Establishment and Strengthening of 'Institute of Advanced Radio Spectrum Engineering and Management Studies (IARSEMS)'

Report by:-

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Executive Summary

This is in relation to the "Establishment and strengthening of Institute of Advanced Radio Spectrum Engineering and Management Studies (IARSEMS)", for which services of the undersigned were engaged.

The mandate of proposed National Institute is for conducting advanced research & developmental activities on the various aspects for an efficient management of 'radio frequency spectrum' and submits its findings to the Government. The need & justification for such an Institute and its broad activities are enumerated in the following Para.

2. Worldwide in the radio sector, *a*n unprecedented phenomenon is taking place due to the rapid growth and inventions of wireless technologies for the entire radio services in different frequency bands. In the process no country can afford to be behind in adopting the pace of the developments otherwise that country might be loser not only from technology point of view but on economic front as well. It is no secret now that the radio frequency spectrum plays a dominant role in the economic growth of a country. Let it be public telecommunications, broadcasting, terrestrial, satellite, and navigation services etc. The safety, security and privacy are always on the top of the agenda for any country. Low powered devices capable of transferring more information operating in higher frequency bands are going to sweep the world. All these advancements and developments shall embrace various aspects related to human resource, innovation, technology, standards, adoption and so on. The radio frequency spectrum (RFS) plays a vital role and is the most important tool for economic, security, safety, and social values. This happens either directly by investment in infrastructure deployment, or indirectly through the use of the infrastructure to start new business activities. The management of spectrum includes all issues concerning policies, allocations, allotments, optimization, assignment rules and standards. It also determines that how the frequency bands shall be used for

which category of services or wireless technologies without causing interference to any of the services.

2.1 The current regime of 'command and control' in managing the RF spectrum is passing through a phase of transition in view of the fast developments and uses of spectrum dynamically. Therefore, perhaps within the current regulatory frameworks, it would be a challenging task to manage the spectrum for all categories of services and in all the frequency bands. There would be need to adopt necessary amendments in the 'traditional ways' of spectrum management. It has become increasingly imperative and important for the countries to engage people in research on spectrum management and harmonization to ensure that they possess the necessary facilities and expertise to efficiently and effectively manage this finite resource in the public interest. The spectrum management is a complex and tedious process that involves combination of legal, economic, scientific, administrative and technical aspects. Therefore, there would be an essential requirement in understanding all the aspects of the Radio Spectrum Engineering, Radio Spectrum Monitoring, Measurements of the Spectrum Utilization and Spectrum Efficiency Factors, Authorization of Radio Equipments & Devices including topics such as Spectrum Policy, Spectrum Planning, and Spectrum Legal & Economics etc. The tasks of management of RFS require sophisticated skills and forward-looking knowledge for judiciously, effectively and efficiently performing the tasks of spectrum management scientifically for all the services/technologies. An Institute equipped to undertake these studies independently can provide input to the Government for efficient management of spectrum through its detailed research & developmental efforts and results.

2.2 In India, even though large research establishments have been established by the Governments (Central and State), no professional institution is exclusively dedicated to Radio Spectrum Management research activities. Only piece meals of

work relating to Radio Spectrum are being undertaken by some of the existing institutes, which would not suffice to fulfill the demand of research needs to be undertaken towards radio spectrum engineering and management.

It may be noted the Cabinet approved "National Telecom Policy-2012" carries a mandate "*to establish and strengthen Institute of Advanced Radio Spectrum Engineering and Management Studies (IARSEMS) as a Government Society for undertaking policy research in radio spectrum engineering/radio monitoring and related aspects".*

3. Keeping in view, the broad principles and guidelines, a concept for establishment of an Institute exclusively devoted towards research & developmental activities for "Spectrum Engineering, Management & Planning" have been proposed. The Institute is an R & D institute and not a training Institute. A question may arise that why the Institute cannot be set up in PPP model. The response: as the Institute shall be undertaking studies related to all the frequency bands for any services/applications may be commercial, security and safety purposes and due to sensitivities involved in these studies, the PPP model cannot be advisable in the larger interest of the Nation. Therefore, the PPP model is not recommended.

3.1 The Institute shall be committed in carrying out research studies for all 41 radio services without any prejudice to any wireless stake holders, applications and make its recommendations in a totally transparent/impartial manner.

4. The Institute shall be established as a Government Society, and shall have two tiered structures viz. Policy Level Structure and Functional Structure. Policy Level Structure shall consist of the Board of Governors (BOG). BoG shall consider as deemed fit to set up Committee(s)/Council(s) for proper functioning of the Institute.

4.1 The 'Functional Structure' of the Institute shall have five Bureaus, that shall be responsible for all R & D/consultancies/human resource development activities and technical matters, namely (i) Research & Spectrum Engineering Bureau, (ii) New Technology Bureau, (iii) Spectrum Management & Radio Monitoring Bureau, (iv) National and International Support including manpower development Bureau, and (v) Spectrum Economics Bureau. In addition to above, there shall be 'Finance & Administration' Bureau for co-ordination on administrative and financial matters amongst the Bureaus. However, each of the five Bureaus shall have the autonomy to sanction expenditures within the overall Budget limits fixed for it. The tasks of consultancies and related advisory role should also be performed by the respective concerned Bureau. Commensurate to the requirements of theses Bureaus, the Institute shall perform its R & D/consultancies/human resource development functions through laboratories i.e. Spectrum Engineering, New Technology, Simulation/Software Engineering, Cognitive Radio, EMI/EMC, and Radio wave propagation & Spectrum Measurement, and Standards Development etc. The Institute shall set up several open test laboratories for field experiments and trails. The Institute shall periodically review for setting up more laboratories depending on the need and demand from any sector of the stake holders including international and national commitments.

5. The salient objectives of the Institute are:

5.1 impart quality research in radio spectrum engineering and management, radio monitoring and related aspects by adapting to the best global practices;

5.2 provide open platform to discuss and deliberate on the issue of national importance related to Radio Spectrum Policy, Planning, Engineering, management and Monitoring;

5.3 actively participate/contribute in all the meetings related to spectrum management of International Telecommunications Union (ITU)/Asia Pacific Telecommunity (APT) and similar other International organizations;

5.4 develop strategies, regarding spectrum management for presentation to spectrum bodies within international organizations such as International Telecom Union (ITU), Regional bodies etc;

5.5 carry out consultancy/project works from industry, academic institutions and government organizations within India and abroad in all matters concerning spectrum management and planning;

5.6 actively forge strong relationships with existing universities, colleges, laboratories and institutions in India or abroad in order to network and complement infrastructural and faculty resources in the field of spectrum management;

5.7 determine existing and future national spectrum requirements and develop long and short term spectrum strategies considering all types of wireless applications for societal, safety, security etc, technical aspects and equipment limitations;

5.8 provide continuing training programs for faculty/scholars from other agencies, institutions and industry of worldwide and shall organize conferences, seminars, workshops and such other activities for the dissemination of knowledge. Also to develop special package for human resource development required for developing and underdeveloped countries across the globe;

5.9 administer radio frequency plans, coordinating and administering the use of radio frequencies within the country to various communication radio services required for performing technical coordination;

5.10 study the needs of the spectrum or various radio services, in the light of technological developments. There will be more and more demand for spectrum in the near future and the demand will far outstrip the supply etc;

5.11. Develop analysis tools for frequency arrangement, optimization, assignment, and coordination and interference calculation; and

5.12 Develop technical standards for wireless technologies suitable to Indian environment which shall include sharing and coexistence studies, defining of emission mask, spurious emissions etc. Legal aspects shall be examined as the institute is supposed to develop technical standards, measurements etc and shall be dealt under IPR. This shall be examined as per prevalent rules in this regard. However, we can adopt IPR policy of ITU-Radio Sector within the framework of Indian rules as the Institute will perform similar work at national level.

6. **Manpower Requirements-**

6.1 The Institute shall be headed by a Director and assisted by Bureau Chiefs, Research Scientists, and Research Associates/Research Fellows. The support research officers for each Bureau shall be appointed initially for three years and further extension can be need based and on the recommendations of rigorous performance peer review processes. The requirements of highly talented professionals would be periodically assessed. An Administrator in-charge of Finance & Administration Bureau shall also assist the Director in all matters pertaining to Finance & Administration. The non-technical support staff shall also be appointed.

6.2 The Director shall be appointed by the Central Government, while others by the Board of Governors (BoG). The Institute shall start its core activities from 2015-16 and phase by phase shall become fully operational/functional most likely in five years time. The Central Government may consider appointing initially a

professional, who will look after the functions of the Institute. However, the process for selection of the Director may commence simultaneously. Alternatively, there may be perhaps advantage in appointing the Director from the beginning for smooth implementation of the objectives outlined in the Report.

6.3 It is further proposed that during the first year of inception of the Institute, a compact and competent team of about 50 leading professionals with 'apex' expertise/research aptitude in the areas of 'spectrum management' shall be appointed through rigorous selection process including transfer on deputation from the government, industry, research establishments, and academic institutions etc. The Board of Governors (BoG) shall make recruitment rules and shall make appointments from time to time through constituted 'selection committees'.

7. **Infrastructural Facilities**

7.1 It is aimed to build the Institute of world's top level in the field of spectrum engineering, management & planning. The Institute shall be established on a piece of 20-25 acres of land, with plans for future expansion and developments. It is proposed that Institute shall be located at a place where large number research establishments, academic Institutions of excellence, scientific laboratories, availability of research scholars etc do exist. The Institute shall be fully supported by the Central Government. It is for consideration of the Government that an adequate % of revenue earned on account spectrum usage charges, may be given for research & developmental studies relating to spectrum engineering & management. The Institute, when becomes fully operational say after five years, shall be in a position to generate revenue through consultancies, recommendations, sponsored projects, conferences and trainings etc.

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Definitions Broadly Referred in the Report

- "Apex Body i.e. Society" means the 'Board of Governors (BoG), Chaired by the Minister-in-Charge, Government of India;

- "Director" means the Director of the Institute to be appointed by the Government of India;

- "Bureau Chief" means the Bureau Chief of the Institute to be appointed by BoG;

- "Administrator (Finance and Administration)" means the Administrator (Finance and Administration) of the Institute to be appointed by BoG; and

- "Institute" means the Institute of Advanced Radio Spectrum Engineering and Management Studies (IARSEMS), registered as a Government Society under the Societies Registration Act 1860.

Section 1
Introduction

1. Background

1.1 Radio spectrum, a part of the electromagnetic spectrum, is a finite, natural, scarce but renewable resource. Unlike other natural resources, radio frequency spectrum is not consumed upon its usage. Radio spectrum is not easy to manage due to its physical characteristics and propagation pattern. Radio spectrum ranges from 3 kHz to 3000 GHz. So far we are able to exploit only upto 100 GHz (on maximum side). The radio frequency spectrum caters to the requirements of 41 radio services viz., aeronautical, maritime, radionavigation, radiolocation, radio astronomy, meteorological, broadcasting, satellite broadcasting, fixed, fixed-satellite, mobile, mobile-satellite, and space services etc. The radio spectrum has been divided into different bands. Each frequency band has specific characteristics, which make it separate from other frequency bands. In accordance with International Treaties, all the frequency bands are shared amongst different types of radio services for a variety of applications and technologies.

1.2 The Radio Frequency Spectrum (RFS) has the potential to provide significant economic, social and cultural benefits. RFS, a natural resource is available equally to every country. RFS cannot be stored for future use and if it is not used, is being wasted. All the countries, under the International Convention of the International Telecommunications Union (ITU), have equal and right of access to all the frequency bands in accordance with the 'Table of Frequency Allocations' of ITU. It is a resource that holds great potential and with proper development can be used to increase the efficiency and productivity of a nation's work force as well as to enhance the quality of life. RFS must be managed to realize optimum benefit to the public and the economy of the country. Advancements in the technologies create opportunities to use the RFS for greater benefits. Society's increasing use of radio based technologies and the tremendous opportunities that these technologies provide, highlights the importance of radio frequency spectrum and need for its efficient spectrum management. Spectrum Management is the combination of administrative and technical procedures necessary to ensure the efficient operation of radio services. Efficient spectrum management is the art and science of carefully planning spectrum allocation in a coordinated manner and then speedily and efficiently assigning frequencies for the benefit of people at large and with a minimum of harmful interference.

1.2.1 Like any other natural resource, RFS cannot be owned but is shared amongst various countries, services, users, technologies, etc. Assignment of frequencies is governed by the 'International Treaty' formulated under the aegis of ITU, which is signed and ratified by all Administrations including the Indian Administration. Further, this is also subject to various other international agreements entered into with other countries. In accordance with the 'International Treaty', all frequency bands are shared by all countries for different types of radio communication services and there are no exclusive frequency allocations for a particular service, country, user or organization.

1.2.2 In any 'Administration', the radio frequency spectrum is shared by various government and private user organizations like Defence, Police, Intelligence and other Security agencies; Public Telecommunications; Broadcasting; Railways; Public Utility Organizations, Oil and Electricity Grids, Atomic Energy, Mining and Steel, Shipping and Airlines, and so on as well as private and public telecom operators. These organizations use RFS for variety of services/applications including public telecom services, aeronautical and maritime safety communications, radars, seismic surveys, rocket and satellite launching, earth exploration, natural calamities forecasting etc. A frequency which is being used at one place by an agency may be used by another agency for some other purpose in another place leading to the frequency reuse.

1.3 Information and communication technologies (ICTs), in particular, are reshaping many aspects of the world's economies, governments, and societies. ICT is not just the industry, which stands by itself, but also complement and support the development of other industry sectors. It is the enabler of growth and increasingly important either to the Government, private sector as well as the common people.

1.3.1 Recent announcement of the Hon'ble Prime Minister of India for launching a pan India Programme of "Digital India", bridging the divide between digital "haves" and "have-nots", would certainly ensure Broadband connectivity at village level; improved access to services through IT enabled platforms, and increased indigenous production of ICT products. This programme shall usher many new areas of research and product developments and shall take our country to the leading position technologically and economically on the world's map.

1.3.2 Wireless communications technologies are the economical way for development of ICT. Society is rapidly embracing mobile broadband and the traffic on this has grown much faster than ever foreseen with current levels already surpassing the predictions. It is recognised that mobile broadband is the spectrum user delivering the best return in terms of social and economic benefits for the country. The fastest increasing level of traffic and proliferation of new technologies shall obviously require additional radio frequency spectrum bandwidths. Hence, expansion of ICT also depends on effective and efficient use of radio spectrum. The commercial exploitation of the radio services plays a very significant role that make radio spectrum so valuable. There are examples that the 'Administrations' worldwide have earned a lot of revenue by auctioning a small chunk of radio spectrum for public telecommunication services.

1.4 Role of International Telecommunications Union (ITU) in Global Regulation of Radio Frequency Spectrum (RFS) -

An obvious question arises, who is the global regulator managing the spectrum, and makes provisions for use of RFS, worldwide and region wise. In this sub-section, the role of ITU in regulation of RFS is described. For the sake of clarity in understanding, the text relating to ITU produced below has been taken from the ITU web site (www.itu.int):

"*The International Telecommunication Union (ITU) is that body, which regulates the worldwide use of the radio-frequency spectrum, allowing all international wireless communications to be interference-free thereby enabling the relay of vital information and economic data to all parts of the globe. ITU also defines and adopts telecommunications standards allowing industry to provide services that interconnect people and equipment seamlessly. It also fosters the development of telecommunications in developing countries, by advising countries on winning development policies and strategies and by providing specialized technical assistance in the areas of technology transfer, management, financing and mobilization of resources, installation and maintenance of networks, and management of human resources. ITU's biggest achievement has been its pivotal role in the creation of the international telecommunications network, which is the largest ever man-made infrastructure. ITU is an intergovernmental organization, within which the public and private sectors cooperate for the development of telecommunications worldwide. In essence, the Union's mission covers the following domains:*

- *a technical domain* – to promote the development, efficient operation, usefulness and general availability of telecommunication facilities and services;

- *a development domain* – a development domain – to promote the development of telecommunications in developing countries and the extension of the benefits of telecommunications to people everywhere;

- *a policy domain* – to promote the adoption of a broader approach to the issues of telecommunications in the global information economy

The world conferences on international telecommunications, which meet according to needs, establish the general principles relating to the provision and operation of international telecommunication services offered to the public. The ITU works through the following Sectors:

- *Telecommunication Standardization Sector (ITU-T);*

- *Telecommunications Development Sector (ITU-D); and*

- *Radiocommunication Sector (ITU-R).*

1.4.1 ITU-T

The duties of the Telecommunication Standardization Sector (ITU-T) are to study technical and operating questions and to issue recommendations (de facto standards) to foster seamless interconnection of the world's telecommunication networks and systems. The Sector is also being called upon to forge new standards for the interoperability of equipment from once-disparate realms (telecommunication broad casting and computing) and facilitate the development of a new world of multimedia-based communications in a converged environment. The Sector also adopts recommendations on tariff and accounting principles for international telecommunication services and considers policy issues related to carriage and content. (Technical or operating questions specifically related to radiocommunications come within the purview of the Radiocommunication Sector). The decision-making functions of the Telecommunication Standardization Sector fall within the mandate of World Telecommunication Standardization Assemblies which also adopt the work programme and deter mine the timeframe for completion of

work relating to the preparation of standards. In particular, ITU-T is charged with coordinating the development of the systems and technologies which constitute the emerging Global Information Infrastructure. Areas under study include broadband ISDN, Internet Protocol-based networks and groundbreaking technologies related to new multimedia systems, including special protocols and signal processing systems, high-speed modems, digital subscriber line systems (xDSL) and new types of multimedia terminal. Although they are not binding, ITU-T Recommendations are generally complied with because they guarantee the interconnectivity of networks and enable services to be provided on a worldwide scale.

1.4.2 ITU-D

Telecommunication Development Sector supports governments in reforming the ICT sector to create a stable and transparent framework to attract investment and promote universal access. It also offers practical workshops, best practices and tools to help developing countries automating cost-oriented rate-setting and tariff-rebalancing and it helps in training telecommunication engineers, high-level managers and policy-makers to keep step with technology, policy and regulatory changes. A wide range of e-policies and strategies are also developed to foster e-government, e-health, e-education, e-agriculture and e-commerce in developing countries. The ITU-Development Sector (ITU-D) contributes to the creation of enabling regulatory and market environments, the efficient development technologies and networks, effective spectrum management and transition to digital broadcasting, and new ICT applications, promoting Digital Inclusion of people with specific needs, undertaking capacity building activities, strengthening cyber-security, helping develop emergency telecommunication networks and boosting ICT's input to climate change monitoring and mitigation, and implementing projects in all these areas.

1.4.3 ITU-R

The ITU Radiocommunication Sector ensures rational, equitable, efficient and economical use of this spectrum by all radiocommunication services, including those using the geostationary and other satellite orbits. Both the spectrum and satellite orbits are finite natural resources and are increasingly under pressure from a growing number of services. From fixed and mobile wireless services to aeronautical communications, from broadcasting and meteorology to global positioning systems and space research or for communication services that ensure the safety of life at sea

and in the skies - all require spectrum to operate, and a coordinated use of frequencies to avoid harmful interference.

The ITU Radiocommunication Sector manages the radio-frequency spectrum, which ensures that radio-based systems - cellular phones and pagers, aircraft and maritime navigation systems, scientific research stations, satellite communication systems and radio and television broadcasting can function smoothly and provide reliable wireless services to the world.

Through an International Treaty called the Radio Regulations, the ITU Radiocommunication Sector coordinates efforts on a worldwide basis to ensure reliable communications by ensuring that radio stations between different countries can operate without harmful interference. It carries out the technical groundwork to facilitate the taking of sound decisions by world radio conferences held every two to three years to revise the treaty. This work includes the development of regulatory procedures and the examination of planning parameters and sharing criteria with other services in order to calculate the risk of harmful interference, both for terrestrial and space services. It develops technical recommendations on the characteristics of radiocommunication services and systems that serve as a basis for equipment manufacturing.

In implementing this mission, ITU-R aims at creating the conditions for harmonized development and efficient operation of existing and new radiocommunication systems, taking due account of all parties concerned. The primary objective is to ensure interference free operations of radiocommunication systems. This is ensured through implementation of the Radio Regulations and Regional Agreements, and the efficient and timely update of these instruments through the processes of the World and Regional Radiocommununication Conferences. Furthermore, radio standardization establishes ´Recommendations´ intended to assure the necessary performance and quality in operating radiocommunication systems. It also seeks ways and means to conserve spectrum and ensure flexibility for future expansion and new technological developments. The specialists from telecommunication organizations and administrations around the world participate in the work of the Radiocommunication Sector's various study groups broadly to:

- ❑ *develop ITU-R Recommendations on the technical characteristics of and operational procedures for radiocommunication services and systems;*

- ❑ *draft the technical bases for radiocommunication conferences; and*

- ❑ *compile handbooks on spectrum management and emerging radiocommunication services and systems.*

The World Radio Conferences (WRCs) held every three to four years review, and, if necessary, revise the Radio Regulations, the international treaty governing the use of the radio-frequency spectrum and the geostationary-satellite and non-geostationary-satellite orbits. Revisions are made on the basis of various agenda items determined four to six years in advance. Under the terms of the ITU Constitution, a WRC can:

- *"revise the Radio Regulations and any associated Frequency assignment and allotment Plans;*
- *address any radiocommunication matter of worldwide character; and*
- *determine Questions for study by Study Groups in preparation for future Radiocommunication Conferences etc.*

On the basis of contributions from administrations, the Radiocommunication Study Groups, and other sources concerning the regulatory, technical, operational and procedural matters to be considered by World and Regional Radiocommunication Conferences, the Conference Preparatory Meeting (CPM) prepares a consolidated report to be used for the work of WRCs".

The Radio Regulations are revised, complementing the Constitution and the Convention of the International Telecommunication Union, and incorporates the decisions of the World Radiocommunication Conferences of 1995 (WRC-95), 1997 (WRC-97), 2000 (WRC-2000), 2003 (WRC-03), 2007 (WRC-07) and 2012 (WRC-12). The present revision is effective from January 1, 2013. It may be mentioned that the ITU Radio Regulations (RR) are an international treaty, signed by all the administrations that are members of ITU (at present there are 194 Members) and updated periodically in the World Radio Conferences. This RR gives a detailed picture about distribution of spectrum for different services and various Regions. The sharing of spectrum is amongst the many global, regional and national. Regional and National frequency plans can be different from the International plan by ensuring

that there are no potential international interference situations. The spectrum allocations, in the Table of Frequency Allocations, are on "PRIMARY" and "Secondary" basis. As per the Radio Regulations Articles, "*(a) services the names of which are printed in "capitals" (example: FIXED); these are called "primary" services; (b) services the names of which are printed in "normal characters" (example: Mobile); these are called "secondary" services. The stations of a secondary service:*

a) *shall not cause harmful interference to stations of primary services to which frequencies are already assigned or to which frequencies may be assigned at a later date; and*

b) *cannot claim protection from harmful interference from stations of a primary service to which frequencies are already assigned or may be assigned at a later date.*

In accordance with international Radio Regulations 'allocation' is to a particular frequency band in frequency allocation table for use by one or more services under specified conditions. 'Assignment' is to a particular radio frequency or a channel for a radio station to use under specified conditions. Accordingly, based on international Table of Frequency Allocations, the Administrations evolve their national frequency allocation plans by allocating different frequency bands to one or more radio services. These plans do not give any ownership rights to any user of the spectrum, but are meant for development and planning purposes by industry and users. For establishment of a radio communication, every radio station has to obtain frequency assignment with appropriate technical parameters and specified conditions. It may be mentioned that Limited portion of the radio frequency spectrum is useful for specific wireless services owing to the following factors:

- *Propagation characteristics of different types of radio waves;*
- *Availability of technology and equipment for different types of radio frequency spectrum applications;*
- *The suitability of frequency bands for specific applications;*
- *Unlike other natural resources, radio frequency spectrum is not consumed upon its usage and it is also liable to be wasted if it is not used optimally and efficiently;*

- *Radio frequency spectrum usage is therefore to be shared amongst the various radio services and must be used efficiently, optimally and economically in conformity with the provisions of national and international la;.*

- *No single frequency range satisfies all the criteria needed for setting up broadband including IMT systems in those countries having diverse geography and population density;*

- *Several frequency bands shall be required in order to meet both the capacity and coverage requirement; and*

- *High capacity and high speed data rates are achievable in the presence of contiguous bandwidths in a single band as against multiple carriers in multiple bands or in a non-contiguous single band."*

The ITU-R recommendations also play an important role in the standardization and harmonization of radio equipments. While voluntary, such "standards" offer many advantages including allowing economies of scale in the production of radio equipment, facilitating roaming, facilitating interoperability, etc. The commercial value to manufacturers of being able to say that their radio equipment meets relevant ITU-R Recommendations is significant as it instills confidence on the part of purchasers of such equipment.

1.5 Management of Radio Frequency Spectrum

1.5.1 Spectrum Management

1.5.1.1 The work of spectrum management becomes highly complex when it comes to simultaneously fulfil the demand for spectrum for 41 different radio services, each with its own unique requirements and characteristics. For example, the navigational and communication needs in civil aviation and shipping can only be met by use of the radio spectrum, and that the same chunk of radio spectrum needs to be available globally. Radio astronomy requires that certain part of the radio spectrum must not be used for any transmission. The benefits derivable from the use of spectrum are, in general, not easily comparable, as it also varies with technology, economics, social factors and several other considerations. For example, it is not an easy matter to determine whether a particular chunk of spectrum for security use is more purposeful than the use of the same chunk of spectrum for commercial public use, which generates huge revenue and benefits millions of users. Therefore, today's

spectrum management has now been converted into a mechanism to fulfil the requirements of various radio services taking into account technical, economic, social and international obligations.

1.5.1.2 The regulation of radio frequency spectrum (RFS) is entirely different as it is predominantly governed by the scientific features and physical laws of nature. Spectrum management is the process of regulating the use of radio frequencies to promote efficient use and gain net social and economic benefits. Spectrum Management is the combination of administrative and technical procedures to ensure efficient operation of radio services without causing harmful interference to any operation (s) in the frequency band of interest. Efficient and effective spectrum management, therefore, is the art and science of carefully planning spectrum allocation in a coordinated manner without compromising national interests and efficiently assigning frequencies for the benefit of users at large with no or least harmful interference.

1.5.1.3 The spectrum management is a complex and tedious process that involves combination of legal, economic, scientific, administrative and technical aspects. Therefore, there is a need to understand all the aspects of the Radio Spectrum Engineering, Radio Spectrum Monitoring, Measurements of the Spectrum Utilization and Spectrum Efficiency Factors, Authorization of Radiocommunications Equipment & Devices including topics such as Spectrum Policy, Spectrum Planning, and Spectrum Legal & Economics. The process of spectrum management involves various activities namely (i) recognise better usage of national radio spectrum allocation where possible; (ii) spectrum reallocation to existing users; (iii) shifting of their assignments to other frequency bands for better utilization; (iv) vacation of spectrum; (v) interference management; and (vi) appropriate spectrum charging; etc, It is required to deal with topics such as the bases for spectrum management processes formulation and implementation of the latest trends and best practices in spectrum management and their integration into the national activities. The following broad features need to be carefully planned:

- developing the administrative structure, specifying their objectives, jurisdictions etc.;

- studying advantages and disadvantages of each one of the spectrum management models, so that the administration can choose the best combination;

- making guidelines for the definition of spectrum policies to facilitate the adequate planning of the Radio spectrum, seeking fair access for those who needs to use it;

- giving necessary information about how to carry out the radio spectrum planning activities, considering the economic, social and technical components; and

- describing the different tools that establish the mechanisms for the analysis of engineering and measurement of parameters such as interference, noise levels and radiation limits etc.

1.5.1.4 The traditional spectrum management relies on a combination of exclusive frequency assignment, geographic segregation, and limitations on transmission power to meet the avoidance of "harmful interference" among different spectrum users. However, there is even now no formal definition of what constitutes harmful interference. This lack of clarity in definition and established mechanisms for the assessment of impact of interference has led to burdensome regulatory provisions. This also put responsibility, on new technologies and service entrants to prove that they are not harmful, and might be leading to a factor of discouragement them to make investments in new products and services. Most interference issues are argued in a conservative way, which the existing ones taking examples of worst case scenario and apprehending that their network will not function. To-day technologies are available, and will continue to emerge, that can address and manage interference issues effectively. These actors demand rigorous technical studies so that there are rooms available for growth of existing applications and development of new technologies. The ITU considering the latest technological developments, societal needs, astronomical growth of wireless based services is continuously/periodically reviewing and opening additional spectrum to take care of the future requirements. If we continue to be conservative and not addressing the call, we will be left far behind.

1.5.1.5 In the context of today's technological developments in wireless systems, the traditional way of spectrum management may need to adopt modern tools for an efficient and effective functioning. In this context, it may be appreciated that allocation to a 'User' cannot be in an exclusive frequency band as different services share the spectrum. Therefore, a new, more efficient and vibrant plans need to be

made, one in which regulatory process can keep pace with technological changes and see that how best RFS can be managed. A viable solution could be to create wide bands and implement dynamic, real-time, spectrum sharing. This change in perception will allow many users for sharing the same RFS independently. The sharing concepts shall be broadly in frequency, time, location and signal separation etc. In order to implement the concepts of sharing, detailed studies would be required.

1.5.2 Radio Frequency Spectrum Monitoring

1.5.2.1 The increasing use of radio makes it more and more difficult to accommodate all users in the limited spectrum available. Some frequency bands are already overcrowded at times and spectrum managers more often need to know the actual occupancy/vacancy in certain frequency bands. Monitoring helps the enforcement, frequency planning and licensing through the determination of interference and its source; participation in an international co-operation to identify interference sources affecting several countries and the gathering of information on usage and channel occupation in support of frequency planning and licensing. The Monitoring further supports the overall spectrum management efforts by providing general measurement of channel usage and band usage, including channel availability statistics and the effectiveness of spectrum management procedures. Monitoring is also useful for planning, in that it can assist spectrum managers in understanding the level of spectrum use as compared to the assignments that are recorded on paper or in data files. A measurement system can help in some instances where the solution to a problem requires more than knowledge of theoretical characteristics of radio systems. It also obtains information for enforcement and compliance purposes on the operation of individual stations, and it can be used to establish the location and identity of stations causing interference.

1.5.3 National Data Base of Radio Frequency Usages

1.5.3.1 A data base of radio frequency usages in all the frequency bands for all the services/applications by different organizations is extremely useful and important information for planning of spectrum management and evolving new policies. It may be required to be integrated with information available from other sources as well, e.g., the ITU international frequency registers, national monitoring, inspection records, etc. This Data Base containing adequate level of technical and management information serves as the primary resource for evaluating current use.

The Data Base should not only include frequency, user name, and location alone but as well as information related to the functions performed by equipments, costs involved with system implementation, and detailed technical characteristics, topographical data to aid computation of propagation-path profiles in urban/semi-urban/rural areas and over large areas etc. In cases, where international uses are required to be considered, the national level Data Base, be supplemented by the ITU-R's International Frequency Information Circulars. The information obtained through spectrum monitoring about the actual use of frequencies may be used to supplement national Data Base. The spectrum monitoring consisting of spectrum occupancy measurements shall enable to correlate the actual level of use associated with assignment records, which will help in updating national Data Base from time to time.

1.5.4 Economic Aspects of Radio Frequency Spectrum

1.5.4.1 The increasing use of new technologies has produced tremendous opportunities for improving the communications infrastructure of a country and its economy. Further, the ongoing technological developments have opened the doors to a variety of new wireless based applications. Thus, the efficient and effective management of the spectrum, while crucial to making the most of the opportunities that the spectrum resource represents, grows more complex. Improved data handling capabilities and engineering analysis methods are the key to accommodating the number and variety of users seeking access to the spectrum resource. If the spectrum resource is to be used efficiently and effectively, the sharing of the available spectrum has to be coordinated among users in accordance with national regulations within the national boundaries. Considering that RFS is a limited and scarce resource with the main objectives of securing optimum spectrum occupancy and effective utilization, the following broad principles pertaining to economic aspects of RFS are enunciated**:**

a) RFS is the property of the Government. Thus, any spectrum occupancy relating to non-governmental activities is considered to be private occupancy;

b) RFS must be managed in the interests of the national community as a whole;

c) As the owner of RFS, the Government has the right to require private occupants thereof to pay *spectrum fees* (known also as *spectrum occupancy*

fees, *frequency availability fees* or *spectrum usage fees*, or simply as *fees* where there is no ambiguity);

d) The planning, management and monitoring of the spectrum are carried out by the Government. Those activities are essential for ensuring that the spectrum is used for the assigned parameters;

e) The spectrum users including Government users should pay costs arising out of spectrum planning, management and monitoring activities;

f) The establishment of spectrum fees and administrative fees must be carried out with due respect for the rules of transparency, objectivity, proportionality and non-discrimination;

g) In return for the fees they pay, users of assigned or allotted frequencies to the primary services enjoy protection under the relevant provisions of the regulations in force; and

h) The spectrum fees constitute financial resources for the Government as well as for the spectrum managing authority etc.

1.6 Need for an Advanced Level Institute for Study related to Radio Frequency Spectrum Engineering and Management

1.6.1 The foregoing Para amply demonstrate that the 'Spectrum Management Policy and Planning' is highly complex while taking into considerations of National requirements and simultaneously adhering to the "International Treaty" in form of the "Radio Regulations". The tasks of management of RFS require sophisticated skills and forward-looking knowledge for judiciously, effectively and efficiently managing the spectrum scientifically for all the services/technologies. An Institute equipped to undertake these studies independently can provide input to the Government for efficient management of spectrum through its detailed research & developmental efforts and results. The overall spectrum management policy and planning broadly requires (i) sophisticated guidelines and forward looking knowledge; (ii) future technologies and their spectrum requirements; (iii) keeping abreast with the latest spectrum management techniques; (iv) involvement of all stake holders in spectrum; an (v) inputs from the experts in the field and related aspects. In India, even though

large research establishments have been established by the Government, no professional institution is exclusively dedicated to Radio Spectrum Management research activities. Only piece meals of work relating to radio Spectrum are being undertaken by some of the existing institutes/organizations. This would not suffice in fulfilling the demand of research needs of radio spectrum engineering and management. Further, also due to inadequate budget, cumbersome procedures, lack of automation, non availability of data bases, lack of networking and unresponsive procedures, it is essentially required to undertake detailed and exhaustive studies by an independent setup.

1.6.1.1 In the context of setting up of an Institute of this kind, it may be noted the Cabinet approved "National Telecom Policy-2012" carries a mandate "*to establish and strengthen Institute of Advanced Radio Spectrum Engineering and Management Studies (IARSEMS) as a Government Society for undertaking policy research in radio spectrum engineering/radio monitoring and related aspects".*

1.6.2 The above proposed an 'advanced level technical institute of excellence' for radio spectrum technology development in the country shall be a unique world's top class centre and shall be with an intellectually alive atmosphere of research & development. The major focus of the Institute shall be in the "Radio Sector", however, inter-related issues of "Standardisation" and "Development" Sectors shall also be studied. The major thrust will be given to efficient utilization of spectrum in technical and economic terms. The research activities of the institute would not be limited; it would be extended as per needs/demands of the industry, regulating agencies and all other stake holders including the Government Sector, PSUs & Private Sector.

1.6.3 A question might be asked that why the proposed Institute cannot be set up in Public Private Partner (PPP) model. The response: as the Institute shall be undertaking studies related to all the frequency bands for any service/applications may be commercial, security and safety etc purposes and due to sensitivities involved in these studies, the PPP model cannot be advisable in the larger interest of the Nation. In view of this, the PPP model for setting up IARSEMS is not recommended.

Section 2
Objectives of the Institute

2.1 It is well established that variety of applications of radio frequency spectrum, for various services, stimulates economic growth, well being of citizens and participation in the international community. The use of radio is rapidly expanding and by virtue of radio propagation properties at higher frequencies, many new requirements can be accommodated by moving into higher frequency bands. An advance identification of spectrum conflicts will help ensuring cost-effective or efficient solutions while continuing to encourage wireless growth. In the light of technological developments, there will be more and more demand for spectrum in the near future and the demand may outstrip the supply. As the spectrum is a finite resource, effective management is vital for long term growth of wireless services. Timely development of advanced spectrum management tools will be essential for finding such solutions. In this light, the establishment of an Advanced Institute as mandated in the National Policy by name "Institute of Advanced Radio Spectrum Engineering and Management Studies (IARSEMS)" shall be certainly be playing a vital role.

2.2 This Institute shall surely contribute significantly in the development and implementation of an effective spectrum management organization; development and implementation of spectrum policies, rules, and regulations; establishment of capabilities that promote efficient and effective spectrum use; organization, structuring, and authorization of specific radio systems or services. Further, this Institute shall contribute and recommend planning of spectrum in terms of time i.e. short term, long term, and strategic and also in terms of the areas covered i.e. spectrum use, and spectrum management systems. By definition, planning in terms of time can be broadly categorized as:

Short Term Planning	Planning for system's implementation within from 3 to 5 years.
Long term planning	Planning for system's implementation within 5 to 10 years.
Strategic planning	Planning requiring spectrum management solutions beyond 10 years of its implementation.

2.3 The Institute is envisioned as an institute for creative and innovative research and development in the field of Radio Spectrum engineering and Management. The

Institute is envisaged to serve as the fountainhead for the nurturing of world class technical high-calibre human resources capable of serving as the leaders and innovators of tomorrow in the field of Radio Spectrum Engineering & Management and lead R and D groups in our National Laboratories, mission oriented agencies and in industries. The IARSEMS, an autonomous Government Society shall have the objective of making the spectrum sciences/engineering/economics/social and its applications known to all within the global community through the sharing of knowledge and education. The Institute shall provide recommendations to the government for efficient utilization of Spectrum in terms of technical, economic and social aspects. The Institute shall have members who have a special interest as well as knowledge of different parameters, which are required to be optimized to ensure economic and efficient use of radio spectrum.

2.3.1 The research & developmental programmes of the Institute shall support the Government for planning key strategies of fostering advanced communications technologies to strengthen all the sectors namely safety, security, commercial, societal etc in all the frequency bands and take it to the world's top level institution for discussions and adoption. The broad major thrust shall be categorized as:

- Basic research- to enhance scientific knowledge and understanding in cutting-edge areas of all radio services/technologies with a view improving performance of existing and developing new networks;
- Applied research- for testing of elsewhere developed radio based devices/products adhering to the standards & specifications laid down in India. In case no such standards are in place, the Institute shall evolve necessary standards. Evaluation for innovation and development of advanced technologies and services. Contribute in improving public safety, security communications; provide technical input to the Government for policy development and spectrum management. Suggest ways and means for effective utilization of the underutilized spectrum and open new avenues for spectrum users and also development of advanced, techniques for spectrum-sharing. Helping to find solution to the specific problems, which are entrusted by the Central, State and local governments/agencies from time to time;
- Cooperative research and development- to have association, agreement with academia, industry for providing technical assistance promoting

innovation, entrepreneurship, and commercialization in India and abroad; and

- Leadership and technical contributions- to the national, regional and international fora in influencing development of frequency plans/standards/policy of interest to the Government of India and public at large.

2.4 The Institute shall have the broad objectives to:

- impart quality research in radio spectrum engineering and management, radio monitoring and related aspects by adapting to the best global practices and translating to national requirements;

- recommend to the government policy framework for efficient utilization of Spectrum;

- provide open platform to discuss and deliberate on the issues of national importance related to Radio Spectrum Policy, Planning, Engineering and Management;

- organize workshops/seminars as appropriate and sub-working groups commensurate with ITU study groups etc to review specific topics;

- actively participate/contribute in all the meetings related to spectrum management of ITU/APT and similar other International organizations;

- develop strategies, regarding spectrum management for presentation to spectrum bodies within international organizations such as ITU, Regional bodies etc;

- conduct studies focusing to Study Groups & Study Questions of ITU-R Sector including inter-related issues of "Standardisation" and "Development" Sectors of ITU. The Institute shall actively participate and make contributions to the various ITU/APT and other related meetings;

- carry out consultancy/project works from industry, academic institutions and government organizations within India and abroad in all matters concerning spectrum management and planning;

- publish research/white papers and reports on research/analysis carried out and completed;

- issue consultation papers to consolidate the views of different stakeholders and give recommendations to government and the regulatory bodies;

- create cross industry groups to encourage cooperation and information sharing;

- actively forge strong relationships with existing universities, colleges, laboratories and institutions in India or abroad in order to create network and complement infrastructural and faculty resources in the field of spectrum engineering and management;

- support highly talented technical manpower for higher studies (Masters, PhD and Post-Doc) in radio spectrum engineering & management with Institutes of excellence in India and abroad;

- generate significant intellectual property rights (IPRs) through sponsored research programmes in various areas of spectrum management and radio monitoring. The Legal aspects shall be examined as the institute is supposed to develop technical standards, measurements etc and shall be dealt under IPR. This shall be examined as per prevalent rules in this regard. However, we can adopt IPR policy of ITU-Radio Sector within the framework of Indian rules as the Institute will perform similar work at national level.

- do all such things as may be necessary, incidental or conducive to the attainment of all or any of the objects of the Institute as decided from time to time;

- take up recent development of technology for efficient management of radio spectrum;

- develop analysis tools for frequency arrangement, assignment, optimization, and coordination and interference calculation;

- establish processes to optimize the efficient use of the radio spectrum and procedures to harmonize the operation of different services;

- determine existing and future national spectrum requirements and develop short and long term spectrum plans considering all types of wireless applications for societal, safety, security needs etc; technical aspects and equipment limitations etc;

- study the economic aspects of spectrum utilization including spectrum pricing to promote the secular growth of wireless technologies throughout the country with emphasis on rural and inaccessible remote areas keeping in view the affordability of public telecom services to a common man as envisaged in the Government Policies announced from time to time. Further, develop tools for improving economic and social efficiency of radio spectrum making it more useful to the society;

- study economic aspects of use higher frequency bands for short range communications and in that case what shall be the differential pricing wrt existing spectrum pricing model;

- study economic aspects, if certain frequency bands are de-licensed visa-vis licensed bands, for their use for the public at large i.e. mass commercialization of short range and low powered wireless devices;

- provide continuing training programs for faculty/scholars from other agencies, institutions and industry of worldwide and shall organize conferences, seminars, workshops and such other activities for the dissemination of knowledge. Also to develop special package for human resource development for developing and underdeveloped countries across the globe;

- guide the wireless stake holders how best they can organize and plan their networks/services to ensure economy of scale; and efficient & optimal utilization of the spectrum;

- attract and appoint high caliber professionals from centrally funded Government Institutions/Departments, academic institutions, public & private organizations etc;

- establish regulations, technical parameters, and standards governing the use of each frequency band for a specific service;

- develop equipment specifications and conducting equipment certification in accordance with approved procedures;

- develop procedures for acceptable levels of transmitter emission, technical plans and procedures including sub-allocation plans;

- develop procedures for band clearing and spectrum sharing;

- evaluate and select engineering and technical analysis tools including propagation models and software such as geographic information systems (Digital Terrain Maps);

- conduct surveys and studies of spectrum use and of spectrum requirements for current and future services;

- carry out audit of spectrum;

- conduct studies and reviews of new technologies affecting spectrum requirements;

- administer radio frequency plans, coordinating and administering the use of radio frequencies within the country for various radio services;

- manage processes to optimize the use of the radio spectrum and ensuring harmonious operation of different services;

- evaluate the consistency of radio frequency usage with national radio laws and international regulations;

- study the needs of the spectrum or various radio services, in the light of technological developments. There will be more and more demand for spectrum in the near future and the demand will far outstrip the supply;

- serve as the fountainhead for the nurturing of world class technical human resources capable of serving as the leaders and innovators of tomorrow in the field of Radio Spectrum Engineering & Management;

- make priority efforts so that the spectrum sciences/engineering and its applications are known to all in the society through the sharing of knowledge and education;

- formulate recommendations, prepare study reports on various issues related to spectrum management, for consideration of the Government;

- guide the wireless stake holders how best they can organize and plan their networks/services to ensure economic, efficient and optimal utilization of the spectrum;

- develop tools for effective monitoring of radio signals in line with the Recommendations of ITU; and

- prepare digital maps of all the wireless stations with their technical parameters in the country leading to creation of strong data base and update it periodically etc.

Section 3
Need and Justification

3.1 The whole world is witnessing an unprecedented growth and invention of wireless technologies in all the radio services & frequency bands. Society is day by day becoming data hungry and the demand is to provide access on demand may be through wire or wireless or an integration of both. Low powered devices capable of transferring more information operating in higher frequency bands are going to sweep the world. These all developments shall embrace aspects related to human resource, innovation, technology, standards, adoption and so on.

3.1.1 The radio sector had been, is and shall be the front runner in the field of engineering and society. The Society became so excited after the pioneer inventions of Maxwell, Bell, Marconi, Sir Bose (mm wave) and many more that technological applications started translating into reality immediately thereafter. The telephone and later mobile telephony in parallel with Internet have significantly influenced people, communities and growth worldwide. Nowadays, ICT is taking role position in contributing a dream of 'New Digital Era' and the 'Digital India' mission of Hon'ble Prime Minister of India.

3.1.2 A modern economy relies heavily on its communications infrastructure, of which radio services play an important role. The Radio Spectrum is a national resource. It is the backbone for a wide range of activities in sectors including telecommunications, broadcasting, transport, defence, public security, emergency services, research and development, scientific services and applications such as alarm, remote controls, hearing aids, microphones, and medical equipment. Spectrum also supports public services such as security and safety services, including civil protection, and scientific activities, such as meteorology, Earth observation, radio astronomy and space research. Radio spectrum, therefore, has an impact on county's economic, safety, health, public interest, cultural, scientific, social, environmental and technical implications. Every citizen uses services which rely on spectrum on a daily basis - be it broadband, using their mobile phones, security gadgets, availing of weather reports or using the real time transport service, using taxis, watching television or listening to the radio. It is clear that from a cultural, leisure and economic perspective right up to the defence of our society, the use of spectrum impacts on the daily lives of citizens.

Radio spectrum makes a significant contribution, directly and indirectly, to the economy of the country. Spectrum-based businesses employ hundreds of thousands of people and are one of the fastest-growing, successful and dynamic sectors of the economy. The economic importance radio spectrum can be understood that the total volume of services depending on radio spectrum availability is estimated to be worth at least €200 billion annually in Europe. Radio spectrum is so important that a report says that radio spectrum based mobile, and a similar figure for broadcasting services are generating an overall $3 trillion worldwide and all of this value is generated by just the small slice, less than 2% of overall usable spectrum.

3.1.3 The Administrations worldwide have accepted that the broadcasts, the Internet, and telephony are all essentially needed for the people. The broadcasting agency helps in defining national identity, enhancing social cohesion and is becoming a gateway to knowledge, information and entertainment etc. The hybrid broadcasting is the future. The worldwide phenomenon is to digitize the analogue TV broadcasting any many countries have gone in 'digital mode'. The challenge is how and for what services/applications, the spectrum so made available be used for providing radio based applications.

3.1.4 Let it be providing telephony and or broadcasting services, it shall be either through terrestrial or satellite modes or combination of both. When it is talked about these services, all the applications encompasses security, safety, entertainment, education, health, and social needs etc. When these applications are provided using wireless mode, the radio frequency spectrum (RFS) is the soul and driver.

3.1.5 The radio frequency spectrum (RFS) is the most important basic tool for economic, security, safety, and social values. This happens either directly by investment in infrastructure deployment, or indirectly through the use of the infrastructure to start new business activities. The wireless based devices appear to be boon for remote markets by ensuring access to information, IT literacy, and related. The universal broadband access improves a lot in the sectors of education, health, SME growth, entrepreneurship and job growth, agriculture, financial inclusion and government services. Therefore, it is not only Mobile industry but all the sectors i.e. broadcasting (expansion of LPTs and HPTs for providing coverage to all villages), satellite (foot print all over country), security (electronic war fare), safety (aircraft, ships), public protection (disaster rescue and relief), and oil exploration etc. need

RFS. All the Government Departments (including security agencies), PSUs and Private Organizations (including individuals) are the stake holders.

3.2 The spectrum planning is an essential tool of the spectrum management actions or decisions that directly govern how the spectrum will be used. This management includes all issues concerning policies, allocations, allotments, optimization, assignment rules and standards. It also determines that how the frequency bands shall be used for which category of service or wireless technology. The basic objective of the spectrum management is 'to live' and let 'others live'. The task of spectrum manager is of a 'Traffic Police', who ensures there is regular flow of traffic without any collision, this he ascertains through certain regulations revised from time to time keeping in view the latest trends/developments. On similar footing the spectrum manager through policies/regulations sees that in the same lane of frequency band, where many services are allocated, there is smooth functioning without causing interference. Further also he takes care that side by frequency bands (lanes) are not affected.

Therefore, the whole area of spectrum policy and planning is one which has significant importance for society and the economy, particularly in terms of its contribution to the digital economy and the deployment of next generation networks and applications. The following factors that broadly impact spectrum planning are:

(a) **Policy & Lega**l- National radiocommunication law, regulatory requirements, International (ITU) frequency allocation, Regional frequency management bodies, National frequency allocation procedure, frequency management procedures of neighboring administrations, standardization policy, telecommunications infrastructure, industrial issues, user demands, security and public safety.

(b) **Economic** – Globalization, overall economic development, structure of prices and tariffs for equipment and services, market needs and marketing issues, procedures and practices used by service providers, spectrum auctions or fees.

Now a day's radio spectrum is not limited to mobile telecom services only but radio spectrum is used for economic, social, cultural, scientific and developmental purposes with an enormous number of end-user services: communications for

industries, households and public bodies, including critical safety and security communications used by defense forces, emergency services and air traffic control; various kinds of radar; broadcasting; scientific research; and so on.

3.3 Two-three decades back, the word spectrum meant 'the rainbow thing' to most people and hardly anyone relate this word with radio frequency. Prior to 1980, radio spectrum was mainly used by security forces and some other government agencies. In public domain, radio spectrum was related with broadcasting services. During this period, no one thought that radio spectrum has any revenue potential like any other natural resource e.g. minerals etc.

3.4 After the advent of mobile communication technology (GSM/CDMA) during 80s, we heard demand of radio spectrum for commercial use. Envisaging the future demand of spectrum for commercial applications, ITU through its Radio Conferences had started identifying several frequency bands for mobile telephony. During this same period, the battlefield information requirements for modern war fighters also began to grow dramatically. By the end of the '80s, government and industry, and nations, were on a collision course over the access to frequencies. Historic spectrum management policies and practices were being challenged and in process warranted of being re-looked.

3.5 In recent years, technological innovation in the field of communications has placed increasing demands on the radio spectrum. In the area of telecommunications, new services have been launched, such as 3G/4G mobile communications and so on, unlicensed wireless devices and wireless broadband Internet access, while digital broadcasting has ushered in a new range of services such as high definition television. Meanwhile, existing demands in the form of traditional broadcasting, mobile voice services, public safety services and security have also grown, placing an increased strain on the finite amount of radio spectrum available.

3.6 The world wide increasing number of wireless devices as a part of mobile networks contributes significantly to global mobile traffic growth. Also year by year, a large number of news devices with increased capabilities and intelligence are being launched in the market. It is evident that past more than half decade has been witnessing an astonishing growth of wireless technology. Devices namely smart phones, tablets, and many other have made mobile information access an essential tools for our day-to-day needs. In the coming years, the radio frequency spectrum,

required for the wireless based systems, will be a significant foundation for global economic growth and technological challenges. The number of devices being connected to mobile networks worldwide would be around 10 times by 2020. These wireless based technologies will contribute significantly towards global economy in terms of expansion of existing business and creation of new opportunities. This growth requires huge demand wireless spectrum.

3.7 The need for identification of frequency bands for mobile services (now popularly referred as International Mobile Telecommunications-IMT) was appreciated by ITU, and it began its work in the mid 1980's defining the next "generation" of mobile radio standards to on a global basis. This led to allocation of a new globally available frequency bands. Also, convergence of many other existing mobile wireless technologies took place. The World Administrative Radiocommunications Conference (WARC)-1992 identified 1885-2025 MHz and 2110-2200 MHz making a total of 230 MHz for International Mobile Telecommunications-2000 (IMT-2000). At the World Radiocommunications Conference (WRC)-2000, all the major existing cellular bands were also added, increasing the potential IMT-2000 spectrum availability by approximately three times. WRC-2000 identified the frequency bands i.e. 806- 960 MHz, 1710-1885 MHz and 2500-2690 MHz for IMT applications. This earmarking of frequency bands led to completion of ITU standards for the third generation of mobile radio technologies and its economically attractive commercial usages of IMT-2000 (3G) in the year 2000. Presently many of the advanced countries are focusing towards "broadband" multimedia services, in view of saturation in mobile services. These new services shall be provided through enhancements of 3G, IMT-Advanced (4G) and beyond in the future. At the WRC-2007, IMT was given the name for 3G/4G. For broadband applications because of the requirement of wider bandwidth, spectrum above 2 GHz shall be needed. The World Radio Conference-2007 identified additional spectrum bandwidths for IMT, both below 1GHz and above 2 GHz. The frequency bands 450 – 470 MHz, 790 – 960 MHz, 1710 – 2025 MHz, 2110 – 2200 MHz, 2300 – 2400 MHz, 2500 – 2690 MHz and 3400-3600 MHz are currently identified for IMT applications globally.

3.8 The National Telecom Policy (2012) of the Government of India has mandated to make available additional 300 MHz spectrum for IMT services by the year 2017 and another 200 MHz by 2020, for ensuring adequate availability of spectrum and its allocation in a transparent manner through market related processes.

3.9 The international treaty, known as the Radio Regulations, was revised and updated by the World Radiocommunication Conference 2012 (WRC-12) to achieve the global connectivity goals of the 21st century and pave the way for the future of wireless communications. WRC-12 addressed issues related to frequency allocation and frequency sharing for the efficient use of spectrum and orbital resources, thus ensuring high quality radiocommunication services for mobile broadband and satellite communications, maritime and aeronautical transport as well as for scientific purposes related to the environment, meteorology and climatology, disaster prediction, mitigation and relief. Through a Resolution of WRC-12, a Joint Task Group (JTG) was established for *consideration of additional spectrum allocations to the mobile service on a primary basis and identification of additional frequency bands for International Mobile Telecommunications (IMT) and related regulatory provisions, facilitating the development of terrestrial mobile broadband applications. The JTG had series of meetings during the period of 2012-2014 and has recommended a large chunk of additional spectrum for IMT applications. These recommendations shall be discussed in next World Radio Conference scheduled to be held in 2015. These identified frequency bands shall need to be thoroughly studied as in each band there are allocations of more than one different service. Country/region/local wide, the existing applications in the band and other legacy issues might have technological impacts in the introduction of IMT applications in that band.*

3.10 Looking towards the future, the development and distribution of new wireless products and services will accelerate, driven by consumer demand for ubiquitous access to communications and information. Together with an increased demand for radio spectrum, boundaries between new services will also grow increasingly blurred, departing from established industry categorizations and rigid regulatory definitions. This will inevitably make radio spectrum management more difficult and less predictable.

3.11 In the present scenario, radio spectrum from about 30 kHz to about 50 GHz is under extensive use. It is a facilitator to business, our social welfare, security and to our safety. The radio spectrum management is highly complex as to accommodate different commercial services, security and other public utility services in very limited frequency bands and at the same to draw maximum revenue from it.

3.12 There are two types of efficiency which have to take into account while considering radio spectrum management. First, technical efficiency which principally

refers to the requirement that different users and different uses of radio frequencies should not interfere with each other. It also refers to the need to tackle a host of related problems, such as the suitable frequency bands for new services, use of faulty or non-standard equipment, the unauthorised or illegal use of frequencies, spill-over signals from neighbouring administrations, the use of inappropriate levels of power, finding the optimum location for antennas, and so on. Therefore, technically, the efficient use of spectrum implies the fullest possible use of all available spectrum.

3.13 The second type of efficiency is economic efficiency. Economically, the efficient use of spectrum means the maximization of the value of outputs produced from available spectrum including the valuation of public outputs provided by the government or other public authorities. This is a much wider issue because it involves a judgement regarding the allocation of relatively scarce spectrum among alternative uses to provide different, in some cases competing, types of services. Markets will change over time, and so will the prices consumers are willing to pay for different categories of services delivered by radio, and therefore so will the value a service provider places upon the spectrum they use. If the economic value of spectrum is to be included in the allocation decision, then it follows that there should also be some mechanism to allow spectrum to be reallocated as market valuations change over time.

The spectrum is unique natural resource in that it is both non-exhaustible and non-storable. Unlike other natural resources, the spectrum will never run out, although it may become increasingly congested. Also, it cannot be accumulated for later use. These factors put a premium on a streamlined process for making spectrum available for purposes which are useful to society. In fact, because spectrum has so many uses, arbitrating among them in cases of shortage can be difficult.

3.14 Radio Spectrum cannot be restricted within geographical boundaries of a country or a region. Due to this unique property, an efficient planning and management is required not only at national level but also at regional and international levels. It is pertinent to mention that two signals cannot be transmitted on the same carrier frequency in a geographical region as both will get interference from each other. Therefore, a proper planning after considering technical and economic issues attached with radio spectrum at various levels will need to be done.

3.15 Every country has its own requirement based on their geographical boundaries, population distribution etc. which may not be necessarily same for other countries from interference resolution point of view. Hence, each country needs a separate planning and management of radio spectrum.

3.16 At present, wireless technologies have been so advanced that different radio services can work in the same frequency band, a judicious planning is required making radio regulator impartial/unbiased for any technology.

3.17 With growing demands being placed on radio spectrum both nationally and internationally together with the increasing difficulty of managing spectrum within current regulatory frameworks, it has become increasingly important for any country to engage people in research on spectrum management and harmonization to ensure that they possess the necessary facilities and expertise to efficiently and effectively manage this finite resource in the public interest.

In a nut shell, Radio spectrum is the main resource for spectrum based business and is also used for a vast range of business, cultural, social and scientific purposes. It also contributes significantly to the economy of the country. Only a small part of radio spectrum has so far been made usable and has to accommodate 41 radiocommunications services within this portion in sharing mode. More than one radiocommunication services share some radio spectrum band, which make its management more tedious. Further, a small part of this usable radio spectrum has significant economic value. Radio spectrum has now been used almost each and every sector of the society and services. Each sector has its own requirements which are different from other sector. But demands of each and every sector cannot be fulfilled being a limited natural resource. Therefore, efficient management is essentially required not only at administration level but also we need professionals for management of radio spectrum for each and every sector. An efficient radio spectrum management will improve the sector health and also enhance the revenue of the sector. Therefore, Radio spectrum management should have the core areas of research: Spectrum Engineering, Spectrum Management Policy, Interference management, Spectrum Economics, Tools for Spectrum Monitoring and Enforcement and coordination with national/international agencies on a regular basis. Radio spectrum management has now been hot subject for research globally. Most of the administrations have their own setup for policy research on radio spectrum

management and several universities have separate department for radio spectrum management. However, there are no institutes which cover all aspects of radio spectrum management at one place. Developed countries are working in this direction. However, no such steps has so far been initiated in the India.

3.18 Indian research and technology development activities need to progressively reviewed and make it more oriented towards economic benefits. It may be mentioned that countries like Korea, Israel, and Taiwan have shown successfully how research programs can be used effectively to transform the economy of a nation. It is now possible to develop a chain of activities from knowledge generation to wealth creation. In India, even though large research establishments have been established by the Government, an academic technical university is not dedicated to Radio Spectrum Management research activities. Only piece meals of work relating to Radio Spectrum are being undertaken by the existing institutes, which would not suffice to fulfill the demand of research needs to be undertaken towards radio spectrum engineering and management. Therefore, radio spectrum management along with achieving both types of efficiency are really the work of regular research for which a separate institute dedicated to radio spectrum management is essentially justified and required.

3.19 Linkages with Other Institutes/Agencies

3.19.1 The proposed institute shall have linkages with other institutes/agencies/laboratories involved in research in the areas of spectrum engineering, monitoring, not only in India but other in countries also. The institute shall work towards the efficient use of spectrum and may submit its findings to the Government as and when desired. The institute shall also do assignments for other agencies/institutes in India and abroad. The institute shall support industry, academia, government and the general public with research activities geared to develop and nurture new methods of exploring and utilizing the spectrum.

3.19.2 The institute shall also establish collaborative and exchange relationships with other Institutes and other bodies within the country and abroad which are engaged in similar or related endeavor. The purpose of these relationships is to increase the capabilities of the Institute of Excellence and to keep them up-to-date with modern technology and best practices.

3.20 Strategy

3.20.1 No alternative strategy is available to achieve the objectives. Radio Spectrum has now entered in every sphere of the society whether it is an industry or a village and become an essential tool for infrastructure development of a country. In this context, the Institute shall be centered for the creation and dissemination of knowledge in the field of Radio Spectrum and would catalyze the development of high technology tools and its use by radio regulatory agencies and industry. The institute shall focus on the creation of a pool of highly talented and creative individuals with specialized knowledge in the field of Radio Spectrum Engineering and Management. This Institute shall have National Character in terms of body of its faculty profile and also its mandate to work with national level institutions with a national mandate. This would be retained at all costs, nurtured and further strengthened.

Section 4
Structure and Working of the Society

4.1 The structure of the Society is proposed to be a two tiered one viz. Policy Level Structure and Functional Structure. Policy Level Structure shall consist of the Board of Governors (BOG) as an 'Apex Body'. BoG shall, depending on requirements for functioning of the Institute, constitute Council (s)/Committee (s). However, it may be mentioned that the existing National level Institutes have Board of Governers (BoG), Academic Council, Finance & Accounts Committee and Building & Works Committee etc. It may also be mentioned that the Centre for Development of Telematics (C-DOT) a Telecom Technology development centre of the Government of India, established in 1984 as an autonomous body has three tier policy structures in the Governing Council, Steering Committee and Project Board. Their Governing Council is chaired by the Minister-in-Charge.

The Functional Structure of the proposed Institute shall consist of five Bureaus.

4.2 Policy Level Structure:

4.2.1 Board of Governors (BOG)

4.2.1.1 At the helm of the Society will be a Board of Governors (BoG) with more than fifteen members consisting of senior functionaries of the government departments, academic institutions, eminent scientist/technologist, industrialist and Chief Secretary of the State (where Institute shall be located). Minister-in-charge, Government of India shall be the Chairman of the BoG. All the Members of the Board of Governors (including the Chairman), other than ex-officio Members, shall hold office for a term of three years. The proposed composition of the BoG is:

1.	Minister-in-Charge, Government of India.		Chairman
2.	Secretary, Department of Telecommunications (DoT).	Service	Member
3.	Secretary, Ministry of Science & Technology (or his nominee not below the rank of Additional Secretary).	Service	Member

4.	Secretary, Department of Electronics & IT (or his nominee not below the rank of Additional Secretary).	Service	Member
5.	Secretary, Department of Expenditure, Ministry of Finance (or his nominee not below the rank of Additional Secretary).	Service	Member
6.	Secretary, Department of Space (or his nominee not below the rank of Additional Secretary).	Service	Member
7.	Secretary, Ministry of Information & Broadcasting (or his nominee not below the rank of Additional Secretary).	Service	Member
8.	Member (Finance), Telecom Commission.	Service	Member
9.	Member (Technology), Telecom Commission.	Service	Member
10.	Wireless Advisor to the Government of India.	Service	Member
11.	Chief Secretary, State Government, (where the Institute shall be established).	Service	Member
12.	Director, Indian Institute of Science Bangalore and Directors, Indian Institutes of Technology, Delhi, Chennai, Bombay and Hyderabad.	Service	Member
13.	Director General, Defence Research and Development Organization (or his nominee not below the rank of Additional Secretary).	Service	Member
14.	One eminent Scientist/Technologist	Service	Members
15.	One eminent industrialist	Service	Members
16.	Director, Institute of Advanced Radio Spectrum Engineering and Management Studies (IARSEMS) Society.	Service	Ex-officio Member Secretary
17.	Administrator (Finance & Administration) of the Institute	Service	Special Invitee*

*without any right to vote

4.2.1.2 The eminent scientists/technologist and an eminent industrialist in the BoG shall be nominated by the Central Government.

4.2.1.3 Functions of the BOG:

4.2.1.3.1 BoG is the top policy making and guidelines providing body and is responsible for the general superintendence, direction and control of the affairs of the Institute and shall exercise all the powers of the Institute. Its broad primary functions shall be to:

- Set the broad policy guidelines with respect to Spectrum Engineering, Management and Policy Planning. Each member from Government Department would also get the long-term and yearly spectrum budget of his Ministry/Department assessed;

- Select and appoint the Bureau Chiefs and Administrator (Finance & Administration) of the Institute;

- Terminate the services of the Bureau Chiefs and Administrator (Finance & Administration) of the Institute;

- Take decisions on questions of policy relating to the administration and working of the Institute;

- Create posts - both academic and non-academic, to determine their numbers, qualifications and cadres with the prior approval of the Central Government and to make appointments on such posts on the basis of the recommendations of the Selection Committee (s);

- Consider and pass resolutions on the annual report, the annual accounts and the budget;

- Make estimates of the Institute for the next financial year and submit them to the Central Government together with a statement of its development plans; and

- Constitute Council(s)/Committee (s) as deemed necessary for an efficient functioning of the Institute;

4.2.1.4 The Board of Governors shall meet at least two times a year by giving Notice at least one month in advance. The Chairperson may call a special meeting of the Board at a short notice to consider issues requiring decisions urgently.

4.2.2 Working of the Society

The Society shall provide an open platform to discuss and deliberate on the issues of national importance related to Radio Spectrum Policy, Planning, Engineering and Management taking the inputs from experts in the field. Efforts would be made to tap the expertise from private, public and international arena to arrive at the optimum solution. For this, regular meetings shall take place in persons and also via audio/teleconferences. Workshops and seminars shall be organized as appropriate and sub-working groups commensurate with the Study Groups of ITU etc. and also relevant to national requirements assessed from time to time. This shall be established as required to review specific topics and report back to the main working groups. The objectives of the working are to be an agent for co-ordination, problem resolution, change etc and the deliverables will include:

- Recommendations to the Government on the issue of Spectrum Policy, Planning and Management;
- White papers on research/analysis that had been undertaken and completed;
- Research papers and reports summarizing research findings;
- Recommendations for further research. Research activities shall involve all forms of explorations and development of the spectrum, spectrum management and technology/development;
- Issue consultation papers to consolidate the views of different stakeholders and give recommendations to government and the regulatory bodies; and
- The creation of cross industry groups to encourage cooperation and information sharing.

4.2.5 Functional Structure

4.2.5.1 Functional Bureaus: It is proposed that the Institute shall have the following five functional Bureaus, which shall be responsible for all research & Developmental activities and technical matters:

i) Research & Spectrum Engineering Bureau;
ii) New Technology Bureau (Spectrum Dependent Technologies);
iii) Spectrum Management & Radio Monitoring Bureau;
iv) National and International Co-ordination Support including Manpower Development Bureau; and
v) Spectrum Economics Bureau.

The tasks of consultancies and related advisory roles should also be performed by the respective concerned Bureau.

In addition to above, there shall be one more Bureau, 'Finance & Administration', which shall be responsible for all affairs of the Institute relating to administration and finance. This Bureau shall be headed by Administrator (Finance & Administration) and supported by Deputies etc.

4.2.5.1.1 Detailed work descriptions of Each Bureau

The detailed description of responsibilities to be performed by the abovementioned five Functional Bureaus are:

4.2.5.1.1.1 Research and Spectrum Engineering Bureau

- To take up recent development of technologies for efficient management of radio spectrum.

- Keep abreast of all technological innovations in the wireless networks and services.

- To enhance analysis tools for frequency arrangement, assignment, and coordination and interference calculation.

- To analyze interference problems, establishing technical parameters, and standards for developing procedures & techniques required for interference analysis and resolution.

- To develop software engineering and technical analysis tools based on propagation models and interface with geographic information systems/Digital Terrain Map (DTM).

- To develop software and simulation tools for radio spectrum management.

- To identify the frequency band (s) for requirements of societal, safety, security and commercial applications and study/establish their electromagnetic compatibility with existing and proposed services/applications.

- To establish processes to optimize the efficient use of the radio spectrum and procedures to harmonize the operation of different services.

- To focus on future developments of various wireless technologies, its applications in the global scenario and its applicability to Indian conditions.

- To support industry, academia, government and the wireless users with research activities geared to develop and nurture new methods of exploring and utilizing the spectrum.

- To forecast/prediction of application of new technologies or spectrum demand trends, and estimate of their impact.

4.2.5.1.1.2 New Technology Bureau

- To develop methodologies and facilities for testing of all emerging wireless based technologies/services.

- To calculate link analysis and path loss, propagation, field strength contours, service area, and interference between wireless stations by using specialized

tools namely Inter-modulation Analysis, Electromagnetic Compatibility, Terrain Profile and ITU Satellite Tools.

- To have detailed studies of Ultra wide Band (UBD), RFID, low powered, indoor wireless devices, open wireless architecture (OWA) and any other future systems/technologies.

- To study in detail the future convergence of wireless technologies/standards.

- To study channel modelling for wireless access technology.

- To study in detail about the implications/impact of Soft Defined Radio (SDR), Cognitive Radio (CR) and White spaces on overall spectrum management and existing services/applications.

- To study Dynamic Spectrum Access Device (DSAD), which is capable to exploit dynamic spectrum access to transmit and receive information without causing interference to the services to which the band allocated by employing cognitive capabilities.

4.2.5.1.1.3 Spectrum Management & Radio Monitoring Bureau

- To develop and suggest modifications in the existing methodologies for spectrum management.

- To develop efficient spectrum management processes for advanced technology and techniques.

- To study and identify additional frequency bands periodically, for exempting them from licensing requirements for operation of low power devices for public use.

- To have detailed study of alternative aspects of spectrum management i.e. dynamic spectrum management (DSM).

- To evolve and recommend national spectrum management planning in relation to the issues needing resolution or systems to be implemented during short term of 3-5 years, long term of 5-10 years and strategic beyond 10 years.

- To study spectrum use issues i.e., allocation, allotment, assignment, standards etc of future wireless based services.

- To study and make recommendations on the overall spectrum management techniques, analysis methods, organization, resources, and computer implementation etc

- To identify the timely future requirements, in order to propose any necessary redistribution including redeployment of spectrum or spectrum assets.

- To help the administration to have and update/validate the inventory of spectrum users (e.g. frequency register), and also in carrying out spectrum audit.
- To determine the frequency bands in which the majority of which technologies developed for national security purposes, relief operations and safeguarding human life operates. Further, to review the occupancy in these bands and recommend re-distribution/re-location of the existing operations so as to exclusively make allocations/allotments/assignments for the usages in the event of national emergency.
- To develop plans and recommend to the administration in order to meet the RFS requirements for like sea and air navigation, Broadcasting, Space.

- To develop and recommend the frequency plan distribution, channeling plan etc at local and national level.

- To suggest specific plans concerning spectrum management for improving software models, data gathering and mathematical simulation capability, and data retrieval capabilities etc.

- To study and recommend the spectrum planning policies, regulations and programs for the use of RFS above 40 GHz, for any wireless based technologies.

- To study all aspects of RFS beyond 100 GHz and Wireless Infrared Communications.

- To study and evolve detailed spectrum management plans for indoor mobile communications to be operated in the frequency bands from centimetric to millimetric waves.

- To study and recommend various techniques/simulation tools to be used for performing frequency channel occupancy and frequency band occupancy measurements, including processing and presentation methods.

- To recommend procedures for providing of information relating to valuable radio monitoring & measurements data to the spectrum management authority required for actual use of frequency and bands.

- To assist Administration in providing valuable monitoring information for programmes organized by the ITU-R Bureau in preparing reports to Radiocommunication Conferences etc including those administrations seeking assistance for eliminating harmful interference.

- To study and recommend how to cover entire country through manned and un-manned radio monitoring capabilities and also methodology for monitoring during major events/emergency/disaster situations.

- To study and propose methodologies for wireless sensing.

- To develop simulation models for monitoring of spacecraft emissions, broadcasting monitoring, monitoring of cellular systems, monitoring of all wireless based systems/applications and also for reception of very weak signals from space.

- To make contributions in earth exploration and space research.

4.2.5.1.1.4 National and International Co-ordination Support and Manpower Development Bureau

- Study the potential global innovations and market growth which would arise following spectrum de-regulation; and put forward policy proposals in the area of international coordination and harmonization of spectrum uses, etc.

- Participate and represent in National preparations and follow up actions for major conferences like ITU Plenipotentiary Conference (PP), ITU Council,

World Radio-communication Conferences (WRCs), Radio-communication Assembly (RA), Conference Preparatory Meetings (CPM), Regional preparatory activities of Asia Pacific Telecommunity (APT) related to radio conferences, etc.

- Participate and contribute in the meetings of ITU (T) and ITU (D) relevant to the areas of radio frequency spectrum.
- Interact with and participate in National Working Groups (NWGs) corresponding to Study Groups of Radio-communication Sector of ITU (ITU-R) including ITU-T & ITU-D Sectors related to the aspects of radio frequency spectrum (RFS), examination of the documents of ITU-R Study Groups, associated Working Parties/Task Groups, etc, documents and examination. Carrying out studies for adopting theses documents/studies in the Indian scenario.

- Form strategic alliances with government, industry, and academia for the purpose of advocating, influencing, and promoting emerging technology and associated policies concerning efficient and economical use of RFS.

- Develop strategies, regarding spectrum management for presentation to spectrum bodies within international organizations (e.g., The International Telecommunication Union, regional bodies etc.)

- Establish collaborative and exchange relationships with other Institutes and other bodies, within the country and abroad, which are engaged in similar or related endeavor.

    - The purpose of these relationships is to increase the capabilities of the Institute of Excellence and to keep them up-to-date with modern technology and best practices.

    - Identification of the programs to be set up in a partnership mode.

    - The relationship with Partners providing in-kind or in-cash contributions will be governed by appropriate Memoranda of Understanding (MoU) and relevant project documents.

- Association with top levels of worldwide institutes/regulatory board on Spectrum Management, Radio Spectrum Management center of the several leading Universities in India & abroad and other leading Institutes in India and abroad etc through International Partnerships, joint ventures and active collaboration.

- Be a facilitator in skill enhancement of its own personnel and the officers and managers of other organizations through training and counseling sessions.
- Be a facilitator in ensuring that officers responsible for planning the spectrum have the knowledge, skills and abilities to develop presentations and support them representing the country in international forums and conferences on telecommunications.

- Be a facilitator for high quality manpower leading to Masters, PhD and Post-Doctorate progammes in collaboration with Indian Institute of Science (IISc), Indian Institutes of Technology (IITs) & other Institutes of National Importance and also leading Universities/Institutes abroad.

- To hold national and international conferences and seminars to share the experiences and for cross breeding of ideas.

- Serve as a focal point for training, professional development, research and information on matters related to Spectrum management issues.

- Serve as an epic-Institute for regional and global information Society initiatives on Spectrum Management.

- Develop latest training modules for imparting trainings in the fields of 'Spectrum engineering, management, policies, spectrum economics, legal aspects of spectrum management and spectrum measurements & monitoring to under developed and developing countries.

- Develop and maintain resource databases to support the selected programs. Resource elements would include regional experts, international experts, reference literature, regional activity and case studies to illustrate best practice.

- Develop integrated programs combining various pedagogical methods. State of the art technology and e-learning systems should also be introduced to increase the effectiveness of the transfer of knowledge process and sustainability of the learning.

- Improve awareness on recent international developments through publications, handbooks, etc.

- Modular training programs providing substantial knowledge transfer for short terms made available over the Internet and on CD.

The following Advisory and Consultancy Functions shall be performed by the concerned Bureaus mentioned in the foregoing Para.

- To determine existing and future national spectrum requirements and develop long and short term spectrum management strategies considering all types of wireless applications, technical aspects and equipment limitations. This function will also include the organization and structuring of specific systems and services etc. in the development of spectrum policy.

- Identify/suggest measures for resolving gaps and overlaps in the current spectrum uses, markets and technologies – highlighting where the removal of the barriers to entry for new technology and approaches could be achieved and explore for future potential.

- Propose methods of transition from historic spectrum constrain to future use and ensuring inter-operability of wireless equipment and services, as well as safe guarding existing uses during the transitional period.

- Explore and test practical solutions to facilitate the transition to the spectrum sharing regime in the future and formulate appropriate sharing criterion between different wireless services as well as technologies for their applications in India.

- Development of new technology of national radio communications and the preparation of long term strategies in consultation with the radio industry, user group, Government organization etc. Analyze requirements for proposed

frequencies in accordance with national plans for allocation of frequencies etc.

4.2.5.1.1.5 Spectrum Economics Bureau

- Study the economic aspects of spectrum utilization including spectrum pricing to promote the secular growth of Telecommunication throughout the country with emphasis on rural and inaccessible remote areas keeping in view the affordability of telecom services to a common man as envisaged in National Policies.

- To analyze charges arises due to spectrum re-farming/re-planning to make the way for more efficient wireless technologies.

- Study the economic approaches that have been/proposed for promoting efficient radio frequency spectrum in different frequency band.

- Study the advantages and disadvantages of various economic approaches the spectrum management and recommend the best approach

- Study the factors e.g. geographical, topographical, infrastructural, social, legal etc affecting the economic approaches.

- Study the benefits and costs of RFS management options in relation to employment and/or GDP.

- Study and recommend best suitable models for allocation of RFS for commercial and other applications.

- To study the relationship between spectrum redeployment to accommodate various future wireless services/technologies and spectrum pricing.

- Study and recommend levying of spectrum charges for different frequency bands e.g UHF, SHF and EHF and also for different terrain areas of the country.

- Study and recommend the levying of spectrum fee for the non-profit making government sector organizations and also the public/private sector organizations.

- Study and recommend various modern methods for levying annual spectrum usage including license and its renewal fees for all categories of wireless applications.

- Study and recommend cost to be charged for resolving interference issues, carrying out radio noise survey and other related analysis through radio monitoring services for various profit and non-profit organizations.

- Study and recommend cost to be charged for regional and international coordination resolution of interferences of terrestrial and satellite networks.

- To study economic ideas and how they apply to spectrum management and contribution of the radio spectrum to economic growth.

- To study impact of spectrum policy on competition in communications markets.

Section 5
Requirements of Faculty and Staff

5.1 The Institute shall have a sanctioned strength of the order of 125 Faculty members including Research Scientists/Research Associates/Research Fellows. To begin with, in the first year of its inception, the Institute will start with a compact group of 50 Faculty including researchers and phase by phase build up the full strength over a period of five years.

5.2 The Society is proposed to be an Institute for Advanced Studies & research in the field of Radio Spectrum Engineering and Management. The selection for the recruitment for various positions in the Institute shall be on a highly critical, rigorous and competitive basis. The support officers & staff for Administration/Finance & Accounts Division shall be sourced from public, private or international market. The manpower structure shall be flexible which can accommodate right professionals from various sectors of Government, PSUs, academia and industry. The faculty and Research Scientists/ Research Associates/Research Fellows positions shall be filled by highly qualified professionals from Institutes of national importance (IITs, IISc, IIMs, National Laboratories and other Institutes of National importance etc) and other user Department amongst Ministry of Defence including DRDO, Department of Space, and Ministry of Information & Broadcasting (MIB) etc. The Research Scientists/ Research Associates/Research Fellows shall be provided incentives in the form of initiation grants, travel subsidies, joint appointments etc. The Institute shall strive to build excellence and the cornerstone of this quality will be based on the quality of Faculty, Research Scientists/ Research Associates/Research Fellows. The Human Resource Policy of the Institute shall be decided by the BoG, as per the needs and the requirements evolving from time to time.

5.3 The support staff is a crucial element of Institute manpower. Indian institutions in general suffer from an overburdened strength of this category of manpower. It is strongly suggested that the institute will keep the support staff strength to a minimum. The support staff strength at present is recommended to be 75. The Institute should outsource many services and avoid employing staff on a permanent basis for all functions. To begin with the strength of the order 15-20 would suffice. The full sanctioned strength will reach in a period of three to five years after having a thorough review and with approval of BoG.

5.4 The Finance & Administration Bureau shall be responsible for all finance and administrative matters of the Institute. The institute shall be headed by Director and shall be responsible for overall technical, financial and administrative affairs of the Institute. It is proposed that day to day functions of five functional Bureaus shall be discharged by Bureau Chiefs with support of highly qualified and talented teams consisting of Research Scientist, Research Associates and Research Fellows, who shall be important pillars of the Institute for supporting the management in all the issues of Research & Developmental/consultancy/training activities.

5.5 Senior Functionaries Managing the Institute

The Director, Bureau Chiefs and Administrator (Finance & Administration) are the senior functionaries responsible for overall control and management of the Institute and are answerable to BoG.

It may be noted that the total emoluments/perks & facilities and terms of appointment for the various positions of the Institute shall be based and revised from time to time on the recommendations of Pay Commissions of the Central Government and also acceptance/decisions of BoG. BoG, if, necessary can consider adopting pay scales and facilities of other similarly placed centrally funded Institutions of National Importance.

5.5.1 Director

Appointment of the Director

(i) The Director, being the academic as well as administrative head, is expected to have proven administrative and technical background (including significant experience in Radio Spectrum Management) with leadership qualities. He/she should have strong Academic background with Bachelor/Masters in Engineering/Technology or Post graduate in Electronic/Telecommunications. He/she should be an eminent and highly acclaimed personality with more than 25 years experience as an Administrator in Spectrum Management & Planning and radio frequency monitoring. He/she should have represented and made contributions at several ITU-Radio Sector/APT meetings. Ph.D. in relevant field may be desirable.

(ii) The Director appointed by the Central Government shall be a whole time salaried officer of the Institute. He/she shall be the principal academic and

executive officer of the Institute and shall be responsible for the proper administration of the Institute and for imparting of instruction and maintenance of discipline therein.

(iii) The Director shall be appointed for tenure of five years, subject to his not exceeding the age of sixty-five years (which may be revised as per the recommendations of the Central Government from time to time). A person so appointed shall be eligible for re-appointment for not more than another term.

Powers & Functions of the Director: -

(i) The Director being the principal executive officer shall exercise general supervision and control over the affairs of the Institute and implement the decisions of all the authorities of the Institute;

(ii) The Director, unless otherwise provided, shall be the ex-officio Member-Secretary of BoG;

(iii) The Director shall have the discretion to invite eminent scientists/technologists/professionals to serve as faculty/researcher at the Institute.

(iv) The Director shall have the powers to employ technical staff including research scientists; research associates/research fellows on contract basis within the overall budgetary allocation of the Institute with the approval of the BoG;

(v) The Director shall have the powers to send Members of the staff for training or to attend a conference or for a course of instruction within India and abroad subject to such terms and conditions as the BoG may lay down from time to time;

(vi) The Director shall have the powers of a Head of Department for purposes of Regulations in the Account Code, the Fundamental and Supplementary Regulations and other Regulations of the Government in so far as they are applicable or may be made applicable to the conduct of the business of the Institute;

(vii) The Director shall exercise general control over the affairs of the Institute and shall be mainly responsible for implementation of the decisions of the various authorities of the Institute;

(viii) Subject to the budget provisions made for the specific purpose, the Director shall have the powers to incur expenditure in accordance with the procedure as may be laid down by the BoG from time to time;

5.5.2 Bureau Chief

Appointment of the Bureau Chief

- He/she should have strong academic background in Engineering/Technology with Bachelor degree in Engineering/Technology in relevant stream or its equivalent. Masters/Ph.D. in Engineering/Technology or its equivalent in relevant field is desirable. He/she should have more than 15 years experience as an Administrator in Spectrum Management & Planning and radio frequency monitoring, should have represented and made contributions at several ITU/APT study groups meetings. He/she should have served for more than 3 years in the capacity equivalent to Joint Secretary.

- The Bureau Chief appointed by BoG shall be a whole time salaried officer of the Institute. He/she shall be appointed for tenure of five years, subject to his/her not exceeding the age of sixty-five years (which may be revised as per the recommendations of the Central Government from time to time). A person so appointed shall be eligible for re-appointment for not more than another term.

5.5.3 Administrator (Finance & Administration)

Appointment of Administrator (Finance & Administration)

(i) He/she should have strong Academic background having Bachelor Degree in any stream and served at least 20 years in the ICT Sector, out of which minimum 10 years in field of Finance/Administration. Master degree and experience in dealing with Radio Spectrum related issues are desirable.

(ii) Administrator (Finance & Administration) appointed by BoG, shall be a whole time salaried officer of the Institute.

(iii) The Administrator shall be appointed for tenure of five years, subject to his/her not exceeding the age of sixty-five years (which may be revised as per the recommendations of the Central Government from time to time). A person so appointed shall be eligible for re-appointment for not more than another term.

5.5.4 Research Scientist, Research Associates/Research Fellows

The research scientists, research associate/research fellow of the Institute are important and essential functionaries. Their requirements for working on various projects of the Institute shall be deliberated and recommended by BoG. They shall be the backbone of all the research & developmental activities particularly in development of software/simulation tools, performing project activities, development of IPRs, undertaking consultancy works and developing new projects in emerging areas of ICT. They shall contribute significantly in designing training capsules, organizing seminars, workshops, conferences of national & international excellence. They shall guide Masters and PhD scholars. Highly talented, capable and strong aptitude in research activities shall be selected through rigorous screening mechanisms. PhDs in the fields of ICT from reputed universities in India and abroad shall be preferred. Their total emoluments/perks/facilities etc shall be determined based on their competence, qualifications and experience etc and in order to attract & retain, the emoluments shall be much more than (more than 1.5 times) their counterparts receiving in any other Institutes of national importance/national laboratories etc. The Institute shall employ them on contract basis from 3 to 5 years, which shall be renewed after assessing their performance and the requirement of the Institute. These terms and conditions shall be decided by BoG.

Section 6
Research Areas and Laboratory

6.1 The institute shall undertake research & developmental activities on its own and also entrusted by other government departments/institutes/industries/other agencies within India and abroad. The Institute shall also take up consultancy projects/works. These activities shall be performed by the faculty members with the support from research scientist/research associate/research fellow. Research scientist/research associate/research fellow shall be appointed on contract basis as per requirement of the project to be undertaken.

6.2 The major thrust will be given to efficient utilization of spectrum in technical and economic terms. Major research areas, which the Institute shall undertake and objectives of the Institute are enumerated in detail in Section 2 of the Report. However, the research activities of the institute would not be limited/confined to those issues only. It would be further extended and considered as per needs/demands of the industry, Government regulating agencies, international bodies namely ITU/APT and including from those partners with whom the Institute has signed MoUs.

The Institute shall provide excellent research environment, collaborative working environment to create and apply knowledge and internationally and nationally recognized areas of research strength.

6.3 In order to accomplish the detailed research & developmental including consultancy works, the Institute shall establish several well developed and modern laboratories equipped with latest state of art for the implementation of the objectives mentioned in Sections 2 and 4.

6.3.1 Spectrum Engineering Laboratory

This Laboratory shall be devoted to investigate the spectrum engineering practices and analysis tools of spectrum management. The technical parameters include equipment specifications, certification, and definitions, while the engineering analysis tools include frequency assignment techniques, frequency arrangement, assignment, and coordination etc. and also theoretical models of radio wave propagation. Studies shall address protection ratios, noise, radiation limits and site selection from engineering point of view. The specifications of equipments provide

that what should be the minimum acceptable technical characteristics of an equipment, to be deployed by many users by the same radio service. The specifications shall be different for licensed and de-licensed (generally low powered devices) frequency bands. The equipment parameters are extremely important as if not adhered might lead to severe interference issues. The equipment parameters can be classified as (i) carrier frequencies, (ii) transmitter power, (iii) frequency tolerance, (iv) bandwidth, (v) unwanted emissions, (vi) inter-modulation products (IMPs), and (vii) sensitivity of radio receivers etc.

This laboratory shall also study the radio-wave propagation losses upto frequency range of 300 GHz, which are the key factors in the determination of coverage zone of a radio system as well as extent of unwanted interference. The ITU-R Recommendations in this regard and different models shall be thoroughly studied and modified to the Indian environmental conditions. The different types of terrain, which need to be studied, are sea/river/lake, desert, dense forest, forest, rural, suburban and urban areas.

6.3.2 New technology Laboratory

Technology is an ever-happening field. New developments and products emerge on a continual basis. Keeping this view, different test-beds to analyze emerging wireless technologies, its applications in the global scenario and its applicability to Indian conditions is proposed to setup in the institute. A large number of wireless based technologies are emerging in all services, may be FIXED, MOBILE, BROADCASTING, SATELLITE including those for safety and security purposes. Many new short-range personal communication systems, future IMT systems are being developed which shall operate indoors as well as outdoors. There is a high demand for wireless local area networks (WLANs), UWB and wireless private business exchanges (WPBXs) etc may have impact on radio services. The knowledge of the propagation characteristics within buildings and the interference arising from multiple users in the same area is critical to the efficient design of systems. Due to frequency congestion below 3 GHz, these technologies will operate in mm frequency bands. For the short range systems operating in mm band there are only limited propagation measurements/information available. This laboratory will carry out detailed study about propagation models that shall be used for the design of short-range systems operating indoors, outdoors, and indoor-to-outdoors (operating range less than 1 km) including wireless communication and access systems and WLANs.

Similarly this Laboratory shall also carry out detailed studies on the new developments in any of the technologies of radio services.

The increasing huge number of accumulation of mobile traffic, particularly in highly dense areas such as central market areas, pose challenges for sustaining the good QoS and also meeting the requirements of high data rates within the limited availability of radio spectrum. These limitations and with a view to provide a significant network performance, heterogeneous networks (HetNets) are nowadays being considered. The HetNets are composed of macro, micro and pico cells. There are several challenges that HetNets need to address. The HetNets concepts can be extended to any type of services requiring a multi-layered structure. This may quite useful even for well secured networks. This laboratory shall address the challenges and propose solutions.

6.3.3 Simulation/Software Engineering Laboratory

The proposed setup shall be for development of software engineering and technical analysis tools based on propagation models and interface with geographic information systems and radio spectrum management tools for management of radio spectrum. Simulation tools need to be developed for use in macro, mini, micro and picocell network planning. Further, for predictions for urban cells, indoor receivers in mobile communication networks (penetration of buildings), indoor wireless networks, and planning of wireless LAN's (WLAN). Features include prediction of field strength/received power, prediction of delay spread, and prediction of fast fading. This would lead for making analysis maps. The propagation model shall need detailed knowledge of engineering analysis and system design. The highly accurate RF propagation reports relating to digital terrain map, traffic analysis, handover analysis, automatic frequency planning, will be made with the help of software prediction tools, databases including demographics etc.

6.3.4 Cognitive Radio Laboratory

The world is moving towards a fundamentally new era where mutually-conscious intelligent devices need to be aware of environmental circumstances and the user needs to determine how to communicate via use of spectrum dynamically. Cognitive radio is an emerging technology for enhancing the spectrum use. Presently, worldwide almost all reputed institutes are working at different applications/modules of cognitive radio. Cognitive radios are aware of their

surroundings and are able to dynamically tune the spectrum usage based on location, nearby radios, time of day, etc. This provides for a more efficient use of the spectrum as well as reducing power consumption. ITU has also given emphasis on cognitive radio and the same is being under extensive studies by different study groups of the ITU- Radiocommunications Sector.

In view of the importance of cognitive radio technology and its applications for efficient uses of spectrum, a laboratory dedicated to CR technology has been proposed to be setup in the institute. The Cognitive Radio Laboratory may have Cognitive Radio Test beds for TV White Spaces and White Spaces for other frequency bands. The studies would focus on (i) identifying the closely related radio technologies (e.g. smart radio, reconfigurable radio, policy-defined adaptive radio and their associated control mechanisms) and their functionalities that may be a part of cognitive radio systems, (ii) the key technical characteristics, requirements, performance improvements and/or other benefits are associated with the implementation of cognitive radio systems, (iii) the potential applications of cognitive radio systems and their impact on spectrum management, and (iv) cognitive radio systems promoting the efficient use of radio resources. Different techniques of spectrum sensing shall also be developed.

6.3.5 Electromagnetic Interference (EMI)/Electromagnetic (EMC) Laboratory

Electromagnetic compatibility (EMC) is consensus solution for efficient and economical utilization of radio frequency spectrum. Society's increasing use of radio-based technologies for various telecommunication applications, and the tremendous opportunities provided by these technologies for socio-economic development, highlight the importance of EMC among various radio systems. With a view considering that electromagnetic emissions occur from a wide variety of man-made sources, such as ignition systems in internal combustion engines, electrical machinery, electronic equipment and apparatus, information technology and telecommunications equipment, etc. and reception these emissions degrade the performance of radio systems and networks, this EMI/EMC Laboratory shall study the effect of electromagnetic emissions from man-made sources on the performance of radio systems and networks, and also quantification of these emissions.

The Laboratory shall undertake interference analysis and mitigation studies to provide data for continuously improving the technologies allowing users to share the same radio frequency band or operate in adjacent bands. The Electromagnetic

compatibility (EMC) studies shall be directed towards developing algorithms so that the equipments of a particular technology in shared bands is programmed for limiting interference by sensing the emissions of other devices of the same or different technologies. The Laboratory shall proactively carry out studies even when new devices or new technologies are in developmental stage.

It is also fact that the modern RF electrical/electronic equipments & instrumentation make use of ever increasing sophisticated electronics, making them prone to malfunctioning/mis-operation due to issues related to electromagnetic interference (EMI)/electromagnetic compatibility (EMC) which can either permanently damage the equipment or can even cause damage to the larger system in which the equipment may be embedded/networked. The emission requirement for Industrial, Scientific & medical radio frequency Equipments and also for Information Technology Equipments also need to be tested and ensured. To ensure that such failures do not occur, stringent EMI/EMC compatibility test codes & procedures need to be developed in accordance with the relevant National/ International standards. According to these standards these electrical/electronic products must be evaluated to meet the required minimal specified level of EMI/EMC compliance. To enable to perform the tests there would be to set up sophisticated state-of-the-art semi T anechoic/anechoic chambers. This laboratory shall develop full-featured RF modeling capabilities and terrain-based propagation model analyses for all major wireless technologies for the radio links operating in the frequency range from UHF to 100 GHz.

This laboratory shall too conduct compatibility studies related to (i) TETRA and GSM 900, (ii) between land mobile and broadcasting; (iii) between terrestrial and satellite services; (iv) between short range devices (Bluetooth) and RLANs in the ISM bands at 2.4 GHz and 5.8 GHz; (v) between IMT-2000 and PCS1900; (vi) between ultra wideband systems and other radio systems operating in several frequency bands; and (vii) many more evolved need based from time to time.

The EMI/EMC laboratory shall also be dedicated and authorized by the Government for:

- Type approval of radio equipment;
- Maintenance and calibration of test equipment;
- Acceptance testing and evaluation of equipment purchased for inspection and monitoring;
- Equipping special purpose monitoring and calibration of its equipment.

6.3.6 Radio wave Propagation and Spectrum Measurements Laboratory

6.3.6.1 Radio Wave Propagation- This laboratory shall study and develop prediction models/algorithms for radio wave propagation in a non-ionized media. These studies shall be useful for terrestrial and space communications. A need has been strongly felt and recognized for improving and developing field strength prediction techniques for the planning or establishing of terrestrial broadcasting, fixed (broadband access) and mobile services in frequency bands UHF and above in a point-to-point and multi-to-multi-point modes. For developing accurate prediction techniques, there is need for continuous measurements in the frequency bands of interest with particular attention in the band beyond 10 GHz and for all terrains. This laboratory shall study in detail, about which prediction methods can be used for terrestrial broadcasting, fixed (broadband access), mobile services and other radio services. Further, how the predicted field strengths are broadly influenced by (i) frequency, bandwidth and polarization; (ii) length and properties of the propagation path; (iii) terrain features; (iv) natural structures like hills, buildings and other man-made structures; (v) height and surrounding environment of the other antennas; and (vi) propagation path, e.g., paths over deserts, seas, coastal areas or mountains etc.

6.3.6.2 Spectrum Measurements- Spectrum monitoring is the eyes and ears of the spectrum management process. It is generally found that the assigned spectrum for use of majority of time (could be 24 hours), any climatic condition and location basis is not being used as per adhered parameters. This problem is more severe due to tremendous increase of terrestrial and satellite wireless systems. Hence, the spectrum monitoring should also need to be on a round the clock basis. Broadly the objectives of spectrum monitoring are:

- To resolve interference, so that radio services and stations can co-exist;
- To ensure good quality of radio and TV reception in public interest at large; and
- To provide valuable monitoring data to the Spectrum Manager in terms of vacancy & occupancy of the band(s) in use and also information about assigned technical and operational characteristics. This will help in generation, verification and updation of frequency records etc.

The EMI/EMC studies characterize the emissions of from different devices, whereas measurements of the radio signals provide information of the frequency band, in which the devices operate. Through the measurements, during a specified period at a given location, the amount and nature of the radio signals in that radio spectrum is known. For the best and optimum planning & management of spectrum, the radio measurements are essentially required. While carrying out the measurements, not only the known signals are detected but also the un-known ones along with any background man-made radio noise. For extracting more and more information in a frequency band, it is needed to continuously be aware of the behaviour of radio waves and the radio environment. The spectrum measurements also describe of the current vacancy and occupancy in the frequency band of interest. These data help the spectrum managers to plan realistic strategies for increasing utilization, sharing and vacation of spectrum in providing space for new technologies and services to operate.

This laboratory shall too develop simulation models, algorithms and provide necessary input based on detailed studies to the Wireless Monitoring Organization of the Government in their implementation of schedules of regular monitoring activities. This Laboratory also shall develop specifications for modernizing and automating spectrum monitoring capabilities upto the frequency band of 100 GHz.

6.3.7 **Standards Development Laboratory**

The systematic processes and procedures involved in evolution of any wireless based technologies/systems before commercialization takes place, are (i) allocation of a radio service, in a frequency band(s), in which a technology/system is proposed to be developed, (ii) analyze whether it is a new one or updating of existing ones, (iii) carrying out detailed study about in-band and out-band radio emissions for co-existence of different services/systems, and then perhaps finally (iv) development of standards. The development of standards is one of the key element and complex task. Suppose once an international standard is evolved, by and large most of the countries adopt those standards with a view to keep economy of scale and other technical factors. The glaring example is that ITU through World radio Conferences held from time to time allocated several frequency bands for Mobile (MO) services, thereafter for IMT applications. 2G, 3G, and 4G (LTE and LTE-Advanced) are the standards. However, this may not always be true keeping in view of the national requirements and legacy issues. Hence, an Administration shall consider developing its own strong and un-biased standards related to radio services. The standards take

care of several parameters for permissible emissions from different transmitters so that the probability of un-desirable radiations interfering is minimized. This laboratory shall discuss all relevant issues in detail, contribute and participate in the concerned meetings at the national, regional and international levels in evolving policies supporting the Indian Industries. In this context it may be mentioned that the New Telecom Policy-2012 "provides a roadmap for India to become a leader in cutting edge, state of the art technologies through R&D and creation and incorporation of Indian IPRs in global standards". This Institute in cooperation with the Government agencies, industries shall participate in national and international telecommunication standards development. The Institute shall also provide support to agencies with the development of specifications, standards, proof of concept and demonstration measurements, technical and economic impact assessments, and prototype development.

6.3.8 **Innovative Antenna Laboratory**

The rapid development of wireless based technologies especially for low powered operating in higher frequency bands poses a challenge for development of suitable efficient antenna capable of receiving and transmitting low level signals. Days are gone in use of single and simple antenna structure. The cost effective multiple antennas enhance the performance of wireless networks. Wireless sensors, energy efficient sensing systems for cognitive radios are other areas of concern. This laboratory shall develop necessary protocols exploiting the multiple antennas in innovative ways in ascertaining a long lasting, almost maintenance-free for sensor networks. The Institute shall carry out theoretical and experimental research; provide its practical solutions in real environments, and also build/test prototypes. The Institute shall pay special attention towards development of low cost antenna operating in the frequency range from 60 to 100 GHz.

Another issue for research in this area is on Distributed Antenna System (DAS). With growing penetration of telecommunication industry in modern life style and increasing dependency on the same in socio-economic aspects, lot of innovativeness has been poured in field of telecom to make it generic and approachable resource to every single individual. With wireless communication, the need of investment on medium for message transport has also ceased to exist thereby becoming prime focus today. The concept of DAS network is also a big stride in the area of communication. In very short time DAS has gained lot of focus from entire wireless sector. Deployment of DAS may lead to effective and efficient

management of radio resources. In brief, the very concept is of splitting the Base Station from its antenna system and putting it at one location and then put distributing antenna as several nodes in the network. It is a matter of research and study that DAS network may likely to face challenges under dynamic network environment. The Institute shall carry out detailed studies all the aspects of implementation of DAS in a wireless network and also shall develop prototypes.

6.3.9 Workshop

The primary objective of this Workshop is to initiate the practical aspects of electronics and mechanical used in communications system. This lab shall facilitate to create interacting environment for hand on learning of engineering and technical analysis of studies and consultancy works to be undertaken in the institute. This Workshop shall comprise of the latest/modern computer controlled and aided tools; shall undertake all fabrication works related to all the laboratories proposed to be set up by the Institute.

Section 7
Institute's Infrastructure

7.1 The Institute shall be located on a 20-25 acres piece of land. It is proposed that Institute be located at a place where large number research establishments, academic Institutions of excellence, scientific laboratories, availability of research scholars etc do exist. There shall be zoning of land for academic and research activities such as lecture room complex, laboratory buildings for teaching and research work and residential facilities like- faculty housing, guest-house, hostels etc. There shall be a separate Administrative Complex housing offices of the Chairman (BoG), the Director, the senior most Bureau Chief and the Administrator. The Site development will involve landscaping, plantation, lawns and gardens, boundary wall, road lightings, optical fiber network for communication, water supply, sewage disposal, etc.

7.2 It is tentatively proposed to construct two floored building (GF & FF). The total plinth area (Floor Area) as per the present estimation shall be of the order of around 55,000-60,000 square meters. Civil construction and infrastructure development will be carried out over a period of three to five years. The requirements for various categories of infrastructure are as follows (it may be noted that these Plinth area description is indicative).

Sl. No.	Item	Plinth Area (in sq. m.)
1	**Academic Complex**	
1.1	Academic-cum-Administrative Building	8,000
1.2	Lecture Hall/Seminar Complex	6,000
1.3	Research Laboratory	5,000
1.4	Research Area	5,000
1.5	Anechoic Chamber	1,000
1.5	Modern Workshop	5,000
1.6	Conference Complex/Auditorium	4,000
1.7	Library	2,000
1.8	Cafeteria/Canteen	500
	Sub-total(1)	**36,500**

2	**Residential Complex**	
2.1	Visitor's Guest Houses and Hostels with common facilities	6,000
2.2	Faculty Housing	10,000
2.3	VIP Guest House	2,500
	Sub-total(2)	**18,500**
	Grand Total (1+2)	**55,000**

7.3 The academic area of the Institute shall consist of lecture and tutorial halls, faculty offices, research area, laboratory spaces, meeting rooms, spaces for administrative support services, library, laboratory, offices for the Director and other officials, senate hall and auditorium. The residential area of the Institute will consist of hostels, residence for faculty and guest house. The Institute will provide expansion in both vertical and horizontal directions. The campus will be provided sufficient green cover. The campus will be developed taking into account the measures of energy conservation, rainwater harvesting, waste water treatments etc.

7.4 The institute shall need office equipment, logistics and supporting infrastructure. The test lab equipment will be based on the research Program to be developed by the faculty of the Institute. It is expected that the inventory of such equipment will grow as the Institute grows in terms of number of faculty and the Programs and will also be augmented through sponsored projects. It is expected that all laboratories and buildings will be fully developed over a period of three to five years.

Section 8
Closure Observations and Salient Recommendations

8.1 The proposal to set up Research Institute on Radio Spectrum Management is a response to an in depth analysis of the present state of the wireless technology world. The wireless world expands manifolds in last two decades. Radio spectrum is essential raw material for wireless based services. The emerging scenario of globalization demands new strategies to be adapted for management of radio spectrum and it's engineering. Even though India has large number of research institutes, but it is difficult to make any claim of research in Radio Spectrum Engineering & Management in such existing Institutions/laboratories. It is, therefore, necessary to establish research institute which shall give emphasis on Radio Spectrum Engineering & Management exclusively.

8.2 The establishment of the Research Institute on Radio Spectrum Management is a strategic decision for emerging global competition and would be landmark in the research field in the country. Adaptive management structure provides the Institute the ability to respond to the challenges of the future R & D in Radio Spectrum Management sector. This would provide sustainable competitive advantage to Indian R & D system in the increasingly globalized techno-economic environment. The Institute would not only help the Country to meet the requirement of high quality manpower in managing radio spectrum but to move up the value chain in global R & D arena, where India shall be positioned at the top level.

8.3 Salient Recommendations

It is recommended that a Core Team (CT) be set up in the Government, which shall be responsible for take on further activities regarding establishment of the 'Institute of Advanced Radio Spectrum Engineering and Management Studies (IARSEMS)' after submission of the Report. Broadly, the responsibility of this concerned/authorized 'CT' shall be:

- To study the Report and open for discussions among different stake holders from Government, Industry Associations etc. for inviting comments/observations;

- To revise the Report if, necessary, based on the comments from the stake holders;

- To prepare document relating to Memorandum of Association (MoA);
- To prepare and finalize Laws and Bye-Laws of the Society;
- To register a Government Society at a place, where the Institute is to be set up;
- To prepare and finalize, Cabinet Note for establishing Institute;
- To prepare and finalize, Note for Expenditure Finance Committee (EFC)/SFC as applicable;
- To constitute the Board of Governors (BoG);
- To appoint a Director for the Institute;
- To submit a note to Finance Division for making Budget Provisions;
- To open a project office at a location, where the Institute is proposed to be established and also allocate suitable accommodation for starting the initial functions until the Institute owns its building;
- To engage consultant (s) for preparation of layout plan of the building;
- To take clearances from other Ministries/Departments/State Government, if any, required for construction of the building;
- To finalize of Tender for award of construction works;
- To take necessary action for award of construction to the eligible/selected bidder;
- To define/identify quality check mechanisms;
- To ensure the commencement of construction work;

- To set up a strict monitoring mechanism for over viewing the construction work; and

- Any other activities evolving from time to time in the best interest of the Institute.

8.3.2 The Institute is proposed to be set up on a piece of 20-25 acres land. The Institute shall be headed by a Director and he shall function with the support of more than 125 faculty/research scientists/research associate/research fellows and other non-technical staff. The requirement of additional technical experts shall be assessed from time to time depending on latest technological developments and input from various sources. There shall be five functional bureaus in different areas of research. These functional bureaus shall have several laboratories including open test facilities for field trails and experiments. Requirement of setting up more facilities shall be periodically reviewed based on the inputs from various stake holders. The Institute shall be fully operational with its complete strength after five years. However, it is proposed that immediately after the approval of the Cabinet/competent authority to the establishment of Institute, a Director be appointed by the Central Government. Also in parallel, during the first year (may be 2015-16) of inception of the Institute, a compact team of 50 leading professionals comprising of Faculty and research scientists/research associates/research fellows with 'apex' expertise/research aptitude in the areas of 'spectrum management' shall be appointed through rigorous selection process including transfer on deputation from the government, industry, research establishments, and academic institutions etc. The Board of Governors (BoG) shall make recruitment rules and appointments from time to time through constituted 'selection committees'.

This Skelton of the faculty, research scientists etc shall establish different laboratories; carry out core research activities planned for short term planning; contribute and attend ITU-Radiocommunications (ITU-R)'s study group meetings including those of ITU (T &D) study groups relevant to radio spectrum; set up open test laboratory for EMI/EMC measurements; and set up propagation measurement laboratory.

(Dr. Ashok Chandra)
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