportunities for CSIR technologies in the market place. Accordingly, CSIR will seek to partner strategically with Indian industry for : innovative research; application and development of technology; commercialisation of technology; technology transfer, especially to SME's and help certain weak industrial sectors to regain their growth rates and become competitive globally.

12.5 Other factors which influenced the formulation of CSIR programmes for 10^{th} Plan are : responsibilities on CSIR arising out of International IPR arena; continuous training and retraining of CSIR staff; advancement of knowledge through enlarging the scope of fellowships to transdisciplinary areas and supporting fully basic research that dovetails with its own requirements; extension of S&T by extensively involving the NGOs to proliferate CSIR technologies to the masses at the grass roots levels.

12.6 The 10^{th} Plan Programmes of CSIR have been formulated under six schemes, viz., National Laboratories; National S&T Human Resource Development; Intellectual Property & Technology Management; R&D Management support; New Millenium India Technology Leadership Initiative; and Infrastructure Renovation and Refurbishment.

National Laboratories

12.7 The 10^{th} Plan Programmes of National laboratories have been formulated under 14 sectors, viz., Aerospace; Biology & Biotechnology; Chemicals; Earth Resources & Natural Hazards Mitigation; Ecology & Environment; Electronics & Instrumentation; Energy; Food & Food Processing; Health Care and Drugs & Pharmaceuticals; Housing & Construction; Information Dissemination & Products; Leather; Materials, Minerals & Metals and Manufacturing. Based on an overall SWOT analysis of the sector and of the CSIR laboratories servicing the sector, specific themes of R&D projects and specialized facilities to be created to service these sectors were shortlisted. These were then relooked

by CSIR on ZBB basis. Further shortlisting and prioritization were done on the premise that pre-competitive science, research and technology is a public good to be financed through public funding and specific industry oriented R&D needs resource sharing. In the selection of the programmes, the guiding principles have been : high levels of novelty and innovativeness; global competitive positioning in science and / or technology; potential industrial, economic strategic, societal benefits that could be captured and will accrue to the Indian economy. At the macro level the overall approach has been to source at least 40% of investments for national laboratories from outside of the budgetary provisions. For externally funded projects the strategy has been to establish technology partnerships with the stakeholders right from the stages of project identification to target setting, monitoring and utilization. Some of the important programmes/project areas of National Laboratories in the 14 sectors mentioned above and which will form part of 10^{th} Plan are as follows.

I. Aerospace : Proactive R&D which should be able to provide timely inputs for the aerospace programmes which mainly envisage completion of the HANSA-3 and SARAS and their stretched versions; Design and Development of Civil Aircraft; Support to National Aerospace Programmes; Developing and Sustaining High Technology Competence on High temperature composites, magnetic bearings, futuristic propulsion concepts etc.; New National facilities such as national 1m Hypersonic Wind Tunnel, open air engine test facility etc.; Specialized Aerospace Materials like Silicon Carbide (SiC) fibre technology, Ceramic radome technology and ceramic coatings.

II. Biology & Biotechnology : Cell & Tissue Engineering; (Blood-vessel research & vascular cell biology; Hematopoeitic stem cell research & applications; artificial skin development; collagen polymorphism.); exploration and exploitation of Microbial Wealth of India; Molecular biology of entric pathogens; Molecular characterization of water borne pathogens and their monitoring in major water resources; Toxicogenomics of polymorphism in India population to industrial chemicals for development of biomarkers; Designing animals and plants as bio-reactors for proteins & other products; Conservation of genetic resources of economic, medicinal and aromatic plants; Medicinal plant chemotypes for enhanced marker and value added compounds;

Development of novel value added plant products, pesticides and biofertilizers; Development of agrotechnologies for production of quality plants and flowers.

III. Chemicals : Coordinated programme on catalysis & catalysts; Green Technologies for organic chemicals; Specialty Polymers; Eco-friendly Agrochemicals; Inorganic Chemicals; Globally competitive chemical processes and products.

IV. Earth Resources and Natural Hazards Mitigation : Mesozoic sediments and Hydrocarbon exploration; evaluation of Gas Hydrates of Indian Continental Margins; Marine Mineral exploration; Exploration, Assessment & Management of Ground Water; Oceanic processes along Carlsberg – Central Indian Ridge (CR-CIR); Studies on environment and geodynamics of continental margins; Study of Lithosphere, Earth's Interior and Geodynamics Processes; Acquisition of Oceanographic Research Vessel (ORV); Seismic Hazards Assessment; Seismic motion simulation for testing of structural models and structural components (New); Natural disaster mitigation measures for earthquake/landslide prone areas.

V. Ecology & Environment : Atmospheric Environment and Global Change; Study of Oceanographic Processes of North Indian Ocean in Reference to Global Change; Air Quality, Inventorisation and Modeling for Management Strategies; Water Quality Monitoring especially with reference to Pathogens; Industrial Waste minimization and clean up; Pollution Mitigation in Urban Conglomerates.

VI. Electronics & Instrumentation : A selective approach in taking up developmental programmes for sub-sectors of electronics industry; strategic electronics and medical electronics will be continued and made applications specific. A programme on photonics will be undertaken with a view to make the country a global player in that domain. Another major programme to be launched is on microelectromechanical systems (MEMS), an area that is emerging globally. The other areas are : Electronics For Societal Purposes; Ionospheric Tomography for Space Weather Studies.

VII. Energy : Coal Preparation; Coal combustion; Utilization of high sulphur lignites and Assam coals; Coal Characterization & Resource Quality Assessment; Utilization of Coal fines for energy generation; New generation fuels & lubricants; Development and demonstration of Fuel cells for transport and stationary applications; Proton Exchange Membrane Fuel Cell (PEMPC) for stationary applications;

Transportation fuel Cells; Lithium batteries for vehicular traction; Advanced Lead Acid Batteries for Solar Photovoltaic (SPV) applications.

VIII. Food & Food Processing : Nutraceuticals and neutrigenomics; Health and convenience foods; Natural, nature identical or similar biomolecules; value addition to spices and plantation crops; Innovative processes and products; Centre for testing of Genetically Modified Foods; Food safety certification centre at CFTRI, Mysore; Food irradiation facilities.

IX. Health Care and drugs & Pharmaceuticals : Mission on Asthma; World class drug research institute; Coordinate programme on discovery and development of new bioactives; Predictive medicine using repeat and single nucleotide polymorphisms; Drug target development using In-silico biology; Animal models and animal substitute technologies; Advanced facility for safety evaluation of genetically modified/ engineered drugs; Herbal preparations standardization, validation and new introductions; Cost effective processes for generics; Infectious diseases handling storage and Research Facilities.

X. Housing & Construction : Habitat; New Building Materials; Special structures; Bridges; Roads; Traffic & Transport; Retrofitting & rehabilitation of distressed structures.

XI. Information Dissemination and Products : Traditional Knowledge Digital Library (TKDL); National Science Digital Library (NSDL); Digital Copyright Management System (New); Development of Science & Technology Databases, Information Products and Electronic Publishing; Application Service provider Technology; Science – Technology – Industry (STI) portals; Establishment of CSIR Net Academy; Mathematical Modelling and Computer Simulation.

XII. Leather : Leather Processing Technology; Leather Product Technology; Leather Environment Technology; Leather Chemicals Technology; Biotechnology in Leather; Leather Policy & Management Centre; Human Organizational Development for Leather industry.

XIII. Materials, Minerals, Metals, and Manufacturing : Custom tailored special materials; Comprehensive technology packages for disaster prevention and management in underground coalfields; Coastal placer mineral mining capacity building;

Biomineral processing for extraction of metal values from ores and concentrates; Technology for processing of strategic minerals and mineral sands; Special Materials; Advanced Manufacturing Technology; Residual life assessment and evaluation of in-service components/equipment.

XIV. Metrology : Physico-mechanical Standards; Electrical and Electronic Standards; Realization of the Base Unit of the Amount of substance 'Mole'; Networking of Calibration & test facilities in CSIR Laboratories.

National S&T Human Resource Development

12.8 The CPYLS scheme and SPM fellowship will continue. A 'training and motivation' programme to selected science teachers will be initiated. One more scheme is to attract youth to science and to promote interest, excitement and excellence in science education at school and undergraduate levels. In that, each CSIR laboratory will adopt at least one school and one college in its sphere of influence and will offer not only its facilities for project work and experimentation but also carry out student guidance and motivational programmes. There are two more schemes that will be initiated. In one, fellowships will be offered to researchers in transdisciplinary areas and in other, a spirit of entrepreneurship will be inculcated in the research scholars to establish their own R&D enterprise through appropriate motivation, skills development and venture financing.

Intellectual Property & Technology Management (IP&TM)

12.9 The IPR regime is presently in a state of flux and there are major unresolved issues with respect to 'traditional knowledge', 'genomic sequences', 'copyright on the Net' etc. NISTADS in CSIR has been mandated to coordinate this activity through enhancing the foreign portfolio of patents from 500 to 2500 by the end of 10^{th} Plan end; identifying potential threats and opportunities to IPR regime; creating electronic/digital database on CSIR's IP & knowledge base holdings; developing educational programmes on IP & TM etc.

R&D Management Support

12.10 During 10^{th} Plan CSIR envisaged a programme on setting up of an organizational Human Resources Development Centre at Ghaziabad as a follow up of the

CSIR Review Committee in 1986. The Centre is expected to train annually around 500-600 senior personnel over 5000 participant days. Other activities under this relate to : initiation of partnerships that could synergise and add value to R&D activities in the National laboratories; popularization of CSIR activities among masses through multimedia and print world; continuing support to the Unit for R&D in Information products, to catalyse and mobilize packaging of information products based on CSIR databases and developments to make it self-sustaining.

New Millenium India Technology Leadership Initiative (NMITLI)

12.11 The objective of the scheme, initiated in February 2000, is to capture for the country global leadership position in a few selected areas based on technology. In the first year (2000-2001) of its operation, CSIR initiated nine 'proof of concept projects'. Five of these projects on completion will qualify for development to the next stage of specific product/process/application/development and upscaling. Around 20% of the funding for these projects will come from external sources. This scheme will enable India to acquire global leadership/monopoly position in at least 3 niche technology domains.

Infrastructure Renovation and Refurbishment

12.12 Two programmes are envisaged under this scheme. The first is on the Use of IT in CSIR in which internet connectivity to all the laboratories will be sought through a national level ISP including VPN solutions to establish a CUG (Closed User Group), high speed, satellite-based communication network, interconnecting 100 nodes : Hqs & 39 labs and 60 field centres to provide an "on-line" Management Information System (MIS) for : R&D Project management System, Technology management System, Intellectual Property Management System, Human Resource Management System, Financial Accounting & Management System and Investment Management System. The MIS and the CSIR Net varsity will be hosted on the CUG.

12.13 The second programme relates to Refurbishing the Antiquated Physical Infrastructure. CSIR infrastructure was built or acquired more than thirty years ago. Some of the laboratories like the CDRI, CFTRI, CSMCRI etc. are housed in palaces which are centuries old. The premises were converted into laboratories by carrying out only small renovations. Most of the CSIR laboratories are not suited for modern day R&D especially

in terms of GLP, ISO, NABL requirements for accreditation and certification. Also many of them today are at a stage of dilapidation and pose safety hazards. Most of the buildings need renovation.

Core Programmes/Mission Mode Programmes

12.14 The Core Programmes of CSIR have been categorized under three heads : (i) Mission Mode Programmes identified by the Steering Committee, (ii) Mission Mode Programmes identified by the Working Group of CSIR and (iii) Other Core Programmes identified by the Working Group. A brief description on the Programmes at (i) above is given below.

Mission Mode Programmes identified by the Steering Committee

I. Design & Development of Civil aircraft – Stretched SARAS and HANSA

12.15 The present R&D programmes pertain to two small 'niche ' civilian aircraft : HANSA -a two seater all composite trainer aircraft with 750 kg all up weight with day and night flying certification and SARAS-a 14 seater multirole Light Transport Aircraft being designed to FAR-2 regulations. The objective of the mission during the 10^{th} Plan period is to design and develop the stretch versions of these aircrafts with 90% indigenous components, particularly through development of sub-systems like propellers, starter generators, passenger seats, flight components etc. The main participants in the programme are CSIR (through NAL) and HAL. Partnering with IISc, IITs and civil aircraft industry is also envisaged for realizing indigenous development of components & subsystems. By the end of the 10^{th} Plan, development of stretch version with 4-6 passengers will be taken up in the case of HANSA-3, production standards and third flying prototype of SARAS established and indigenous development of selected subsystems of SARAS like propellers, starter generators, passenger seats undertaken. In addition, design of stretch version for 19 seater LTA; and design, demonstration and popularisation of micro air vehicles will be taken up.

II. Exploration and Exploitation of Microbial Wealth of India for novel compounds and biotransformation processes

12.16 A large percentage of microbial products in use today had come from soil dwelling culturable microbes. These sources have been "mined" quite extensively and it

is likely that most of the soil microbes that can be cultured in the laboratory have, in all probability, been examined already. The objective of the mission, therefore, is to look for newer sources for prokaryotic biodiversity in exotic habitats likely to harbour a higher percentage of hitherto unexplored microbes and understand their expression system for commercial applications. CSIR would synergise on the core competencies internally (IMT, IHBT, IICB, IICT, NEERI, RRL-JM, RRL-JT, RRL-BHU) and externally with academia such as universities of Assam, Himachal Pradesh, Punjab, Pune, and Rajasthan, and with the ICAR and Dept. of Biotechnology. Industry will also be involved appropriately. The broad steps involved in the project implementation/the outputs to be realized are :

- Collection of samples from different exotic habitats and standardization of methodologies for large scale isolation of oligotrophic bacteria;
- Phenotypic characterization and taxonomic description of the isolates;
- Screening of the isolates for novel (antimicrobial, cytotoxic) compounds and their bio-transforming properties;
- Molecular characterization of the isolates involving amplification and sequencing of the 16S rDNA genes;
- Sequencing of the genes and analysis of proteins of interest; and
- Development of a bacterial genomics databases.

III. Molecular biology of selected pathogens for drug targeting

12.17 The objectives of / methodologies involved in the project are : identification of important proteins from M.tuberculosis which could serve as potential drug target proteins and enzymes at the molecular level; analysis of diversity of genomes of Vibrio cholerae and Shigella dysenteriae for : (a) determing virulence factors, (b) identifying of genes required for environmental survival, and (c) establishing the molecular basis of epidemic potential; and identification of specific genes induced in host and in bacteria during infection (Host-pathogen interaction).

12.18 The targets to be achieved are : identification of genetic determinants controlling the stringent response of pathogens under various environmental conditions,

e.g., cold shock proteins in V. cholerae; construction of a combined physical and genetic map of S. dysenteriae type1 and comparative genome analysis for understanding the evolution of newer strains with epidemic and pandemic potentials; construction of combined physical and genetic maps of three V. cholerae O1 biotype El Tor strains and comparison with the genome of classical and O139 vibrio for vector and vibriophage development as therapeutic tools. The specialized biotech departments in universities and pharma industry will be involved in the project.

IV. Study of Mesozoic sediments for hydrocarbon exploration in coordination with DOD.

12.19 Mesozoics are an additional potential sources of hydrocarbons that have not been fully explored in the country. The objective, therefore, is to exploit this resource by refining the techniques and introduce new strategies for the location of hydrocarbons in Mesozoic sediments and to apply these for survey work in promising regions. The targets to be achieved are : mapping of the identified 60,000 sq./km of subtrapear region by using the newer techniques and strategies and delineation of the basement configuration and detailed structural features to understand the depositional history for hydrocarbon exploration. More specifically, seismic studies of 1000 line kms, gravity studies at 12,000 stations, magnetotellurics at 600 stations, and deep resistivity sounding of 100 stations will be undertaken. The project will be taken up in close collaboration with ONGC, (KDMIPE), DG,HC, and concerned state governments and academia circles. DOD who is responsible for ocean related activities will be associated appropriately.

V. Evolving Pollution monitoring system devices for air, water and solid waste

12.20 As a result of rapid urbanization and industrialization, most Indian cities have higher levels of gases, particulate matter and chemical pollutants than permissible. Mortality and morbidity statistics also indicate that respiratory infections and chronic conditions are becoming wide spread within the urban population. The quality of water in most waterbodies has considerably degraded and in most cases cannot be used for any human purposes unless adequately treated. Solid wastes abound in cities and their hinterland. This imposes a high cost on the economy in terms of loss of mandays,

productivity and production. There is, therefore, an urgent need to understand pollution and its impact on human health so as to devise systems and methods for its mitigation. Accordingly the objectives set for this Mission Mode Project are : development of analytical tools and devices for monitoring of selected pollutants in small quantities in water, air and food materials; new instruments/methods for analysis and monitoring of the pollutants (including biosensors and probes); and also development of cleaner technologies for reduction of waste generation and waste disposal especially of industries impacting environment of metropolitan and industrial conglomerates.

VI. Development of microwave Electron Tube Technologies for ultra high frequency Communication for large scale applications

12.21 Microwave tubes are used in UHF communication including satellite communication, radars, particle accelerators etc. besides a few civilian applications. Specialised tubes with stringent specifications and in few numbers are required by Department of Defence, Space and Atomic Energy. For a variety of reasons these are not available to Indian users from abroad. The objective of the project is to enhance the competence level and excellence built up in this area to global levels to develop & produce electron tubes of the following type for large scale applications :

- 7.5-18 GHZ Gain and Phase Matched Mini Helix TWT for Sanghraha & Sanyukta programme of DRDO;
- C-Band 60 Watt Space TWT for G-SAT programme of ISRO;
- C-Band and 70 KW Coupled Cavity TWT for Akash and Rajendra radar programme of DRDO;
- 3 MW, S-Band Tunable Pulsed Magnetron for Accelerator programme;
- 5 MW, S-Band Pulsed Magnetron for Accelerator programme;
- 40 KV, 3KA Hydrogen Thyratron for Pulse Laser programme.

CSIR will intimately interact and network with the users and BHU to optimize on the testing and basic knowledge. Efforts will also be made to explore the possibility of exporting these devices to other friendly countries.

VII. Development of technology for control of Asthma caused due to pollution.

12.22 Genes and environment both play a very important role in Asthama. Environment contributes in precipitating the disease due to the increased exposure to sensitizing allergens and reduced stimulation of the immune system. A clear understanding of the cellular and molecular mechanisms of this allergic disease is lacking. However, discovery of the highly expressive gene for asthma brings optimism and the possibility of preventing this disorder by inhibiting the expression of the genes.

12.23 The objective of the project is to devise interventions that enable the human body to inhibit or block the anti-asthamatic and allergic responses from genetic and external stimuli. The targets for various activities are : collection of samples from 10,000 affected population (first degree relatives and siblings); identification and validation of specific novel genes involved in asthma and co-relation of gene polymorphism; identification and development of molecular markers for asthma; development of newer animal models for allergic diseases and asthma; pharmacogenomic studies with new targets for screening; development of herbal therapeutics and leads. CSIR will dovetail its core competences (CBT, CCMB, IICT, RRl-JM) with the best competencies available in India (Patel Chest Institute) and elsewhere and come up with an effective herbal curative, molecular targets and leads for it.

VIII. Newer scientific herbal preparation standardization, validation and introduction

12.24 The objective of the project is to develop in the case of herbals : standardized and optimized superior formulations; trimmer preparations molecularly defined; formulations related to detoxifiers and antioxidants; and derive optimized molecular leads. CSIR has already established a wide spread networking of 20 of its laboratories with the leading players in Indian systems of medicines.

12.25 US, FDA now permits herbal preparations to be marketed as therapeutics. As a result there has been a visible resurgence in the interest of herbal preparations by Indian pharma industry. Modern biological tools, techniques, processes and focused R&D can assist the Indian industry to market herbal therapeutics globally. Also, CSIR will help the local industry to put validated and standardized products in the Indian market. CSIR has already entered into a strategic alliance with Arya Vaidya Sala (AVS) and Central Council of Research in Unani Medicine (CCRUM) for this purpose.

IX. Traditional Knowledge Digital Library (TKDL) for bringing out comprehensive information and document on traditional knowledge.

12.26 The objectives of the project are : collection, compilation & transcribing in digital format of over 150,000 pages of information on medicinal plants used in diverse Indian systems of medicine & ethnomedicine; collection and compilation of arming practices & implements; traditional artisinal designs, techniques & technologies; setting up of TKDL portal in Hindi, English, German, French and Japanese including a web-based search interface providing full text search and retrieval of traditional knowledge on International Patent Classification.

12.27 India (CSIR) pioneered the recognition and acknowledgement of `Traditional Knowledge' in international fora for `patent search' and the `Team India' initiative to set-up the first ever TKDL. The onerous responsibilities of hosting and operationalising the TKDL for Indian System of Medicine has been assigned to CSIR at NISCOM by the Government. This will be further enlarged to cover the entire gamut of non-cultural traditional knowledge such as farming practices and implements, artisenal techniques & technologies, environmental practices etc.

X. Environment friendly Leather Processing Technology

12.28 The objectives of the project are : management of solid wastes from tanneries; control reduction of total dissolved Solids (TDS) control in processing; develop cost control and waste minimisation measures in processing; develop cleaner leather processing technologies aimed at reduction/avoidance of pollution & hazardous solid wastes generated and avoidance of eco-sensitive and toxic substances/chemicals; degradation of toxicants and removal of pathogens from waste waters; and develop process technologies/strategies for imparting value addition to finished leathers with main focus on lower selection raw materials and leathers from goat skins, buffalo hides and splits; training of workers engaged in the associated diverse activities in the sector; and reaching the unreached segments of the industry. Besides the CSIR laboratories, and academic institutions concerned, leather industry, Ministry of Industry & Commerce, Department of Biotechnology, State Pollution Control Boards and Associations will be involved.

12.29 The Mission Mode Programmes identified by the Working Group of CSIR are: Development of Specialized Aerospace Materials; Cell & Tissue Engineering; Toxicogenomics of Polymorphism in Indian population to industrial chemicals for development of biomarkers; Designing animals and plants as bio-reactors for proteins & other products; Coordinated Programme on Catalysis & Catalysts; Green Technologies for Organic Chemicals; Evaluation of Gas Hydrates of Indian Continental margins; Oceanographic Research Vessel (ORV) : Acquisition; Study of Oceanographic Processes of North Indian Ocean in reference to Global Change; Photonics and Opto Electronics : Key Technologies; Microelectromechanical Systems (Mems) and Sensors; Coal Characterization & Resource Quality Assessment; New generation fuels & lubricants; Positioning Indian nutraceuticals and neutrigenomics on the global platform; World class drug research institute; Predictive medicine using repeat and single nucleotide polymorphisms; Drug target development using in-silico biology; Animal models and animal substitute technologies; New Building Construction Materials; Mathematical modelling and Computer Simulation; Biotechnology in Leather; Custom tailored special materials; Coastal placer mineral mining capacity building; Physico-mechanical, electrical and electronic standards.

12.30 Other Core Programmes identified by the Working Group of CSIR are : Developing and Sustaining High Science & Technology for national aerospace programmes; Medicinal plant chemotypes for enhanced marker and value added compounds; Globally competitive chemical processes and products; Development of Speciality Polymers; Exploration, Assessment and management of Ground Water; Oceanic processes along Carlsberg – Central Indian Ridge (CR- CIR); Industrial Waste Minimization and Clean up; Electronics for Societal Purposes; Coal Preparation for quality enhancement; Natural, nature identical or similar biomolecules; Genetically Modified Foods Referal Centre; Advanced facility for safety evaluation of genetically modified / engineered drugs; Infectious diseases handling storage and Research Facilities; Coordinated programmes on discovery and development of new bioactivities; Special

structures including bridges; Roads; National Science Digital Library (NSDL); Leather Policy & management Centre; Comprehensive technology packages for disaster prevention and management in underground coalfields; Biomineral processing for extracting of metal values from ores and concentrates; Advanced Manufacturing Technology.

CHAPTER 13

TENTH FIVE YEAR PLAN PROGRAMMES – BIOTECHNOLOGY

13.1 The Tenth Five Year Plan Programmes in Biotechnology area have been formulated within the framework of a Ten Year Perspective for the biotechnology R&D and by keeping in view : the progress made during the 9th Plan, the infrastructure already created, expertise and the facilities available in the country and the fact that India is well poised to embark on biotechnology based national development where frontries of knowledge of new biology and biotechnology could be harnessed for creation of wealth in hormony with the environment. The underlying principle for the policy framework is that the biotechnology developments will have the greatest impact on humankind for their food, nutrition, health, environment and livelihood security.

13.2 In view of the fact that the recent advances in many areas of biological research, notably genomics, cell biology, structural biology and molecular approaches to biological function hold a great promise for the future developments in biotechnology, long term support would be provided for basic biology research in areas related to infectious diseases; metabolic engineering, biomaterials, stem cell research, chemical ecology etc. by creating necessary infrastructure and instrumentation facilities. The highlights of the programmes in biotechnology to be undertaken during the 10th Plan are given below.

13.3 In the field of Agriculture, application of biotechnology research will be mainly in the crop improvements. Enhanced yield for sustained sufficiency is sought to be achieved through the new techniques. Crop improvement for the products such as food additives, flavors, food colorants, vegetable oils and fats, which command a high export value will be obtained through genetic modification of other crops or through in vitro techniques. Other approaches in this field are: fine mapping of genome regions harbouring useful genes; developing transgenic biofertilisers; creating an awareness among farmers on the benefits of biopesticides and IPM technologies; etc.

13.4 For achieving food and nutritional security, a mega network involving competent institutions/scientists will be launched for development of analytical methods for testing of genetically modified foods and products derived therefrom other methods in this direction are : utilization of agricultural byproducts for value added products;

resolving food safety issues vis-a-vis development of rapid diagnostic kits for food toxicants, pesticide residues, adulterants, and food borne pathogens; development of high yielding rice varieties with β carotene etc.

13.5 Research on plant biotechnology is directed towards: molecular and genetic phenomena associated with process of infection, progression of disease (infectious and systemic) and the underlying pathology; metabolic engineering using recombinant DNA technology to enhance the activities of a cell by manipulating its metabolic pathways and enhancing the potential of organism producing antibiotics etc; characterization of enzymes involved in carbon and nitrogen assimilation to identify critical regulatory processes to improve yield and nutrition; plant tissue culture aimed at: large scale production of forest tree species enrichment of genetic diversity, post harvest biotechnology for important horticultural crops, genetic engineering and molecular biology tools for forest tree improvement etc.; bioprospecting of wild plants for commercially valuable genetic and biochemical resources; generation of a network programme on Bioengineering of Crops for Biofuels & Bioenergy through production and demonstration; identification of alternative sources such as algae and other aquatic organisms; biofuel production (biodiesel, bioethanol etc) from biomass and other waste material; and adopting bioengineering techniques for the production of alternative sources of energy / fuel; development of medicinal & aromatic plant crops with value addition in terms of proteins, minerals, vitamins and biomolecules of therapeutic value and industrial use, genomics of selected medicinal and aromatic plants; etc. In animal biotechnology, the focus during 10^{th} Plan will be on large animals and employment of newer techniques like cloning and stem cell derived animals (transformed and non-transformed).

13.6 In the area of Aquaculture and Marine Biotechnology, a Marine Biotechnology Centre would be set up with emphasis on novel enzymes, bio-remediation, extremophilic organisms, bio-medicals, genomics and proteomics of various marine organisms. This centre will be strengthened by bringing into its fold molecular biology research in fisheries institutes. The areas of focus for medical biotechnology research are: TB, HIV, Malaria, Cholera, Japanese Encephalitis, Edible Vaccines, Helicobactor pylori, Rabies, Cancer and Drug Delivery Systems. The prioritization of the programmes will be

made taking into consideration the criteria like disease burden, cost effectiveness of technologies and potential utility of these technologies for community needs.

13.7 The broad areas of activity identified for Genomics (human, animal, plant and microbial) are : computational genomics and genome-sequence data analysis, microarray technology, structural genomics of humans and microbes, single-nucleotide polymorphism (SNP) analysis and Pharmaco-genomics. For undertaking genome research, a high throughput microarray facility and national facilities will be set up. Other activities under genome research include: Fish Genomic studies for sequencing genes of interest besides studying their various biochemical properties; genome sequencing of pathogenic microbes with special emphasis on gemini viruses etc. The focus of Microbial Genomics and Proteomics will be on the utility of selected microbes for human benefit.

13.8 Under Environment and Biodiversity area, the projects to be initiated relate to: collection, conservation and sustainable use of bio-diversity; bioremediation, waste recycling and wasteland reclamation; development of biosensors, bioindicators; phytoremediation; and engineering of microbes for pesticide degradation, production of industrial and specialty chemicals, resource recovery and waste recycling etc.

13.9 Major new initiatives in the expanding area of Bioinformatics include: Dedicated High Speed Network for the BTISnet to achieve nearly instantaneous access to the Biological Databases; setting up of Teraflop Super Computer Facilities for Bioinformatics; establishment of National Bioinformatics Institute for carrying out various activities like policy making for Bioinformatics, creation of a Centre for Genome Informatics for carrying out research related to genomics and proteomics which include database mining, computational gene discovery, sequence similarity searching, gene expression analysis, etc.

13.10 Besides continuing the existing biotech facilities and repositories at various places, the new facilities to be set up pertain to: high field NMR imaging facility, mass spectrometry and microarray facilities at 2-3 centres; pilot plant facilities and biotech incubators for diagnostics; GMP Facilities in collaboration with private industry participation etc. Biotechnology Parks and Biotechnology Incubators will be set up in a few states in collaboration with the state Governments concerned. A few centres of excellence will also be set up in emerging areas such as: Marine Biology, High Altitude

Biology, Medical Molecular Biology, Molecular Ecology, Invertebrate Neurobiology and Computational Biology. To address Biotechnology related IPR issues in a holistic manner, a Biotechnology – IPR Centre will be set up as an autonomous society under DBT to serve as an institutional mechanism, several training programmes organized and a Patent Information Networking System set up.

13.11 Another area of thrust is the Human Resource Development whose scope will be widened by giving support to 20 additional institutions, 100-150 fellowships, instituting distinguished biotechnology professorships, biotechnology chairs and national biosciences career awards. Popularisation of biotechnology will be intensified through the use of mass media and cocurricular programmes. In order to attract a large number of small and medium scale biotech entrepreneurs, Biotech Venture Capital Fund in collaboration with organizations like SIDBI, IDBI etc. will be initiated.

13.12 In the sphere of biotechnology products, efforts will be focussed on: development of small peptides/ proteins/ carbohydrates present in animals/ humans as therapeutics; enzyme-mediated synthesis of chiral drugs; microbe/enzyme-based processes, specially for paper, leather, arsenic etc., for pollution control; microbe-engineered/ rDNA processes for bio molecules/ drugs; microbes/ enzymes for waste disposal, especially plastics, or waste utilization/ value addition especially press-mud, fusel oil; etc.

13.13 Biotechnology based programmes for the benefit of society, especially the rural poor are: helping the farmers with information and material to intensify annual multiple cropping of land through introduction of industrial crop(s) in between conventional crops, without adversely affecting food grain and vegetable production; popularization of the recently evolved transgenic hybrid-, disease and pest resistant-, and/or improved quality-, varieties of crops such as cotton, brassica, groundnuts, sunflower, rice, potato and other vegetables which will ensure better returns to farmers; familiarization of farmers with recently patented herbal coating procedure for N and S fertilizers; transferring the latest biotechnologies for mushroom cultivation and vermicomposting for augmenting their income/profit; transfer of health care related biotechnologies to industry engaged in manufacture of diagnostics, vaccines and pharmaceuticals; making available simple, rapid and reliable biotechnology based

diagnostic devices to the public and private health care systems; etc. The ongoing programme relating to Jai Vigyan Mission Programmes on Herbal Products, Coffee improvement and Mirror sites will be continued.

13.14 A high priority activity for the National Bioresource Development Board is to develop a broad policy framework and a scientific plan of action for effective application of biotechnological and related scientific approaches for R&D and sustainable utilization of bioresources especially for the development of new products and processes.

13.15 In respect of International Collaborations, while the existing programmes will continue, the focus for the initiatives will be on Basic Research in New Biology for understanding molecular and genetic phenomena of pathogenesis in plants, animals and human, plant molecular biology, biosensor development, metabolic and tissue engineering; and product and process oriented research involving scale up/ field trials and validations through technology transfer of both techniques and materials.

13.16 The Autonomous Institutes under the auspices of DBT viz., National Institute of Immunology (NII), National Centre for Cell Science (NCCS), Centre for DNA Fingerprinting and Diagnostics (CDFD), National Brian Research Centre (NBRC), National Centre for Plant Genome Research (NCPGR) and Institute for Bioresources and Sustainable Development (IBSD) will continue to pursue research activities in various aspects of biotechnology within the framework of the policy guidelines laid down for the 10^{th} Plan in coordination with DBT. Each of the Autonomous Institutes will be implementing one or more Mission Mode Programmes. The new Institutes, namely, CDFD, NCPGR, NBRC and IBSD will receive major thrust for making them fully operational including completion of their buildings, infrastrucutral facilities etc.

Core Programmes/Mission Mode Programmes

13.17 The details of the Core Programmes and Mission Mode Programmes are given below.

13.18 The Core programmes are: (i) Genomics covering human, plants, animals and microbes; (ii) biotechnology based programmes for societal development with focus on SC/ST population, rural development and women; and (iii) Autonomous Institutes. The details of (i) are discussed in the following pages and those of (ii) in the previous pages. The areas of thrust for (iii) are given below.

Mission Mode Programmes

I. Genomics covering human, plants, animals and microbes with emphasis on drug targeting

A. Human

13.19 The objective of the programme is to sequence some of the specific pathogens like H.pylori, M.tuberculosis, Leptospira and those responsible for diabetes. This will be taken up in a mission mode to understand genes responsible for infection, clinical symptoms, drug susceptibility or responses, better molecular diagnostics and better immunological interventions.

13.20 H.pylori is a gastric pathogen responsible for peptic ulcer disease and gastric carcinoma. In this case earlier attempts to classify various isolates were not successful. The Indian isolates appear to be entirely different from the isolates of other parts of the world. Therefore, the sequencing of these microbes from different geographical regions in the country will help to identify better target for diagnosis and differentiation of the strain responsible for the ulcer formation or gastric cancer. Mycobacterium tuberculosis is a major human pathogen that claims more lives than any other single infectious agent. The wide spread emergence of the drug resistant strains and its deadly combination with Human Immunodeficiency Virus (HIV) in recent years have necessitated an urgent need to understand the biology and physiology of this bacteria and develop newer therapeutics against this opportunistic pathogen. There are several sarovars of Leptospira which are responsible for fever to damage kidney and heart. The variability in such clinical syndrome/ pathology calls for identification of genes responsible for such varied clinical status. Sequencing of Leptospira has not yet been done globally. Therefore, it is essential to sequence the genome of various sarovars of

these organisms in a mission mode programme. Diabetes is one of the important metabolic disorders which is frequently present both in young children (Type-I) and in adults (Type-II). Several genes have been associated with the onset of diabetes. The mission programme will ultimately lead to better management of diabetic subjects.

B. Plant

13.21 In regard to Rice Genome the first objective of the program is to sequence a 10-Mb segment of the rice chromosome 11 over the next 5 years at the two proposed centres. The minimum requirement to maintain the membership of international rice genome project is 1 mb/year. The sequence information of about 1-Mb will be provided in the year 2001 and 2 Mb per year in subsequent years. Another objective is to find genes of economic importance in the DNA sequence generated by the International Rice Genome Sequencing Project (IRGSP). Participating countries are required to submit the sequences of individual PAC clones within 3-6 months of the beginning of the program. Withholding data for patent is not compatible with the IRGSP. Hence, a functional genomic component would be followed to identify patentable sequences fast.

13.22 In respect of Genomics of chickpea in India, since chickpea ranks first in both area and production amongst pulses accounting for approximately 75% of the world production and is a major source of protein for human diet and animal feed, there is a potential need for the improvement of chickpea with respect to the yield potential and to provide disease resistance. The objective, therefore is to analyze its genome, identify genes, develop a suitable regeneration and transformation protocol in order to produce genetic engineered chickpea crop with better yield and high nutritional quality and which can also withstand biotic and abiotic stresses. Chickpea genome needs to be characterized with respect to physical and functional landmarks. Availability of molecular markers will greatly aid and accelerate the conventional breeding by marker assisted selection. Construction of a saturated molecular marker map will also be a prerequisite for positional cloning strategies. With the establishment of high throughput DNA sequencing

facility, the National Centre for Plant Genomic Research (NCPGR) will endeavor to establish an EST database of the chickpea genome.

13.23 In the case of Genomics of Catharanthus roseus the overall objective is to reveal the genes and functions related to alkaloid biosynthesis in C. roseus. Towards this objective, to identify the QTLs controlling alkaloid yield, upto 500 recombinant inbred lines (RILs) will be developed from a cross between two parental lines bearing contrasting traits. Genomic and cDNA libraries will be constructed for their members to serve as molecular markers in the RFLP mapping of phenotypes undergoing co-segregation with them. The already known genes will also be placed on the map. The cDNAs will be partially or wholly sequenced to inventorize EST/ gene expression in tissue/ condition in specific manner.

II. Development of new drugs and molecules from important medicinal plants

13.24 The objective of the programme is to search for molecular targets/active principles in medicinal plants with respect to anti-cancer, anti-diabetic, anti-arthritic, anti-brain disorders, immunomodulatory properties and cardio-protective agents. Multi-disciplinary and focussed disease oriented approach will be followed towards developing globally accepted new drugs and molecules from the research leads already available in the country. Efforts will be concentrated for developing new therapeutic applications from medicinal plants for specific diseases for which no treatment is available in modern system of medicine. The medicinal plants described in Indian traditional system of Medicine such as Ayurveda, Siddha and Unani literature will be selected for identifying molecular targets/active principles. High throughput screening facilities will be set up at selected institutions for rapid screening of a large number of medicinal plant extracts for various therapeutic properties. Multi-institutional Network Programme is planned to be launched following the multi-disciplinary approach towards developing new drugs and molecules from important medicinal plants used in traditional system of medicine. Several molecules/active principles are expected to be identified at the end of proposed programme which will be patented and subsequently developed as a modern commercial drug for a particular disease. In addition, secondary metabolites of therapeutic value would be produced through the in vitro route – through culture of cells/tissues/organs in

bioreactors directly or through biotransformation. It may be necessary to set up bioreactor facilities at one or more institutes.

III. Bioresource Characterization and Inventorization and Documentation of Endangered Eco System

13.25 Under the National Bioresource Development Board (NBDB) digitized inventories would be prepared for bioresources – plant, animal, microbial and marine. Expert groups have been constituted for the preparation of inventories of medicinal plant resources; economically important species other than medicinal; and animal, microbial and marine resources. Projects have been sanctioned for the development of these inventories. To begin with, all these inventories will be prepared by compilation of secondary data. In addition, databases containing primary information are also being compiled, and already such projects have been funded for the plant and microbial resources of Himachal Pradesh. The prime objective for the latter is to document the folk knowledge with respect to microorganisms used in traditional fermented foods and beverages and also mushrooms. In the 10^{th} Plan, primary data will also be generated on the various bioresources at different levels for special ecosystems. There is need to prepare these on an effective computer software platform so as to be query based and user friendly. At the end of 10^{th} plan the bioresources specially of the endangered ecosystems would have been characterized and documented.

IV. Production, Demonstration and Testing of Biofuels

13.26 The objective of the programme is to investigate into the methods of production, demonstration and testing of biofuels from the source material, viz., biomass resources of the country. Biomass is the oldest known source of renewable energy. Domestic biomass resources include agricultural and forest wastes, municipal solid wastes, industrial wastes, and terrestrial and aquatic crops grown solely for energy purposes, known as energy crops. Biomass is used in the production of energy in the form of: Solid (wood, charcoal for domestic cooking); Liquid fuel (Biodiesel and bioethanol); Gaseous fuels; Electricity/ThermalPower. The DBT has initiated a discussion to generate a network programme on Bioengineering of Crops for Biofuels & Bioenergy. A multi-institutional programme will be evolved in a mission mode with an

end to end approach concentrating on: Bioenergy Plantation, Bioethanol Production, Biodiesel and Hydrocarbon, Hydrogen production.

V. Development of New Generation Vaccines

13.27 The burden of the communicable diseases continues to be the biggest concern of the public health workers and bio-medical scientists. Although several infections are prevalent in the country, the three important ones responsible for the highest degree of morbidity and mortality are Malaria, Tuberculosis and HIV. India has the highest number of Rabies cases in the world. The infections like Cholera, Japanese Encephalitis, Leishmaniasis, and Filariasis etc. add to the miseries of the human subjects and lead to a fairly high degree of morbidity and also mortality. The infections are responsible for colossal economic loss to the country. The strategies like immunological intervention in terms of affordable and efficacious vaccines are essential. The gene era and the advent of newer technologies could generate vaccines most suitable for use in the country like ours.

13.28 The Department had an ongoing Jai Vigyan Mission Programme on Generation of Vaccines for six diseases. Under the Mission Programme the diseases targeted are Rabies, Cholera, HIV/AIDS, Tuberculosis, Japanese Encephalitis and Malaria. The programmes are at various stages of implementation. They will be completed in Tenth Plan.

VI. Food and Nutritional Security - enhancement of the crop productivity, value addition and genetic engineering for enhanced nutritional status

13.29 The objective of pro-vitamin A Rice is to develop it through the use of more innovative tools of biotechnology and genetic engineering. For this purpose, the research and development projects related to transformation of indica rice lines with provitamin-A related gene constructs as well as introgression from japanica to indica breeding will be considered under Indo-Swiss Collaboration in Biotechnology (ISCB) as per Bilateral Agreement procedure. The expenditure related to R&D in India will be shared between DBT and ICAR. In this programme small projects on need and technology assessment will also be taken up in collaboration with Swiss scientists to survey, study and analyse needs and trends in vitamin-A alleviation programmes, the

potential of pro-vitamin-A rice, other alternatives to supply vitamin-A in diet, safety and risk assessment as well as public acceptance.

13.30 The objective of the project relating to Nutritionally Enhanced Potato, Chickpea etc. is to develop value-added plants by introducing the genes from the Amaranthus plant which is an important source of economically important genes and novel promoters and similar nutritionally important crops to improve the crop quality in terms of protein, carbohydrate and seed oil components of other crops. NCPGR will implement this programme. In order to achieve these goals, two novel gene: AmA1 from Amaranthus hypochondriacs have been used for generating transgenic plants of agronomic importance. Transgenic potato with high nutritional quality has been developed with the introduction of AmA1 gene. A MoU has been signed with Central Potato Research Institute (CPRI), Shimla for field trials of the most promising transgenic lines. The other crop of importance is Chickpea which will also be taken up under the programme for analyzing its genome, identify genes, develop a suitable regeneration and transformation protocol in order to produce genetically engineered chickpea crop with better yield and high nutritional quality and that is able to withstand biotic and abiotic stresses.

13.31 The objective of the project relating to the Use of Molecular Marker Technology and Genetic Engineering in Wheat Quality Breeding is to improve the wheat grain quality by integrating modern biotechnological tools such as marker assisted selection and genetic engineering in bread wheat breeding programme. The quality parameters that have been selected are grain protein content, kernel weight hardness and bread-making quality apart from enhanced nutritional quality of the grain. Promising leads from the earlier multi-institutional project on characterizing and using quality trait in wheat aided by molecular markers will be taken into consideration in achieving the objective. The successful completion of the project will lead to breeding of superior grain quality wheat varieties which will not only have better export potential but will also meet the current requirement of India population. This programme will be implemented by 6 institutions, viz., DWR, Karnal; PAU, Ludhiana; ARI, Pune; IARI, N. Delhi; CCS University, Meerut and NCL, Pune.

13.32 The objective of Low cost Nutritious Food is to devise nutritious food formulations costing not more than Rs. 5/- per packet, through biotechnological approaches. These food supplements are supposed to provide above 400 Kilocalories, and the formulated packets will be between 80-100 grams in weight. The packets will be so designed as to enthuse preference by the school going children between the age group 6-14 years. Four such formulations which have been developed and validated for their nutritional and organoleptic properties along with acceptability and growth studies (independently by National Institute of Nutrition, Hyderabad) carried out in children are: soft chikki, Nutro-crispo and surichi-Meetha (Burfi). Taking into account that these formulations are widely accepted by the children, it is now being planned to organize their mass production in different parts of the country through industrial outfits to cater to the needs of the school going children by their introduction in the "mid day meal programme". Accordingly pilot plants will be commissioned for production of Soft Chikki, Nutro-crispo and Suruchi Meetha respectively, in any of the Union State , in consultation with the Ministry of Human Resource Development, which can serve as a "model" for the country.

13.33 Due to its high nutritious and protenous qualities, Spirulina which is a single cell algae is considered as the "green gold of the future". Spirulina's concentrated nutrition makes it an ideal food supplement for people of all ages and lifestyles. It contains about sixty percent complete, highly digestible protein and also more beta-carotene than any other whole food; and is rich in B vitamins, minerals, trace elements, chlorophyll, enzymes, iron and vitamin A. Spirulina can thrive in very warm waters of 32^0 to 45^0C and have even survived in temperatures of 60^0C in saline water and hence, it can be easily cultivated in our country and cost of cultivation is nominal. DBT has taken a major initiative to launch a network programme for its production, technology refinement and training of villagers during the 10^{th} Plan.

CHAPTER 14

SCIENCE AND TECHNOLOGY IN STATES AND UNION TERRITORIES (UTs)

14.1 The efforts made during the last two decades for the application of S&T in the States/UTs have resulted in setting up suitable organizational structures in the form of S&T Councils in all the States/UTs (except in the recently formed States of Uttranchal, Jharkand and Chattisgarh) and making the State departments realise the potential of S&T as a tool for development. The primary objective of the S&T Council in a State is to plan and coordinate the activities of Science & Technology in that State with a view to aiding the socio-economic development of the State. To achieve this objective, the State Governments are required to be in the process of identifying and implementing the S&T programmes in a planned manner by integrating them with their socio-economic sectors' development plans and making specific allocations for the S&T activities. The focus should be to improve the productivity of the various socio-economic sectors of the State through harnessing S&T. It is this task which has to be taken up through an inter-sectoral mechanism at the State level, involving the State development departments, scientific institutions, universities etc. It is in this task that the State S&T Council has to involve itself and play a bigger role than heretofore.

14.2 Though DST at the centre in coordination with the Planning Commission has been actively interacting with the State Governments to promote S&T in the States, most of the States/UTs have constituted State S&T Council which would greatly enhance the role that S&T can play in the development of the state. That commitment at the State level automatically ensures the activities to be undertaken to promote S&T in the States. In fact the State level machinery has to take the role of a major "prime mover" while the centre could play a catalytic and advisory role in encouraging this initiative of the State governments.

14.3 The process of planning of S&T in the States was initiated in the Sixth Plan, but major efforts started effectively during the Seventh Plan when S&T plans were formulated by most of the States and Union Territories as an integral part of their overall socio-economic plans.

The process of formulation and implementation of the S&T plans has made considerable progress during the 8th and 9th Plans with DST's continued catalytic core support to State S&T Councils in all the States to ensure requisite S&T capabilities for implementing State S&T programmes vis-à-vis development of professional S&T manpower in the State S&T Councils. Linkages have also been established between the Central S&T programmes and those of the State, e.g., in the areas of : science Communication; S&T enterpreneurship development; NRDMS and GIS; societal development; biotechnology; remote sensing; non conventional energy and conservation of energy and environment. Several types of programmes including location specific R&D and technology development projects, S&T studies and surveys and information exchange programmes have been implemented.

14.4 The 8th and 9th Plan outlays/expenditure clearly indicate a commitment of the State/UT governments for promotion of S&T activities (Annexure 4). There is however, a need for them to take more active part during the 10th Plan in integrating the S&T component with the plans of their socio-economic sectors which alone ensures better performance as well as long term benefits of the society. For this, they should be activated through the concerned S&T Councils by intensifying their interaction with the socio-economic departments of the State as well as Centre. In this connection, the following specific measures which were already advocated during earlier plans are reiterated for a rapid adoption of S&T as a tool for socio-economic development in the States.

- Formulation of a long term S&T policy and programmes with reference to the natural endowments/geographical features and socio-economic conditions of a particular State and its various regions with more active involvement of the scientific community in the State.
- Wherever needed, S&T Councils/Departments should be strengthened adequately in terms of scientific and technical manpower to enable them to function properly.
- The State S&T Councils should have enough flexibility and operational freedom for ensuring smooth and effective implementation of various S&T Programmes and a strong professional S&T secretariat to serve the State S&T Councils.
- The role of a S&T Council is two fold. The first is to identify the needs at the gross root level where S&T inputs can be highly effective. The second is to formulate and develop detailed programmes for implementation in specified and selected areas in coordination with the

development departments of the State government by establishing effective working linkages with them.

- It is not only necessary to have in the S&T Council representatives from the universities, research institutions, development departments and experts from the production and services sectors, from both the Central and State levels, but there is also a need for holding regular meetings of the State S&T Council to discuss policies and formulate programmes and implementation strategies to derive maximum benefits from S&T.
- While it is important to support location-specific, region-wise science and technology based programmes, they should be judged against the criteria of employment and income generation for integrated holistic development of the less developed regions.
- The State S&T Councils should be made to play an appropriate role in the implementation of the Mission Mode Programmes identified by the Scientific Departments like DBT, DSIR etc. and also of IMM-2020 during the 10^{th} Plan.
- The S&T Councils themselves may not be able to implement all the identified programmes. There is a need to identify appropriate Voluntary Organizations to handle some of the programmes as they will be more closely associating themselves with the gross root level masses. Close interaction with them will help in successful implementation of S&T programmes within the State.
- The States should utilize the latest technological developments for deriving the maximum benefits. For example, under the National Natural Resources Management System (NNRMS), an enormous amount of remote sensing data would be available. The State S&T Councils may co-ordinate with the concerned user departments in the State and NNRMS / NRDMS units to obtain ground truths related to the remotely sensed data, particularly in the important areas of agriculture, forestry, water resources (both ground water and surface water), mineral deposits, environment etc.
- With a view to exchange the experiences of the neighbouring States, periodical regional conferences of the S&T Councils may be organized and regional development programmes initiated. DST at the centre should take a lead role in this aspect.
- Networking of State S&T Councils and Central S&T agencies/departments through NICNET will help the disadvantaged States to benefit from the experiences of the other States.

- For dissemination of information on successful development projects, suitable mechanisms through State S&T newsletters etc. should be evolved.

CHAPTER 15

THE INDIA MILLENIUM MISSIONS – 2020 (IMM - 2020)

15.1 The broad objective of the IMM-2020, which is a structured matrix of a set of inter-departmental National Economic and Social Missions, is to make a strong and developed India by the year 2020. These Missions which are indeed a campaign for national development involve close, sustained and intense cooperation and collaboration between various agencies of Government of India, State Government agencies, industry and business and several other NGOs. They have been formulated on the basis of India's distinctive competencies and competitive advantages derived from the documents generated for TIFAC with inputs from a large number of experts coupled with seminars and group discussions organized for the purpose by the multi-disciplinary Experts and also from Government departments.

15.2 The intrinsic property of such a set of Missions is that the time dependent and time independent strategies within each of them act concurrently in such a manner that the basic technology levels of the country in areas related to Economic Growth and Social Development are constantly upgraded. Several Missions have been identified which are in the areas such as : electric power, civil aviation, water ways, road transportation, food and agriculture, engineering industries, health care & population, services, agro-food processing, NEWARS (National Early Warning and Response System), life sciences & biotechnology, chemical process industries, special education, meteorology, strategic ocean technology, energy, advanced sensors, telecommunication, electronics & communication, critical technologies, information security, trans-atmospheric vehicles & hypersonic technologies and renewable energy sources. These mission areas have plans of actions in relation to goals and specific targets during the 10^{th} Plan period. The details of these illustrative Mission areas are given at Annexure 2.

15.3 The aspect as to how rural areas can be made attractive through Rural Connectivity, providing physical, electronic and market connectivity has been demonstrated in Figure-1. It is a crucial innovative mission with a systems approach. After several studies,

field visits and interaction with local people and officials, this concept has matured into a good system design with a possibility of viable proposals after a few select demonstrations in different parts of India. To start with, 10 locations have been selected for the 10th Plan.

15.4 Most of these Missions, having multiple objective of creating National Wealth, Social Development, Health Security, Food Security etc envisage proactive integration of S&T and user Ministries/Departments, their field establishments, academic institutions, private sector, State government agencies and NGOs. Accordingly, they provide a coherent and synchronized drive for National competitive advantage in the global market while comprehensively securing the wealth thus generated. The Implementation Strategy, which consists of a set of comprehensive and interactive transformation strategies and which has been formulated on the basis that the future is in many ways dynamic with changes and that the need is to guarantee agility and flexibility to adapt to changing conditions in time, goes beyond today's economic structures to those the Nation will require by 2020.

15.5 Several aspects will be taken into consideration in devising appropriate Mission Management structures. They should horizontally coordinate and revitalize the functioning of various stakeholders in the government (Central & State) and private sectors all aiming at the mission objectives. Many innovative systems and mechanisms of implementation would need to be created. These will be done while working out the details of each of the projects/programmes/missions in a transparent and competitive manner. Concurrently as a part of the process of technology transcilience, most of the participants would need to vertically decentralize and adequately empower their mission management teams. The specific details of the required mission management structure and the extent of horizontal coordination and vertical decentralization will be worked out during the initial phases, being responsive to the needs of Ministries/Departments, and other partners, as well as to emerging ground realities. Flexibility and Agility will be the key to such structures. Empowerment of those who have to deliver goods and services will be another important principle to facilitate effective mission implementation. Thus a novel and a new set of Mission Management structures will have to be evolved. Details of the IMM-2020 Missions is given at Annexure 2.

15.6 A number of direct and indirect **benefits** accrue from the successful completion of these missions the quantification of which shall be carried out during the initial phase and will be continually monitored and reviewed. Illustrative list of benefits is given below:

Direct Benefits

- Generate globally competitive technologies that will directly assist Indian industry, agriculture and service sectors with strong impact on production for both domestic and export market; employment opportunities and quality of life for all people in India.
- Raise in agricultural productivity and value added production to meet self-sufficiency and exports resulting in increased wealth for the farmers.
- Emergence of India as a major super power with large human resources cadre to meet Indian and global needs.
- Health care and education (especially for the rural and urban poor) providing ultimately health security for all.
- Enable the country to fully exploit the benefits of advances in communication and remote sensing technologies for achieving national goals.
- Catalyze R&D in the private sector, strengthen the bonds between R&D activities, both public and private, and the industry and kindle entrepreneurship and innovation to attain immunity from any unilateral control regime or technology denial.

Indirect Benefits

- Enable India not only to successfully withstand the pressures of sanctions and technology denials.
- Enhance the quality of life amongst all sections of the population in the country.
- Create national coherence leading to a holistic approach to Economic growth and Social development.

15.7 The implementation of these Missions will spread over a period of 25 years with a total outlay requirement of Rs. 302300 crore by various departments/agencies. The Tenth Plan requirement of Rs.3000 crore is to catalyse and initiate a process of major demonstrations. Major participation by private sector both in India and abroad is envisaged. Hence the outlay required as an additional demand on the financial resources of the government projected above takes this possibility into account.

CHAPTER 16

FINANCIAL ASPECTS

16.1 Recognizing the fact that the contribution of scientific innovations and the consequent technological advancements to the socio-economic development of a country is immense, Government of India has been according considerable importance to Science & Technology and related activities. Accordingly, increasing outlays have been allocated to S&T in the Five Year Plans. The S&T plan outlays and expenditure during the 8th Plan and 9th Plan under the Central S&T Departments/ Agencies and States are given below.

(Rs. in crore)

	8th Plan (1992-97)		9th Plan (1997-2002)	
	Outlays	Act.Exp.	Outlays	Anti.Exp.
A. S&T Departments/Agencies	4095	6126	12022	12393
B. S&T in States	193	159	377	289

16.2 The above figures pertain only to plan component. In addition there is non plan component also. The S&T expenditure as percentage of Gross National Product (GNP) is often taken as an indicator of the growth of S&T. It was 0.66% of the GNP in 1996-97. This percentage is considerably small compared to that in developed countries like USA, UK, Japan, France, Germany etc. whose R&D expenditure is about 2% to 3% of their GNP. There is, therefore, a pressing need to raise the level of R&D spending substantially in our country. In consonance with the Prime Minister's statement on 3rd January 2001 that 'Government would like to see that the investments in the R&D sector are hiked from the present level to 2% of GDP over the next five years', the target for the 10th plan may be set to reach that level at least by the end of 10th plan. The question is how to achieve this and what kind of efforts should be made to devise an appropriate strategy to reach the target.

16.3 Two issues arise in devising such a strategy. First is to explore the sources from which additional funds could be obtained to reach the desired level of R&D investment

and the second relates to the priority sector where they should be deployed. Considering the second issue first, one has to learn from the developed countries that it is the industry sector where substantial funds are being deployed by them since long to reach the present level of development. This will be clear from the fact that the ratio of R&D expenditure in industry to total R&D expenditure in 1996-97 in the developed countries varies between 50 to 70 whereas it is only about 28 in India. Even in terms of percentage of industrial R&D to the sales turnover, it is only 0.49% in 1996-97 in India whereas it varies between 1% to 3% in developed countries. These observations indicate that the R&D expenditure in industry in our country is much less than the desired. Coming to the first issue, since government funds are limited, it is again the industry and to a limited extent the users who should be encouraged to provide additional funds. It should be examined at this stage as to the extent to which Indian Industry can participate.

16.4 As already stated (vide para 3.2 & 3.3), only in the 1990s industry in India has started using technology developed by indigenous sources. During the last few years it has become more conscious of the S&T sector as knowledge generator and in reciprocation the S&T sector is also favourably inclined towards industry. In the post GATT liberalized and competitive environment, Indian industry needs support of indigenous S&T in a big way so as to compete effectively with multinational corporations in the domestic as well as international markets. Fortunately, the Indian academic and research institutions also have very good capabilities and have been developing state-of-the-art technologies in many areas. The interface between industry-R&D-academia is gaining strength in keeping pace with the technology race and acquiring expertise in the latest developments in S&T. Therefore, it is necessary to encourage this trend and make the industry spend increased amounts on S&T.

16.5 Promotion of basic research, technology development and demonstration as well as strengthening and modernization of S&T infrastructure need to be continued at a significantly enhanced level under the Government through budgetary support.

16.6 The major source from which a large part of investment for R&D can be expected to achieve enhanced R&D expenditure at desired level is of course the industry. In the present liberalized environment, it is the industry which will try to upgrade its technology through radical technology jumps. The Technology requirement model for a business firm (para 3.5) explains the need for a business firm to upgrade its technology continuously. For

technology upgradation, strengthening of industry-R&D-academia interaction is highly essential. During these processes, several measures like creation of institutional mechanisms, incentives to those who deploy investments for R&D etc. will boost the R&D expenditure. In the government sector, besides increasing the outlays of the Central Scientific Departments/ Agencies, however depending on their spendable capacity, the Socio-Economic Ministries (like Agriculture, Health, Petroleum, Energy etc.) may be encouraged to spend enhanced outlay on R&D. Only then, as indicated earlier (para 1.15), S&T will be able to play a dominant role than hitherto in improving the existing infrastructure in several socio-economic sectors, in inducing them to utilize the indigenous technologies and thereby accelerating economic growth and deriving maximum societal benefits. Another measure that may be adopted for increasing R&D expenditure is to approach Financial Institutions for help in case of genuine S&T projects having commercial potential.

16.7 Annexure 3 summarizes the progress of outlays/expenditure in the 8^{th} , 9^{th} and 10^{th} Plan (proposed) as well as the outlays for the 10^{th} plan recommended by the Steering Committee for the Central Scientific Departments/ Agencies and Annexure 4 gives the State-wise outlay/ expenditure during the 8^{th} & 9^{th} Plans under the State Plan.

Annexure- 1

No. 12018/75/2000-S&T
Government of India
Planning Commission
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Yojana Bhavan, Sansad Marg
New Dell1i-110001.
Dated: 9.11.2000

Subject: Steering Committee on Science and Technology for the Formulation of the Tenth Five Year Plan (2002-2007).

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In the context of the Tenth Five Year Plan (2002-07) for Science and Technology, it has been decided to constitute a Steering Committee on Science and Technology (S&T). The composition and the terms of reference of the Steering Committee would be as follows:

1) **Composition**

1. Dr. A.P .J. Abdul Kalam, Principal Scientific Adviser to GOI.	-Chairman
2. Dr. D.N. Tewari, Member, Planning Commission	-Co-Chairman
3. Principal Adviser/Adviser (S&T), Planning Commission	-Member
4. Secretary, D/o Atomic Energy	-Member
5. Secretary, D/o Space	-Member
6. Secretary, D/o S&T	-Member
7. Secretary, D/o Biotechnology	-Member
8. Secretary, D/o Scientific & Industrial Research/CSIR	-Member
9. Secretary, D/o Ocean Development	-Member
10. Secretary, Defence Research and Development Organisation	-Member
11.DG, ICAR	-Member
12. DG, ICMR	-Member
13. President, Indian National Science Academy, New Delhi	-Member
14. President, National Academy of Sciences, Allahabad	-Member
15. President, Indian Academy of Sciences, Bangalore	-Member
16. Director, Indian Institute of Science, Bangalore	-Member
17. Vice Chancellor, Jawaharlal Nehru University, New Delhi	-Member
18. Vice Chancellor, Central University, Hyderabad	-Member
19. Chairman, UGC	-Member
20. Chairman, AICTE	-Member
21. President, CII	-Member
22. President, FICCI	-Member
23. Chairman, Society for Rural Industrialisation, Ranchi	-Member
24. Chairman, Kerala State Committee on S&T, Thiruvananthapuram	-Member
25. Scientific Secretary to PSA-GOI	-Member Secretary

II) Terms of Reference

1. To evolve Approach on S&T for the Tenth Five Year Plan keeping in view the strength of S& T, socio-economic needs of the country, international scenario in the wake of WTO and IPR and also future needs for the development of the country.
   (This needs to be completed within one month of the constitution of the Steering Committee for integrating in the Approach Paper for the Tenth Plan)
2. To recommend long-term and short term S&T policy framework towards achieving self reliance.
3. To identify thrust areas with inter-se priority, keeping in view the National objectives and priorities for developing technological capabilities and their application in major areas of development.
4. Suggest suitable mechanism and methodology for increased participation of industry and strengthening interface between industry, R&D institutions and the academia for the development, application and utilization of S&T in the country.
5. To evolve S&T manpower development strategy for attracting and retaining highly skilled and talented S&T personnel in the important fields of Science and technology and Education and also encouraging students to take up science as a career .
6. To identify areas for international S&T cooperation/collaboration and suggest establishment of state-of -art internationally competitive facilities in the country as well as participation in major facilities abroad. .
7. To evolve mechanisms and identify programmes for application of S&T in improving the quality of life of the people, particularly, the weaker sections and women, and development of rural areas for reducing regional imbalances and inculcating scientific awareness.
8. To review and assess the progress made by the various Central S&T Departments/ Agencies during the Ninth Five Year Plan identifying the achievements, weaknesses/ shortfalls and gap areas.
9. 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 Tenth 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 on-going commitment and new programmes proposed to be undertaken, keeping in view the overall resource position in the country .

Ill). The Chairman may constitute sub-groups if necessary and co-opt members for specific tasks.

IV) The expenditure on TA/DA in connection with meeting of the Steering Committee and its sub-groups will be met by the Planning Commission. Non-Official members will be entitled to TA/DA as admissible to Grade-I Officials of the Government of India.

V) The secretariat support will be provided by the Office of the PSA/ Technology Information, Forecasting and Assessment Council (TIFAC).

VI} The report of the Steering Committee would be submitted within a period of six months from the date of constitution of the Steering Committee.

Sd/-

(T.R. Meena)
Deputy Secretary (Adrnn.)

Copy forwarded to:

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

Sd/-

(T.R. Meena)
Deputy Secretary (Admn.)

Annexure-2

DETAILS OF IMM-2020 MISSIONS

1. MISSION:- Electric Power

DETAILS:- The objective of the Mission is to improve energy efficiencies from generation through clean technologies to transmission, distribution and energy efficient appliances. This involves development and demonstration of new coal utilization technologies, improved transmission and distribution of technologies and systems to reduce losses and initiating studies on energy efficient appliances and methodologies for their promotion. Among the benefits expected are sustained high economic growth through reliable and assured power and improved quality of life for the population.

2. MISSION:- Civil Aviation

DETAILS:- The objective of the Mission is to factor India's growing Civil Aviation needs for the growth of Indian Aerospace Industry, registering the industry's presence in the global market and to position an integrated command and control system and structure for Indian airspace towards better regulation of civil air traffic. This involves evaluation of India's Aviation needs and develop/design offset programmes for increased manufacturing activities in this sector and initiating detailed studies to suggest technologies & systems for ensuring civil aviation air space safety. Among the benefits expected are that India's foothold in the high-tech aerospace industries would be assured and that complete knowledge of Indian airspace leads to efficient air traffic control.

3. MISSION:- Waterways

DETAILS:- The objective of the Mission is to fully utilize nearly 15,000 Kms. Of inland navigable water system in the country thereby reducing transport bottlenecks, cost and controlling pollution. This involves mapping and assessment of waterways in the country and identifying technologies and systems for development of inland water transport. Among the benefits expected are increased share of water transport from a current level of 6.5% in the National transport system and that a diversified multi model inland transport system would be improved.

4. MISSION:- Road Transportation

DETAILS:- The objective of the Mission is to improve road design, construction and maintenance and development of appropriate technologies for rural and urban areas. This involves development and demonstration of improved road- building machineries, materials

and transportation vehicles and improved road transport management using modern technologies and navigation aides. Among the benefits expected are improved road transportation reduces transportation cost and contributes to competitiveness.

5. MISSION:- Food & Agriculture

DETAILS:- The objective of the Mission is to increase food productivity and achieve a production of 360 million tons of food grain and optimal use of national resources in agricultural practices. This involves demonstration of increased productivity in respect of paddy, wheat and vegetables in five eastern states of the country and initiate studies for large-scale use of organic farming. Among the benefits expected are that better agricultural practices, environment and pest management together with enhanced food production, would contribute significantly to economic growth and food security.

6. MISSION:- Engineering Industries

DETAILS:- The objective of the Mission is to gain Eco-friendly textile export as well as production of Geo & Technical textiles by 2010 and to make Indian capital goods industry to be globally competitive. This involves programming for upgradation of textiles machineries with new technology inputs and then India will be a leading textile producing country in the world. Among the benefits expected are technologically advanced and self reliant capital goods industry is a pre- requisite for sustained industrial growth.

7. MISSION:- Health Care & Population

DETAILS:- The objective of the Mission is new technologies (preventive, diagnostic and curative/corrective) to substantially reduce the incidence of critical disease, such as AIDS- T8. Cancer, malaria etc. and defence against influx of novel virulent pathogens introduced into the community, naturally or deliberately as acts of biological warfare or bio-terrorisms and establishment of disease forecasting capability. This involves developing and commercializing a few selected medical equipments and developing a system of maintenance and leasing of medical equipments. Among the benefits expected are health security, freedom from critical diseases for large sections of the population and improved standard of living for all and proactive approach to defend against new diseases, both natural and man-made.

8. MISSION:- Services

DETAILS:- The objective of the Mission is to enhance the efficiency and effectiveness in the services sector and thereby establish a global presence of a competitive Indian services industry. This involves identifying and demonstrating new technologies to enhance effectiveness in advertising, media, consultancy, logistics, trading and distribution, enhancing

consultancy support in key sectors (power, water management, health, natural resources, business process reengineering and strategic technology management) and establishing accreditation bodies for qualifying calibration/testing agencies to confirm to intentional norms. Among the benefits expected is massive enhancement of employment opportunities with relatively small investment in capital equipment and large potential for export of accrued earning services.

9. MISSION:- Agro-food processing

DETAILS:- The objective of the Mission is to enhance significantly rural prosperity by generating directly significant employment in agro production activities, and also indirect employment through its forward and backward linkages and reduce post harvest losses and wastes as well as efficient use of by-products. This involves demonstration of technology for harvesters capable of functioning on soil with high moisture content,

salinity & in standing water, initiate use of plastic lined, machine stitched gunnies, assess economic viability of construction of various types of silos for grain storage, form a consortium of modern rice mill to fund research to improve energy efficiency of mills and extract protein from rice bran. demonstrate alternative technology for longer life of raw milk, initiate programmes to measure yield and reduce post harvest losses of fruits and vegetables. Among the benefits expected are selection of appropriate scale and technology of production. up gradations of technology of existing units and establishment of institutional arrangements and suitable linkages between producers and consumers at home and abroad.

10. MISSION:-NEWARS (National Early Warning and Response System)

DETAILS:- The objective of the Mission is to build and launch constellations of small satellites in low earth orbit and a limited number of geostationary satellite to meet expanding needs for public utility and private utility services (Disaster warning. Govt. and District Admn, Telecommunication and Meteorological services). This involves preparation of detailed mission/project report for obtaining approval separately. Among the benefits expected are ensuring effective use of space technology for sustainable development of the nation.

11. MISSION:- Life Sciences & Biotechnology

DETAILS:- The objective of the Mission is development of genetic engineering of model plants e.g. Tomato and tissue culture of cereals & pulses, gene tagging, engineering of tagged genes and intervention of pathways, Bio-availability and bio equivalency studies oh herbal drugs and identification of factors affecting seeds & soil and understand transgenic products. This involves demonstration of tissue-cultured plants, demonstration of plant disease diagnostics, demonstration of biofertilisers and biopesticides on medium scale and demonstration of technologies for PCR, Hybridisation and recombinant DNA/Genetic Engineering. Among the benefits expected are rapid advancement of Health Care, Agriculture, Herbal Industry, Natural & Industrial Bio-technology and environment adds to prosperity.

12. MISSION:.: Chemical Process Industries

DETAILS:- The objective of the Mission is Technology adaptation/upgradation for efficiency cost reduction & energy conservation, meet R&D strategy and demands in new areas, like biosynthesis, catalysts, biotechnology and clean technologies. This involves institute innovation to find new catalysts and new operating parameters to reduce energy consumption and improve economics. Among the benefits expected are that chemical industry will contribute directly to the welfare of society and development of the nation In industrial, agricultural and consumer sectors of all sections of the society .

13. MISSION:- Special Education

DETAILS:- The objective of the Mission is to strengthen and enhance linkages between academia and industry, raise a skilled and talented special human resources cadre through synergising and focusing the vast output of our educational system and using our natural resources and existing infrastructure. This involves establishing more centers of relevance and excellence in education and research towards working close with the needs of the society and economy. Benefits expected are in all walks of Indian economy and governance.

14. MISSION:- Meteorology

DETAILS:- The objective of the Mission is to mesoscale weather forecasting capability over an area of 2.5 kms x 2.5 kms with 80% accuracy for all terrain, and evolving appropriate weather dissemination technologies for crop planning and disaster preparation up to village level. Among the benefits expected is weather prediction and modification would enhance agricultural productivity, accord protectior from weather related natural disasters.

15. MISSION:- Strategic ocean technology

DETAILS:- The objective of the Mission is [a] to develop policies and programr1as for sustainable exploitation of ocean food resources [b] to design and demonstrate technologies for ocean bed exploration and mining. This involves [a] to fully identifying

and mapping ocean resources, including minerals and hydrates, in the seas and ocean adjoining India [b] to design and demonstrate technologies for deep ocean mining, in particular robotics, underwater vehicles and sensors. Among the benefits expected is [a] Indian Ocean being the bridge between Europe, West Asia & Africa and East and South East Asia, Success in the sectors of Ocean technology will add greatly to India's development.

16. MISSION:- Energy

DETAILS:- The objective of the Mission is [a] to conduct studies of technologies for full utilization of India's nuclear energy resources [b] to develop techniques and technologies for exploration of new hydrocarbon resources. This involves [a] to develop and institutionalize mechanism for a comprehensive response to deal with threat to marine environment as a result of oil spills [b] is to initiate extensive use of non-conventional energy sources through technology interventions. Among the benefits expected are [a] better oil exploration, enhanced hydrocarbon production and widespread use of non-conventional energy assures energy security.

17. MISSION:- Advanced sensors

DETAILS:- The objective of the Mission is [a] to initiate an integrated mission comprehensively addressing materials development & characterization, sensor development, sensor fabrication & manufacturing, certification and quality assurance while dynamically linking to the users. This involves [a] to initiate missions on advanced sensors for selected areas. Among the benefits expected are [a] to improved quality, productivity and enforcement of standards through these missions would give tremendous boost to our trade, including agricultural trade.

18. MISSION:- Telecommunication

DETAILS:- The objective of the Mission is [a] A conducive structure for a viable and competitive telecom industry set up [b] Targeted approach to R&D based on development priorities and national strengths. This involves [a] Technology demonstrated for: (i) Gateway services to access a range of data bases held in other host systems (ii)

Intelligent gateways (iii) Integrated TV and FR Telephony on upgraded CATV network (iii) Multimedia MAN (Metropolitan Area Network). Among the benefits expected area [a] Employment generation on a large-scale [b] Enhances education, literacy and healthcare [c] Corrects regional, cultural, gender and linguistic imbalance.

19. MISSION:- Electronics & communication

DETAILS:- The objective of the Mission is identify and develop and range of new products, technologies and services that are typical and specific to country's requirements, IT application in local languages. This involves to initiate studies for choosing adaptable and affordable technologies in IT & communication sector for social and rural applications, augment existing national programmes on photonics and opto-electronics, initiate measures for large-scale development of high-end and embedded softwares to turn our manufacturing sector into a major economic entity, gainfully utilize existing and proposed IT backbone networks for real-time Information transfer towards improving quality of life even in rural and semi-urban areas. Among the benefits expected are India would emerge as a IT superpower meeting export projections of $50 Billion in about a decade, a strong hardware base would be in position to meet a variety of demands and thus contributing to comprehensive development in IT sector.

20. MISSION:- Critical technologies

DETAILS:- The objective of the Mission is to build counter- denial capability and capacities. This involves development of techniques and equipment for ultra precision surface engineering and extrusion & stretching of special aluminum alloys required in aerospace industries, development and production of light weight electrical generators, motors, actuators and electro-hydraulic servo valves, develop technologies for radiation hardened micro-electronic components and devices, augment existing programmes on Micro Electro Mechanical Systems (MEMS) and initiate new programmes in Micro Opto Mechanical systems (MOS) and Micro Opto Electro Mechanical Systems (MOEMS), initiate studies and experimentation on various materials, devices and components to gauge the extent of their criticality, requirements.

21. MISSION:- Information security

DETAILS:- The objective of the Mission is generate enabling technologies and systems for both military and much larger commercial applications to protect and secure Information, Information systems and networks through which the flow of information takes place. This involves initiate programmes for generating variety of high quality softwares and Network-protection technologies, Initiate studies on Mathematical and other advanced tools required in the protection and safeguard of Information, Create an agency to foster excellence in an operating system such as LINUX for which source code is publicly available and hence safe to build networks with, creation of public awareness on protecting information and information sources. Among the benefits expected are information-protectjon technologies when in place would catalyze e-commerce and thereby spur trade and normal commerce. Such technologies being strong force multipliers would enable usher in a dimensional change in strengthening information systems and network.

22. MISSION:- Trans-atmospheric vehicles and hypersonic technologies

DETAILS:- The objective of the Mission is India a key global player in aerospace technology & systems, and their security/economic/commercial applications, for national strength and prosperity. Safe, reliable, routine, low cost fully reusable space transportation system deployed. India a key partner in global missions for space industrialization, including energy from space. This involves proof-of-concept studies and trials completed on major sub-systems required to design, develop and deploy fully reusable space planes. Among the benefits expected are space technology and applications mastered for sustainable development, and high value commercial resource earning missions in space, contributes significantly to national prosperity.

23. MISSION:- Renewable energy sources

DETAILS:- The objective of the Mission is energy famine due to depletion of known resources of fossil fuels is averted, and alternate Renewable Energy Sources operational on Gigawatt scale nation wide. This involves large scale technology demonstrated for one each of the following:. (I) Clean coal technology (ii) Biomass liquids (iii) Biomass (solid

or gas) (iv) Ocean Thermal Energy system (v) Solar/battery driven two/three wheeler vehicles (vi) Gas hydrates. Among the benefits expected are contribute of Renewable Energy systems to national energy requirements will be substantial thereby contributing to energy security and national interests.

CENTRAL S&T DEPTT./AGENCIES
PLAN ALLOCATION/EXPENDITURE

Annexure 3

(Rs. in crores)

Sl. No.	&T DEPARTMENTS/AGENCIES	8th Plan Outlay	8th Plan Actuals	9th Plan Outlay	A.P. 997-98 B.E.	A.P. 1997-98 Act.	A.P. 1998-99 B.E	nnu.Plan 1998-99 R.E.	A.P. 998-99 Act.	A.P. 99-2000 B.E.	A.P. 9-2000 Act.	A.P. 2000-01 B.E.	A.P. 2000-01 RE	A.P. 2001-02 B.E.	9th Plan Ant.Exp	prop. by Working Group (and ** recommended)
1.	Department of Science & Techno	640.00	936.73	1497.35	#####	276.79	305.00		##### *	310.00	##### *	##### #	351.26 *	##### #	1538.44	8524 (5000)
2.	Department of Atomic Energy (R	600.00	663.91	1500.00	#####	173.93	300.00	237.48	#####	325.00	#####	#####	415.27	#####	1612.27	3716 (3700)
3.	Department of Ocean Developme	130.00	199.49	510.62	88.10	83.85	88.00		86.03	90.00	83.16	#####	86.18	#####	481.22	2517 (1500)
4.	Department of Space	######	######	6511.72	#####	838.73	######	1281.00	#####	######	#####	#####	######	#####	6738.82	18593 (17000)
5.	Department of Biotechnology	265.00	395.85	675.00	#####	85.23	107.00	100.81	#####	110.00	#####	#####	140.00	#####	621.15	2075 (1800)
6.	Department of Scientific & Industrial Research (Including CS	656.00	774.96	1327.48	#####	220.53	230.00	225.94	#####	289.00	#####	#####	327.48	#####	1401.49	4900 (4000)
7.	IMM-2020															3000 (2000)
	Total (S&T)	######	######	#######	#####	######	######	1845.23	#####	######	#####	#####	######	#####	#######	'$ 43325.00

* -excluding capital works component
\# -including capital works component
$- excluding additional fund for international S&T Co-operation
** The figures recommended for the Tenth Plan are given in the bracket.

PROGRESS OF S&T PLAN OUTLAY / EXPENDITURE FOR 8th & 9th PLANS - STATES

ANNEXURE 4

(Rs.in lakh)

States/UTs	8th Plan (1992-97) Outlay	8th Plan (1992-97) ACT	9th Plan (1997-2002) Outlay	1997-98 B.E.	1997-98 Actual	1998-99 B.E.	1998-99 Actual	99-2000 B.E.	99-2000 RE	2000-01 B.E.	2000-01 RE	2001-02 B.E.	9th Plan (1997-2002) Anti.Expdr.
A.P.	200.00 *	114.00	937.00	125.00	24.00	325.00	312.00	300.00	300.00	56.22	155.00 *	20.00	811.00
Arun. Prad	47.00	67.00	105.00	23.00	20.00	17.00	16.00	20.00	22.00	223.07	223.07	123.56 !	404.63
Assam	462.00	644.00	1350.00	158.00	17.00	188.00	64.00	185.00	185.00	60.00	60.00	163.00	489.00
Bihar	782.00	227.00	2154.00 @	2700.00	135.00	578.00	172.00	350.00	350.00	300.00	191.00	79.55	927.55
Goa	300.00	153.00	308.00	40.00	28.00	30.00	28.00	30.00	50.00	65.00	65.00	25.00	196.00
Gujarat	550.00	262.00	3125.00	437.00	546.00	437.00	546.00	811.00 $	811.00 $	675.00 $	675.00 $	620.00 $	3198.00
Haryana	662.00	352.00	642.00	135.00	72.00	217.00	81.00	180.00	80.00	150.00	150.00	150.00	533.00
H.P.	275.00	276.00	600.00	90.00	110.00	150.00 *	141.00	148.00	103.00	146.00	146.00	N.A.	500.00
J&K	190.00	136.00	320.00	64.00	30.00	81.00	40.00	604.15 *	76.80	74.37	75.00	76.87	298.67
Karnataka	800.00	1196.00	2500.00	249.00	272.00	238.00	232.00	234.00	252.49	170.00	167.00	156.00	1079.49
Kerala	2193.00	3995.00	7500.00 *	1400.00 *	1203.00 *	1700.00 *	1710.00 *	1780.00 *	1780.00 *	1885.00 *	1900.00 *	1750.00 *	8343.00
M.P.	641.00	767.00	935.00	200.00	100.00	200.00	79.00	200.00	180.00	162.00	162.00	170.00	691.00
Maharashtra	568.00	365.00	885.00	157.00	64.00	397.00	367.00	362.00	362.00	181.30	181.00	200.00	1174.00
Manipur	400.00	382.00	720.00	80.00	60.00	74.00	57.00	85.00	85.00	75.00	226.00	N.A.	428.00
Maghalaya	193.00	213.00	450.00	70.00	49.00	70.00	59.00	93.00	155.00	93.00	93.00	93.00	449.00
Mizoram	195.00	196.00	291.00	65.00	54.00	74.00	42.00	90.00	90.00	90.00	90.00	110.00	386.00
Nagaland	100.00	95.00	400.00	29.00	18.00	25.00	19.00	225.00	221.00	17.00	37.00	32.00	327.00
Orissa	4556.00	1344.00	1655.00	283.00	201.00	300.00	768.00	526.00	404.48	215.68	201.00	167.47	1741.95
Punjab	750.00	160.00	3619.00	150.00	25.00	303.00	43.00	306.00	310.19	138.70	110.00	131.10	619.29
Rajasthan	700.00	639.00	1051.00	250.00	130.00	235.00	188.00	185.00	105.00	100.00	99.00	60.00	582.00
Sikkim	250.00	195.00	800.00	50.00	50.00	58.00	58.00	87.00	78.00	70.00	70.00	N.A.	256.00
Tamil Nadu	1000.00	888.00	2010.00	156.00	232.00	194.00	264.00	177.00	216.93	219.23	232.00	337.44	1282.37
Tripura	225.00	233.00	222.00	40.00	43.00	37.00	38.00	43.00	43.61	27.81	32.00	100.00	256.61
U.P.	1000.00	1955.00	3080.00	715.00	329.00	831.00	874.00	1051.00	205.00	462.00	400.00	462.00	2270.00
West Bengal	1833.00	615.00	988.01	221.00	124.00	265.00	218.00	270.00	170.00	155.00 $	155.00 $	329.30 $	996.30
Total States	18872.00	15469.00	36647.01	7887.00	3936.00	7024.00	6416.00	8342.15	6636.50	5811.38	5895.07	5356.29	28239.86
U.Ts.													
A&N Islands	135.00	122.70	199.85	28.26	22.93	66.00	25.19	60.00	14.00	20.00	20.00	20.00	102.12
Chandigarh	15.00	25.13	37.00	13.00	3.75	7.95	5.72	28.00	28.00	18.00	18.00	32.00	87.47
D & N Haveli	38.00	22.00	30.00	6.00	4.75	7.00	6.94	7.00	7.00	6.00	6.00	6.00	30.69
Delhi	30.00	71.49	15.00	1.00	6.07	3.00	13.63	5.00	5.00	4.00	50.00	5.00	79.70
Daman & Diu	40.00	43.76	47.00	14.00	8.45	15.00	8.17	9.00	9.00	22.00	22.00	10.00	57.62
Lakshadweep	127.61	100.83	643.81	83.05 *	27.73	82.00 *	28.22	35.56	35.56	35.57	30.91	41.00	163.42
Pondicherry	13.00	14.81	60.00	10.00	5.25	35.00	19.87	35.00	35.00	35.00	25.55	35.00	120.67
Total UTs.	398.61	400.72	1032.66	155.31	78.93	215.95	107.74	179.56	133.56	140.57	172.46	149.00	641.69
Grand Total	19270.61	15869.72	37679.67	8042.31	4014.93	7239.95	6523.74	8521.71	6770.06	5951.95	6067.53	5505.29	28881.55

* Including Ecology and Environment

@ excluding Technical Education.

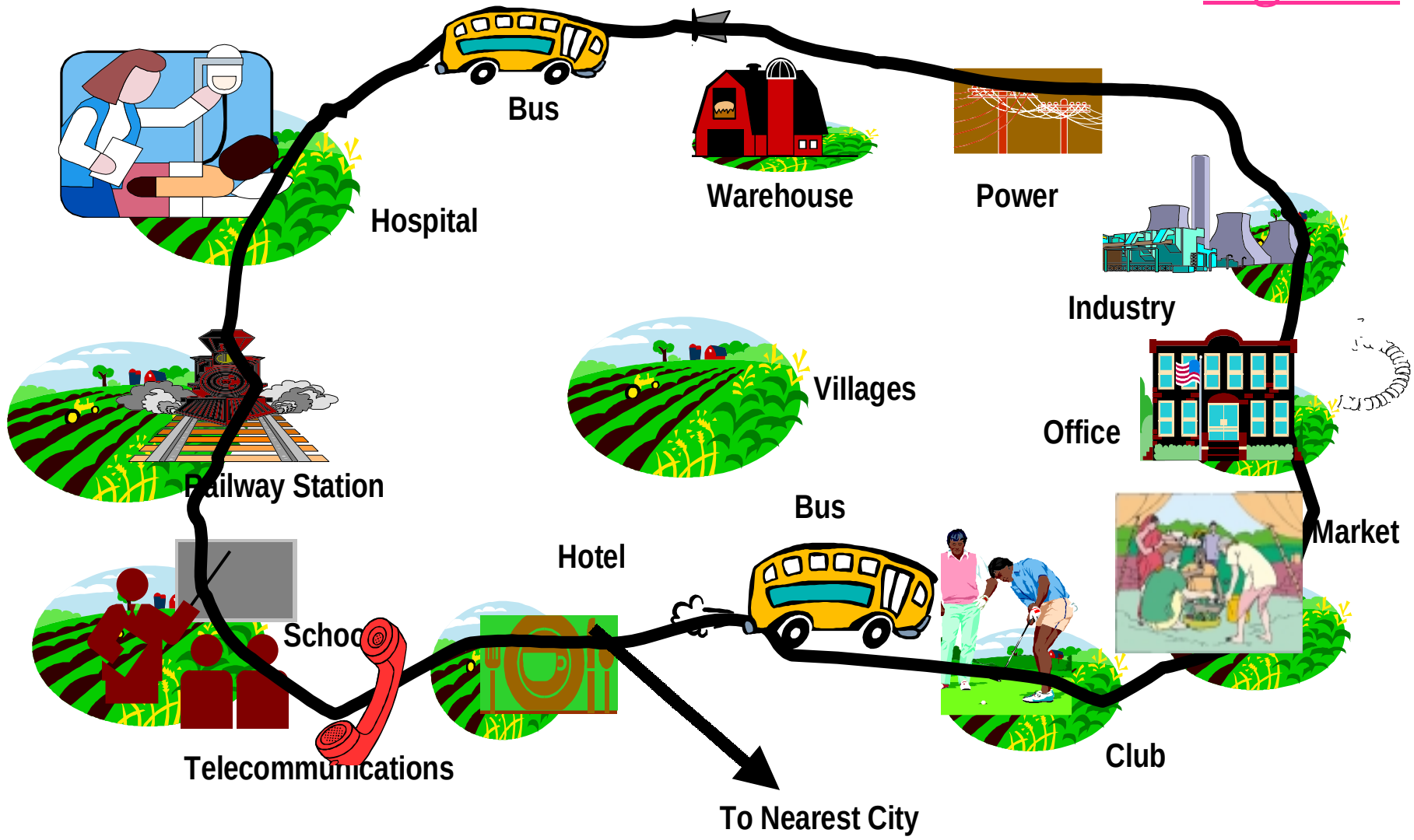
! Including earmarked outlay for TFC

$ excluding Information Technology.

N.A. Not Available

How to make rural areas attractive to investors

Figure-1



Connect a Loop of Villages by a RING ROAD

Thereby, empower Those Villages to Support A Variety of Services

Thus, Convert the Loop Into a *Virtual Town with Potential to Grow*