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PROGRESS IN TELECOMMUNICATION R & D DURING POST-WAR YEARS (1945-84) – A REVIEW

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The telecommunication services in the country started in 1853 under the Indian Telegraphs Department, but the services have now grown considerably under the P & T Department (including the Overseas Communication Services) of the Government of India. The department now provides 2.5 million telephones, through 600 exchanges and 25,000 telegraph offices in the country. Even then the telephone density is only 3 per thousand of population. Commensurate with this, the educational and research infrastructure in telecommunication has also improved considerably, and we have now IISc, IIT's, universities, CSIR, ISRO and DRDO laboratories, where some R & D activities are going on. In the pre-war period, some pioneering work in 'Microwaves and mm-waves' (J.C. Bose) and also in 'Ionosphere and Propagation' (Calcutta University) was done. Presently, some basic research in telecommunication is being done in IIT's and universities, and ISRO, DRDO and P & T laboratories are doing some work in system development. However, the R & D efforts in the areas of new information technologies, system software, digital ESS, etc. leading to ISDN are rather poor as compared to those in the world scene. This calls for a total change in our goal and approach for bringing in new technologies in the national scene.

1. INTRODUCTION

The oldest telecommunication engineering department, the Indian Telegraphs Department, started in 1853 and the officers of the department published several papers on "Earth currents, Magnetic storms, Lightning and related topics" in *Philosophical Magazine, Journal of Society of Telegraph Engineers* (London) and *Journal of IEE* (London), during 1865-91. However, the most notable work during the last decade of the 19th century was on "Microwaves and millimetric waves" by Acharyya J.C. Bose (1895-97). The telecommunication services in the country grew under the control of the Government of India and by 1945, the following departments were responsible for telecommunication and broadcasting: (a) Indian P & T Department, (b) All India Radio, (c) the Indian Radio & Cable Communication Co. (presently Overseas Communication Services), (d) Indian Army Signals, and (e) Indian Airforce (Technical Wing). At the same time, teaching and research in telecommunications were carried out at the Indian Institute of Science (IISc), Bangalore and University College of Science & Technology, Calcutta. The Radio Research Committee and associated subcommittees and panels were formed under the Board of Scientific and Industrial Research (BSIR) and many research projects were sponsored by the Committee, mainly on Radiowave propagation and Ionosphere. The physics departments of the universities at Calcutta, Allahabad, Dacca, Benaras, Delhi and the Research Department of AIR carried out research on propagation and Indian scientists were then at the forefront of ionospheric research in the world.

In the post-war and post-independence period, technical education and R & D in technological subjects received considerable patronage from the Government of India; and new institutions, e.g., IIT's, and research organisations, e.g., ISRO, DRDO and CSIR labs, were established. Telecommunication also received considerable support both in educational institutions and R & D organisations. An excellent historical perspective of telecommunication education and research till 1956 has been given by S.P. Chakravarti[1,2]. The present paper extends the review till 1984 and briefly discusses the current status of telecommunication research in India.

2. Telecommunication Services[3]

The status of telecommunication services during 1945-47 was rather poor: the country had only about 300 telephone exchanges, 82,000 telephones and 3,300 telegraph offices. The long distance network was then entirely based on open wire lines with single and 3 channel carrier systems, and the total capital assets amounted to only about Rs 30 crore. During the successive 5-year plans, however, the telecommunication services grew almost exponentially and the status in 1981 was: Total capital assets – Rs. 2000 crore (approx.), number of telephones – 2.5 million, telephone exchanges – 6000, telegraph offices – 25,000 and 150 telex exchanges with 20,000 connections (approx.). Even then, the telephone density is 3 per thousand only, a very poor performance as compared to the world standard. The technology of switching and networking also changed due to the impact of world trends. The traditional Strowger system of switching was replaced by the Crossbar system in 1965 and then the stored-programme-controlled (SPC) electronic system was introduced by early 1980's. The first 12-channel carrier system was introduced in 1951, the first carrier cable system in 1954, the 4 MHz coaxial cable system in 1958, LOS MW system in 1965, the earth station at Arvi for the Intelsat global network in 1971, the 12 MHz coaxial system in 1972, and TV transmission on MW and coaxial cable in 1975. Services based on these technologies have been introduced in different parts of the national network, e.g., in STD in 1960, Telex in 1963, Tax in 1968, Facsimile Service for newspapers in 1969 and International STD in 1976. At present, there is approximately 17,000 km of MW LOS route covering the whole country. In addition to these, the national satellite programme INSAT is providing, since 1983, the multipurpose telecommunications, e.g., telecommunication, TV and meteorological data to and from the 28 earth stations all over the country. In keeping with world trends, many new technologies, specially the digital techniques in both switching and transmission, are being introduced in the Indian telecommunication services, in the form of PCM trunks, ESS, data networks, and high capacity – 60 MHz, 10800 channel digital MW and coaxial cable systems. The investment in telecommunication has steadily grown from Rs 500 crore in the fourth 5-year plan to Rs 12,500 crore in the seventh 5-year plan.

3. Institutions and Laboratories

Along with the growth of telecommunication services, the R & D activities in many institutions and laboratories also increased during the post-war period. During

the decade 1950-60, the following institutions and laboratories were started and they had facilities for carrying out research in electronics and telecommunication:

(a) Indian Institute of Technology, Kharagpur

(b) Institute of Radio Physics & Electronics, Calcutta University

(c) CEERI, Pilani

(d) Research Department of AIR

(e) Development Section of Civil Aviation Department.

(f) Propagation groups in NPL (New Delhi) and PRL (Ahmedabad)

(g) Defence Science Organisation (presently DRDO) under the stewardship of Prof. D.S. Kothari.

Electronics and telecommunication engineering were taught at Calcutta University; IISc, Bangalore; IIT, Kharagpur; Government Engineering College, Jabalpur; MIT, Madras; and Engineering College, Poona. However, research facilities were available only at Calcutta University; IIT, Kharagpur; IISc, Bangalore; Engineering College, Jabalpur; NPL; and PRL. The physics departments of many universities continued to do research in propagation and ionospheric problems. The CSIR, through its radio research and other committees, continued to sponsor projects in universities to carry out investigations on various radio and propagation problems. The Institution of Telecommunication Engineers (presently known as IETE) was established in 1953 and became a forum for conventions, seminars and symposia in telecommunication science and practice in India.

During the period 1950-60, the research work was mainly conducted in the following areas[2]:

(a) Line communication problems at Engineering College, Jabalpur and in the P & T Department.

(b) Communication circuits and networks at Engineering College, Jabalpur.

(c) Electronic systems at Calcutta University; IIT, Kharagpur; Engineering College, Jabalpur; NPL, New Delhi.

(d) Wave propagation (including atmospherics and ionosphere) at IISc, Bangalore; Calcutta University; AIR; and Engineering College, Jabalpur.

(e) MW communication at IISc, Bangalore; Calcutta University; and Engineering College, Jabalpur.

(f) Pulse communication at IISc, Bangalore; IIT, Kharagpur.

(g) Radiation and aerials at Calcutta University and IISc, Bangalore.

(h) Aids to navigation at Civil Aviation Department.

(i) Electroacoustics at AIR.

(j) Industrial developments at NPL and P & T Department.

A perusal of the research papers published during the period reveals that telecommunication research in institutions and laboratories had taken root by 1960, but the quality and the range of research topics called for further improvement. However, some pioneering work on 'Upper Atmosphere' has been carried out at the Department of Physics and the Institute of Radio Physics & Electronics, Calcutta University, under the guidance of late Prof. S.K. Mitra. This has been widely acknowledged all over the world. The Microwaves Group at IISc, Bangalore, under the guidance of Prof. S.K. Chatterjee, also did commendable research work during the period.

Further expansion of R & D activities in telecommunication occurred during 1960-70, and many more research institutes and laboratories were established. More important ones among them are:

(a) Indian Space Research Organisation (ISRO)

(b) DRDO laboratories at Bangalore (LRDE), Hyderabad (DLRL), Cochin (NPOL) and Visakhapatnam (NSTL).

(c) IIT's at Bombay, Delhi, Madras and Kanpur.

(d) Telecommunication Research Centre (TRC) of P & T Department.

(e) R & D Cells at ITI, and BEL, Bangalore.

In 1970's, these laboratories were further consolidated and some fruitful collaboration between universities/IIT's and industry/defence organisations was started. Most important of these were the special project cells at IISc, IIT's, TIFR and Calcutta University under the sponsorship of the Ministry of Defence (ADGES & AREN Plans). These cells brought together for the first time the users, DRDO scientists and the academicians on a common platform of mutual understanding and real-life R & D activities. A general awareness regarding the scientific and technical capabilities in the country also resulted from these activities. The Department of Electronics and the Electronics Commission were born during early 1970's, as a result of the Bhabha Committee report published earlier. The Department, under the guidance of Prof. M.G.K. Menon, tried to give direction to the R & D activities in electronics and telecommunications, and also controlled production and import in these areas. The decade 1970-80 saw the activities expanding in all areas of electronics and telecommunication, but the growth was rather linear and no longer exponential, as was in 1960-70.

4. Present Status of R & D

The main agencies responsible for R & D activities in telecommunications have been listed above. The important current activities of these institutions/labs are discussed here briefly.

(a) ISRO, starting from early 1960's, developed four large centres:

(i) VSSC at Trivandrum for R & D in rocketry

(ii) ISSAC at Bangalore for the development of spacecrafts and remote sensing satellites

(iii) SHAR for rocket launching activities

(iv) SAC at Ahmedabad for the development of payloads for spacecrafts. The centre also maintains the experimental Earth Station of ISRO.

It is at SAC that most of the R & D activities in telecommunication are carried out. Scientists at SAC have been working on (i) Digital communication, (ii) MW antennas, (iii) TV equipment and software, and (iv) Test equipment. A few advanced technologies, e.g., high-power klystron amplifier, DRS at S band, low cost earth stations, modems, etc. have been developed at the centre and the know-how transferred to industries for production. The centre, in collaboration with TRC of P & T Department and IIT, Kharagpur, carried out an excellent series of experiments with the Symphonie and Apple satellites during 1977-80. This centre was also responsible for initiating and coordinating the famous SITE (Satellite Instructional Television Experiment) experiments in 1975-76.

(b) Among the DRDO laboratories, the following laboratories have on-going R & D activities in telecommunications:

(i) LRDE, Bangalore in the areas of speech processing, digital communication, electronic switching systems, radar systems,

(ii) DLRL, Hyderabad in cryptography, spread spectrum systems, MW components and systems,

(iii) NPOL, Cochin and NSTL, Visakhapatnam, in sonar signal processing.

In general, the scientists and engineers in DRDO laboratories are more concerned with development of equipment and systems in collaboration with industries, e.g., BEL and HAL. They have successfully developed many useful and strategic items for the users.

(c) Among the CSIR laboratories, CEERI, Pilani has contributed in speech processing, digital communication systems (PCM), and antennas; and developed the know-how for black and white and colour TV sets and TV test equipment. At NPL, New Delhi, considerable work has been done in propagation and upper atmosphere. The scientists also conducted a survey of atmospheric refractive index in many parts of the country, leading to a better understanding of M.W. propagation. Scientists at PRL, Ahmedabad and at AIR Research Department also contributed towards propagation studies.

(d) The P & T Department started TRC with the objective of undertaking independent design and development activities for futuristic telecommunication systems, but

unfortunately this did not materialise because of lack of cooperation between the user and the manufacturing agencies, e.g., ITI, Bangalore. However, some excellent developmental work in the area of ESS and PCM systems was done at TRC, but the timeframe was far behind that of the world development. At present, TRC is mostly concerned with specifications and testing of the telecommunication equipment for P & T Department.

(e) The two public sector industries, ITI and BEL, at Bangalore, have some R & D cells attached to them. Of these, ITI R & D cell has done excellent developmental work in the areas of MW-LOS system, PCM/ADM trunks and ESS systems. However, these activities are mostly geared to complement their production activities.

(f) Most of the above agencies are concerned with D & D rather than R & D activities, as their objectives mostly relate to the production and maintenance of telecommunication systems and services. By and large, most of the research investigations are conducted in the academic institutions, e.g., IISc, IIT's, universities and TIFR (Bombay). The main areas in which these institutions contributed to the advancement of knowledge in telecommunications are briefly as follows:

(i) IISc (Bangalore)	–	in MW communication, antennas, propagation, mm-waves, acoustics and signal processing.
(ii) IIT-B (Bombay)	–	in MW-components
(iii) IIT-D (Delhi)	–	in MW ferrites, mm-waves and sonar signal processing
(iv) IIT-K (Kanpur)	–	in MW propagation, radar problems and optimum receivers for tropolinks
(v) IIT-Kgp (Kharagpur)	–	in MW antennas, radar problems, digital communication (ADM), spread-spectrum systems and TV signal processing
(vi) TIFR	–	in electronic switching system, speech processing and systems simulation.

Many papers in the above areas have been published in national and international journals by the faculty and research staff of these institutions. In some areas, specially in digital communication, microwaves and in signal processing, the research output is of international standard, but the volume of the output has been rather small, as compared to the investments made in these institutions.

5. Information Technology

The newly developed exotic information technologies, e.g., videotex (view data and teletext), electronic mail, teleconferencing and interactive CATV, are yet to be introduced in this country. We are still dealing with the traditional media, viz., telephone, radio, and TV; and 100% access to these is yet to be achieved. However, an exciting experiment in communications, probably the largest of such experiments, was done through the SITE programme in 1975-76. In the experiment, approximately 2500 villages had access to the satellite programme through DRS receivers and instructional/ developmental programmes were relayed to them. The software part of the experiment was supposed to support various developmental activities by providing appropriate inputs of information. This information-transfer model for development support function was later partially substituted by the involvement-motivation one, in which the media are supposed to create a sense of involvement in the development process and to provide motivation. The communication experiment in Kheda district (an offshoot of SITE and conducted by SAC, Ahmedabad), was partially successful in realizing the second model of communication support for development. However, much remains to be done in this great experiment, specially to develop the right and adequate software relevant to social upliftment and economic development. Due to the availability of TV broadcast through INSAT, 70% of the population is going to have access to TV programme through 150 regional transmitters and DRS receivers. It is planned that the viewers will have access to a common national programme for 1 or 2 hours and programmes of regional/instructional interests for the rest of the viewing hours. To provide a mix of national, regional, entertaining and instructional programmes, it is indeed necessary to develop the sofware expertise to a highly sophisticated level. Otherwise, all these investments will give no return in terms of national development and integration. With more exotic information technologies, we shall have to provide more careful planning of their software.

6. The World Scene

The future of global and national telecommunication is intimately linked up with the progress of the following[4]:

(a) Development of a 'Computer on a Chip' through VLSI and VVLSI chips.

(b) Horizontal integration of smaller computers and ultimate systematization of computers.

(c) Electronic switching systems.

(d) Diversification of communication services through digital radio, TDMA-satellites, and digital fibre-optic links.

(e) End-to-end 'digital connectivity'.

(f) New information technologies, e.g., videotex, CATV, electronic mail, and teleconferencing, leading to automated (paperless) offices and wired homes.

All these will ultimately lead to fairly integrated general-purpose computer-communication networks, also known as integrated services digital networks (ISDN). To be able to bring in this digital revolution in telecommunication networks quickly, all telecommunication organisations in the world are seriously involved in the development of both software and hardware aspects of futuristic digital technologies, including information technologies.

As compared to the world scene, the R & D activities in the futuristic technologies for telecommunication are rather poor in this country. The national policy so far has been to follow the developed nations and import most of the technologies; thus one need not be concerned with the challenges of the future and the R & D activities may be on a low key. Unless the 'political will' of the nation changes, the R & D activities in telecommunications cannot improve either in quality or in quantity.

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