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OPERATION AND MAINTENANCE OF COMPLETED PROJECTS

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MODERN TELECOMMUNICATIONS ON PAKISTAN RAILWAYS.

By

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1. INTRODUCTION.

1.1 The Beginning.

The Project was envisaged in 1976 and named as the "Telecommunication and Related Signalling Project". A project cell, headed by a Project Director was set up in 1977 to execute the job. The project cell set about doing the job by preparing a PC-II, which covered the consultancy of the scheme, survey and system design.

M/s. J. N. Albertson & Associates Inc. of California, U.S.A., experts in Railway Telecom Systems, were appointed as consultants for preparation of tender specifications, telecom. system design and criteria, and the bid documents. The consultants in collaboration with railway engineers prepared the design and specifications from January 1978 to February 1979. International bids were called for the project in May 1979, and the turn-key contract was awarded in 1980 to M/s Kentron International Inc. of Texas, U.S.A. Route and site survey was carried out by M/s Kentron in 1980 which was approved by Pakistan Railways in 1981, after which the detailed engineering design was prepared and finalized.

Frequencies were got allocated for the various radio systems, from the Pakistan Wireless Board.

1.2 The Scheme.

Telecom Portion.

It was envisaged to provide a microwave radio system on the main line from Rawalpinidi to Karachi and certain branch lines, UHF radio system on all stations enroute, and VHF radio system for communication with trains & mobile crews. The above systems were to be interlinked through a multiplexing system. 17 new telephone exchanges were to be installed to provide local and trunk dialling facility to railway offices/locations through out the system covered by the communication network. Train control communications were to be enhanced, and alternative routing circuits provided for reliable control working. A no. of hot line, telex/teleprinter links and data communication channels were also to be provided.

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Signalling Portion.

To fully utilize the facilities offered by the extensive telecom network it was decided to work the existing token and tokenless block line clear instruments on UHF radio, instead of leased overhead wires, and provide axle counter automatic block signalling system instead of the existing, obsolete, Tyer's instruments on Hyderabad - Lodhran double line section.

1.3 EXECUTION OF THE PROJECT.

The estimated cost of the project was Rs. 829.519 million, which included a foreign exchange component equivalent to Rs. 455.730 million. The cost covered the expenditure on account of administration, the main turn key contract, other local and petty contracts, purchase of land, provision of infrastructural facilities, training of staff abroad, etc.

The contract signed with M/s KENTRON (Pak) Inc. in 1980, was for US $ 37.129 million (F.E.C) and Rs. 14.6 million (local currency). M/s Kentron started the installation work in January 1982 and by mid 1983 had completed the construction of buildings, erection of towers, and installation of telecom and power supply equipment at most of the stations. For testing and acceptance of the system Pakistan Railways had acquired the services of T&T department who carried out Provisional Acceptance Testing of the system on Rawalpindi - Lahore section.

In September 1983, when the work was progressing at top speed, bad luck struck. The main contractors M/s Kentron, due to their internal administrative problems abandoned the project, and their top management in Pakistan escaped from the country, due to which the implementation of the scheme suffered a severe jolt. At this stage Pakistan Railways, engineers stepped in and took control of the situation, and continued with the testing and commissioning of the system on Rawalpindi - Lahore section.

At the same time legal proceedings were initiated against the contractors and their guarantors. The bank guarantees and bonds of the firm were confiscated, and their guarantors M/s LTV Corporation USA, also paid damages worth US $ 10 million. Thus a total of about Rs. 225 million were recovered by Pakistan Railways on this account.

For the unfinished portion of the project the Railway Board decided to call fresh tenders in 1984. M/s Daewoo Corp. of South Korea, who were the lowest bidders were awarded the contract for the remaining job in February 1985. The contract was worth US $ 10.287 million (F.E.C) and Rs. 30.318 million (local currency). This expenditure as well the expenditure on the running of the telecom. Project cell, was met out of the amount recovered as damages from M/s Kentron and their guarantors.

M/s DAEWOO Corporation started work in July 1985 and completed the installation and commissioning of the whole telecom.. network by May 1988. The work on the related signalling portion is also in final stages and expected to be completed by May 1990.

2. THE SYSTEM AND THE EQUIPMENT.

Microwave and UHF line of sight radio communication systems form the mainstay of P.R's telecommunication network. All the speech, telegraphy, teleprinter, telex and data communication systems are working on these transmission media. The network can be used in future for on-line computers and management information systems.

The important data pertaining to the telecommunication system of P. Railways is given at Annexure : I.

Description of the system layout and the equipment used is given in the following paragraphs.

2.1 MICROWAVE RADIO SYSTEM.

960 channels microwave radio system in 7 GHz band (7.125 GHz to 7.425 GHz) has been installed on Karachi - Lodhran - Khanewal - Shorkot - Faisalabad Lahore - Lalamusa - Rawalpindi Sections, Wazirabad - Sangla Hill Section, Sukkur - Jacobabad - Kashmor - Rojhan - Khanpur section & spurs to Multan Cantt ; Kot Adu, and Dadu, 878C-82860 type solid state radio equipment manufactured by M/s AEL Microtel Ltd: (GTE Lenkurt) CANDA, has been used. This System has been equipped with only those MUX Channels which are required by Pakistan Railways at present. The surplus capacity is planned to be leased to other users. The system covers a distance of more than 2700 Kms. In all 44 microwave stations have been established of which 36 are drop/insert stations and 8 are through repeater stations. The P.R. microwave system is shown in Annx. II.

Self supporting as well as guyed towers were erected for this system on which the antennas and wave guides are installed. The tower heights range from 100 ft. to 464 ft., the highest tower being at Khanewal. Parabolic antennas of 4 ft., 6ft; 8 ft; 10ft. 12ft; and 15ft. diameters have been used on different links depending on the length of the hop and the terrain traversed by the microwave signal. (Average path distance per hop is 45 Kms). The antennas are covered by radomes or shrouds to protect their surfaces from climatic effects, thus maintaining its efficiency and enhancing its life. Waveguide totalling upto nearly 59,000 ft. has been installed to carry the signals to and from the antennas. These are protected by waveguide pressurization and desiccating systems.

Pakistan Railways have used hot stand by space diversity microwave system, in which two antennas are provided at each end of the hop, with duplicate on line transmitters and receivers, which choose the best signal and uses it for communication. Thus, the

effects of weather changes which causes fading, are countered to a great extent, and a reliability factor of 99.9999% has been achieved. The threshold level of the received signal is also fairly low in relation to the mean RSL and a fade margin of 40dB has been provided, as against the fade margin of 30dB used by the T&T department. This has further enhanced the reliability of the system.

A supervisory alarm and control system monitors all the microwave stations and equipment and displays alarms at the Divisional Head quarters, as well as the Railway Headquarters in Lahore. A computer analyses the fault data, and prints out the position periodically. Complete metering and alarms are provided at all microwave stations through which the equipment and system performance can be instantly gauged. An engineer's order wire is provided, on which omin-bus communication can take place between all the microwave stations, thus maintenance activities can easily be coordinated.

2.2 UHF RADIO SYSTEM.

UHF radio system in 1429 - 1530 MHz frequency band with capacity of 36 channels has been installed on all stations on Karachi, Lodhran, Khanewal, Shorkot Cantt, Faisalabad, Lahore, Lalamusa, Rawalpindi Section, Wazirabad, Sangla Hill, Khanewal, Multan Cantt, Lodhran, Sukkur, Jacobabad, Kotri, Dadu, Habibkot, and Jacobabad, Kashmor, Kot Adu, Sher Shah Section. These system are used for block working, direct dialling telephones, train control, Deputy Train Control, data system, Morse Telegraph working etc. In all 281 stations (including 18 cable sites) have been equipped with UHF system. 71E3 type radio equipment of M/s AEL Microtel has been used.

At microwave stations UHF antennas have been installed on microwave towers while at other stations separate UHF towers have been erected, which are mostly self-supporting, Parabolic grid type antennas of 4ft; 6ft; and 8ft; diameter have been in the UHF radio links, and coaxial cables have been used as feeders. The average path distance per hop is about 10 Kms.

The UHF radio system is also provided with full metering and alarm facilities and is served by an Engineer's Order wire which extends upto the divisional boundaries of each Railway division.

The UHF radio system layout is shown in Annexur-III.

2.3 CABLE CARRIER SYSTEMS

At some places where line of sight communication was not possible between adjacent stations, underground telecom. cable or overhead wires are installed on which 12 channel carrier systems are provided. This carries the same type of communication channels as the UHF radio. There are 3 such links, while there are 18 stations where communication has been extended on physical cable pairs.

2.4 VHF RADIO SYSTEM.

This system operates in 150 to 170 MHz range and is used for fixed and mobile communication between sectional train controllers, locomotive drivers, certain stations, supervisory vehicles, maintenance crews and in shunting operations in large station yards. There are 64 base stations and 14 yard terminals which are used for communicating on simplex basis with the Walkie-Talkie sets, etc. The VHF channels are carried through to the divisional control offices on the UHF and microwave system. The VHF radio equipment is manufactured by M/s General Electric, U.S.A. Its layout is shown in Annex-VI.

2.5. TELEPHONE SWITCHING SYSTEM.

Stored Programme controlled Digital Electronic Telephone exchanges, seventeen in number, with facilities of expansion, have been installed at Rawalpindi, Jhelum, Lalamusa, Wazirabad, Lahore Faisalabad, Khanewal, Multan Cantt. Samasta, Khanpur, Rohri, Sukkur, Jacobabad, Nawabshah, Hyderabad, Kotri, and Karachi stations. The capacity of telephone exchange varies from 50 lines to 1000 lines. The telephone exchanges have been procured from M/s GTE ATEA of Belgium.

Railway offices, stations, sheds, yards, godowns, hospitals and important residences have been provided telephone connections, with truck dialling facilities on the entire network. The main feature of this system is, however, the wayside telephones, for which channels are carried from the exchanges to remote railway stations, located as much as 100 Km away, over the microwave and UHF radio systems. This has provided access to nearly 170 such towns and villages, which hither to had not provided with any type of telecommunication facility.

2.6 MULTIPLEXING SYSTEM

The multiplexing system has been divided into two categories which have been used either independently or in conjunction depending on the requirement of the multiplex plan. One is the conventional frequency division multiplexing (F.D.M.) using which a base band is formed in standard super groups, which can carry upto 840 VF channels. On P.R. this system has been designated as the High Density Multiplex, and 46A3-C type of equipment manufactured by M/s. AEL Microtel Canada, has been installed.

The second category of multiplexing is the Direct to Line Modulation (D.T.L.) which is called the Low Density Multiplex on P.R. This system uses a two step modulation process to translate the voice channel to the line frequency. While the channel units generate their own frequencies separate frequency generating equipment are installed for other stages of modulation/demodulation. To achieve end to end synchronization of the channel frequencies, separate units are installed for 12 channels.

The multiplex system was subjected to very severe tests to achieve very low levels of noise, distortion, cross talk, phase jitter etc. The Mux. system has not only facilitated voice and teleprinter communication but can be used for high speed data communications.

2.7. TRAIN CONTROL SYSTEM

The microwave, UHF and VHF radio, and multiplexing systems are all integrated to constitute the train control system, which is the mainstay of railway operations. All train working and station operations are coordinated on party line circuits using this system, by Train Controllers sitting in divisional Control Offices. 5 Railway divisions viz; Karachi Sukkur, Multan, Lahore and Rawalpindi are being operated on the new train control system. All the stations enroute are connected to this system, and communication can also be made by the controllers with drivers of trains running in their sections through the VHF radios.

Alternate routing facility has been provided in the system due to which uninterrupted control communication continues even if the UHF system between 2 adjacent stations goes out of order. The controller can, in such a case, call the station via alternate route circuits which are established through microwave and UHF systems. It is remarkable that no interruption in the train control system has occurred for the past 2 years, on sections served by the modern system.

2.8 SIGNAL CONTROL SYSTEM

(a) Tyers' Block double line block instruments are being replaced on Hyderabad to Lodhran section with the Axle Counter System. The axle counters detect and count the axles of moving train and the information so collected is used to check whether the block section is occupied or not. The axle counter system works in a way as auto block signalling system.

(b) Neal's token instruments & Siemen's 61 coded block token less instruments between stations were operated on overhead wired. An interface has been provided to operate these instruments on UHF radio channels, on fail safe principles without jeopardizing the inherent safety of the block instruments.

2.9 TELE TYPEWRITER NETWORK

It is used for point to point teletype traffic. Dedicated Microwave/UHF channels have been used for operation of T-100 and T-1000 (Siemens') type teleprinters. 25 C data modems have been used for interfacing the teleprinters with the Mux channels.

2.10 BACKUP POWER SUPPLY SYSTEM

Diesel Generators of 5, 7.5, 10 or 12 KW rating have been provided. These are assembled by Coleman Engg (USA), and provided with Diesel Engines manufactured

by M/s. Duetz/W. Germany and Generators by LIMA/USA. Generators have been used for primary or standby power. Two generators are used, one actively supplying power and the other on automatic standby at the sites where no commercial supply is available. At those sites where the commercial supply is not reliable, one Generator has been used as standby.

Lead acid batteries are provided at each station to supply power to the radio, multiplexing, supervisory, drop/insert, telephone exchange and train control equipment. These batteries are regularly charged by Battery charging equipment manufactured by M/s. Power Conversion Products (U.S.A.). The PCP battery chargers are provided with facilities of voltage regulation, equalize charging and float charging.

3. OPERATION AND MAINTENANCE OF THE SYSTEM.

The telecommunication portion of the system is operating satisfactorily since its commissioning. There were some teething problems in the beginning, however these have been overcome. The Railway train control operations are now totally being conducted on the new telecommunication system and the interruptions are so rare that there have been only 2 cases of failure of a sub-section in the past 2 years. The telephone exchange system is also working normally except for occasional faults in the under ground cable network, outside plant and house wiring which is a routine matter in the maintenance of telephone exchange systems. The demand for telephones are increasing day by day and we are already providing services to our full capacity.

The only area in which problems are encountered is the operation of the VHF Radio System for communication with locomotive drivers. Since this facility has been provided in the controllers' console, who has also to communicate with all the stations on his section, there is a tendency to resist or to avoid responding to the driver's call. Consequently the VHF communication system is not yet fully operational and this facility is not being utilized. There are other problems in the operation of the VHF locomotive radio, for example, control of the equipment provided in the locomotive, which is hampering the implementation of the scheme. Consultations are presently underway within the railway organization to sought out these administrative problems.

3.1 MAINTENANCE CENTRES.

There is a maintenance organization on each division of Pakistan Railways headed by a Divl : Telecom Engineer. 17 maintenance centres have been set up at the following stations to attend to the preventive and corrective maintenance of the equipment on designated sections :-

1. Rawalpindi.
2. Jhelum.
3. Wazirabad.
4. Lahore.

5. Faisalabad.
6. Khanewal.
7. Multan.
8. Dera Ghazi Khan.
9. Samastta.
10. Khanpur.
11. Sukkur.
12. Jacobabad.
13. Larkana.
14. Dadu.
15. Nawabshah.
16. Hyderabad.
17. Karachi.

Each maintenance centre has a team of skilled Sub Engineers and technicians who are well-versed with the maintenance of telecommunication systems and work under the control of a Foreman/Telecom. They have been provided with necessary spares, tools, test and measuring instruments, transport etc. Elaborate maintenance schedules have been prepared according to which preventive and routine maintenance of the equipment is carried out.

3.2 MAINTENANCE OF POWER SUPPLY SYSTEM.

For the maintenance of the diesel generators and other power supply equipment one power supply maintenance team has been provided in each Railway division. They are required to carry out routine maintenance of the diesel engines, generators, control units, batteries, and battery chargers etc. They also carry out overhauling and scheduling of the diesel engine generators. A No. of portable generators have been provided to each team to meet with emergency.

Efforts are underway to arrange a mobile diesel generating set cum workshop, in a railway coach which will be transported to sites where there is a problem of power supply disruption.

A team in each division has also been formed to supply diesel fuel and lubricating oils regularly to the diesel generating station.

3.3 MAINTENANCE OF BUILDINGS & TOWERS

The maintenance of buildings has been entrusted to the Civil Engineering Department on the divisions. For the maintenance of towers a team of tower technicians, tower climbers, and Riggers has been constituted at the Head quarters level This team conducts regular testing of the nuts and bolts and inspection of the towers and carry out routine maintenance. They also replace tower warning bulbs and carry out alignment of antennas, and painting of towers.

3.4 CENTRAL TELECOM WORKSHOP LAHORE

Central Telecommunication work shop has been set up at Lahore for the testing and repairs of telecom. equipment. This repairing and test facility has been divided into

three classes, namely :

1. Simple servicing.
2. Medium Range Servicing.
3. Complex Servicing.

Simple Servicing

Microwave and UHF test racks are installed in the Workshop for basic servicing of a defective unit. During and after servicing comparison checks are made between a defective unit and a standard unit to see that it meets the specifications.

Medium Range Servicing.

In order to achieve this level of repair microwave and UHF test fixtures have been procured which allow bench servicing of defective unit. The test fixtures are same as those used in the factory.

Complex Servicing.

Additional Microwave test fixtures are provided in order to carry out bench testing of RF microwave portions of the transmitter and receivers.

Repairs of Multiplexing equipment, Control Consoles, Telephone instruments, Signalling consoles, Power Supply units, Battery Chargers, Operators Consoles, VHF Radio equipment, and diesel generator control units are also carried out in the Central Telecom Workshop.

3.5 DIVISIONAL WORKSHOPS.

Apart from the Central Telecom Workshop Lahore, 4 Divisional Workshops have been set up at Rawalpindi, Multan, Sukkur, and Karachi to carry out minor repairs to the equipment installed on the particular divisions.

4. CONCLUSIONS

1. The provision of an elaborate and comprehensive telecommunication system on Pakistan Railways has been fully justified by its utility. The system is playing a vital role in the safe and efficient running of trains, in the running of the day to day business within the organization, and is effectively responding to the calls of emergency. It is also contributing in a big way in saving administrative expenditure and increasing the revenues by improving efficiency in several sectors.

2. The modern and extensive telecom. network has cut across many communication barriers in the Railways, and matters are starting to get simplified.

Direct control of the managers has now been extended to far flung corners of the railway network.

3. Pakistan Railways can use this system for bringing about a rapid improvement in its services through better management, construction of new railway lines, reinforcement of motive power and rolling stock, electrification of railways, provision of management information system etc.

4. The maintenance of the telecom. system is being carried out satisfactorily, however, the following aspects require to be stream lined:-

(i) Procurement of petty stores and spares.
(ii) Shortage of maintenance staff.
(iii) Old transport vehicles to be replaced, and control of its operation transferred to maintenance personnel.

5. RECOMMENDATIONS.

1. Now, that the utility and necessity of modern telecommunications on Pakistan Railways, has been proved beyond any doubt, the system should be extended on other important sections which are not covered by the present telecom network. Thus, the Pakistan Railways should plan extension of the system to Rawalpindi - Peshawar - Jacobabad - Quetta and Lahore - Khanewal sections.

2. Liaison and cooperation between various agencies owning telecommunication networks, which already exists, should be further enhanced and extended in the best national interest and in the interest of the professionals.

3. The spare capacity in Pakistan Railways Microwave system be utilized by other agencies like T&T department, in complementing their own facilities to meet with the growing telecommunication needs, of the country.

4. The T&T department should provide limited number of junction lines to Railway exchanges, in lien of which Pakistan Railways will surrender thousands of telephones which can be allotted to other waiting subscribers. Modalities for the same can be jointly worked out.

5. Pakistan Railways should install on-line-computers, or a management information system on the microwave telecom. network, to provide modern services and facilities to the users, and also derive maximum benefit from the telecom system.

6. Telecommunication engineers and technicians, being highly paid professionals throughout the world, should be given a special professional allowance by the government, with a view to attract talent to these sectors and preventing brain drain away from these jobs.

ANNEXURE : I.

IMPORTANT DATA PERTAINING TO PAKISTAN RAILWAYS TELECOMMUNICATION SYSTEM.

MICROWAVE SYSTEM. (7.125-7.425 GHz)

Microwave Stations	44 Nos.
Drop/Insert Stations	36 Nos.
Through Repeaters	8 Nos.
Microwave hops.	45 Nos.
Microwave terminals.	90 Nos.
Average path distance/Hop.	44.89 Kms.

UHF RADIO SYSTEM (1429-1535 MHz)

UHF Stations.	263 Nos.
UHF Hops.	263 Nos.
UHF Terminals	526 Nos.
Average path distance /hop.	9.957 KMs.
Hot Stand by links	8 Nos.
Terminals with power amplifiers	60 Nos.

VHF RADIO SYSTEM.

Main/Branch line base stations	64 Nos.
Yards & Terminals base stations	14 Nos.
Mobile Radios for train Drivers	515 Nos.
Hand held Radios	100 Nos.
Portable Pack Set Radios	50 Nos.

TELEPHONE EXCHANGES.

GTD-1000 EPABX	10 Nos.
GTD-120 EPABX	7 Nos.
F1 type at Hd. Qrs. Lahore.	1 Nos.
EMD type at Moghalpura Lahore.	1 Nos.
Cross bar type at Pipri	1 Nos.
Available telephone connections out of EPABXs.	2896 Nos.
Out of F1	800 Nos.
Out of EMD	500 Nos.
Out of X-Bar	100 Nos.

TRAIN CONTROL SYSTEM.

Train Controller Consoles	14 Nos.
Dy : Train Controller Consoles.	5 Nos.
Chief Controller Consoles.	5 Nos.
Extension Consolettes	35 Nos.

SIGNAL CONTROL SYSTEM

Stations equipped with Axle counter system.	72 Nos.
Stations having tokenless interfaces	78 Nos.
Station having token interfaces.	109 Nos.
Teleprinter Circuits.	22 Nos.

DIESEL ENGINE GENERATIONS.

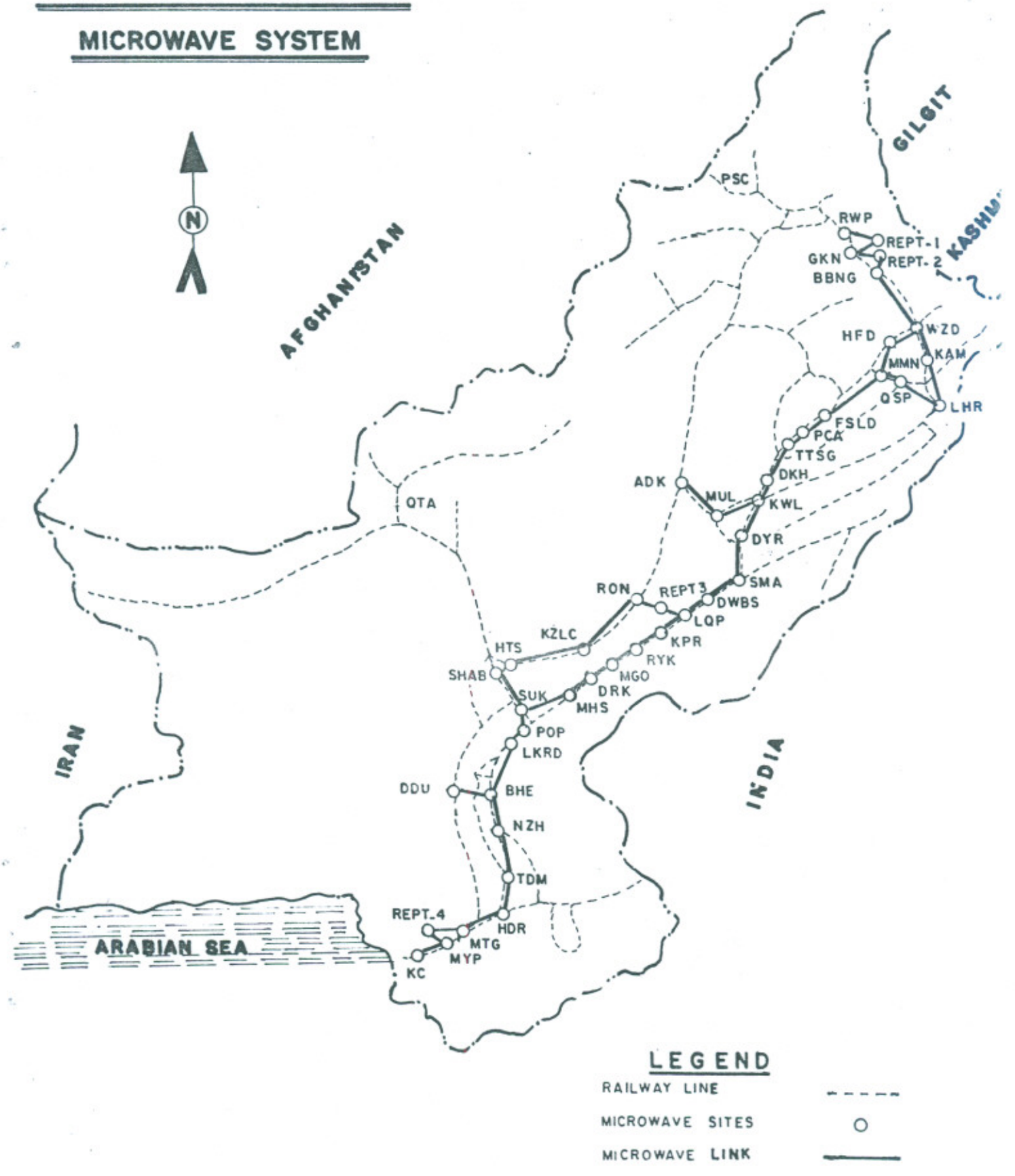
5 KW (UHF Sites: Standby).	14 Nos.
7.5 KW (UHF Sites: Standby).	79 Nos.
10 KW (MW Sites: Standby)	35 Nos.
12 KW (MW Sites: Standby)	4 Nos.
5 KW (UHF Sites: dual)	18 Nos.
7.5 KW (UHF Sites: dual)	24 Nos.
10.0 KW (MW Sites : dual)	6 Nos.

TOWERS.

Self Supported (Microwave)	30 Nos.
Guyed (Microwave)	14 Nos.
Self Supported (UHF)	222 Nos.
Minimum Height.	55 Ft.
Maximum Height.	464 Ft.

PAKISTAN RAILWAYS

MICROWAVE SYSTEM



LEGEND

RAILWAY LINE

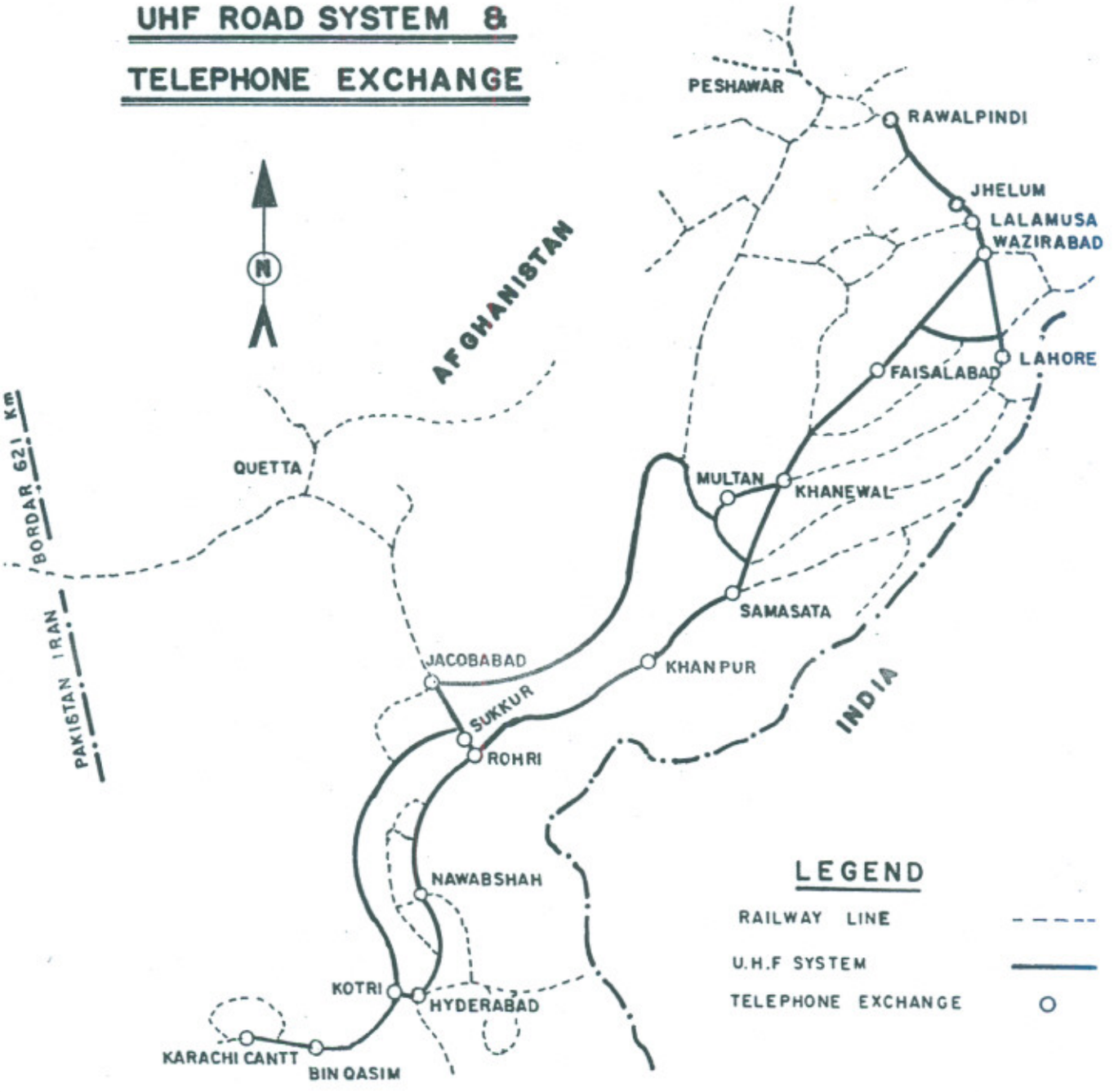
MICROWAVE SITES

MICROWAVE LINK

PAKISTAN RAILWAYS

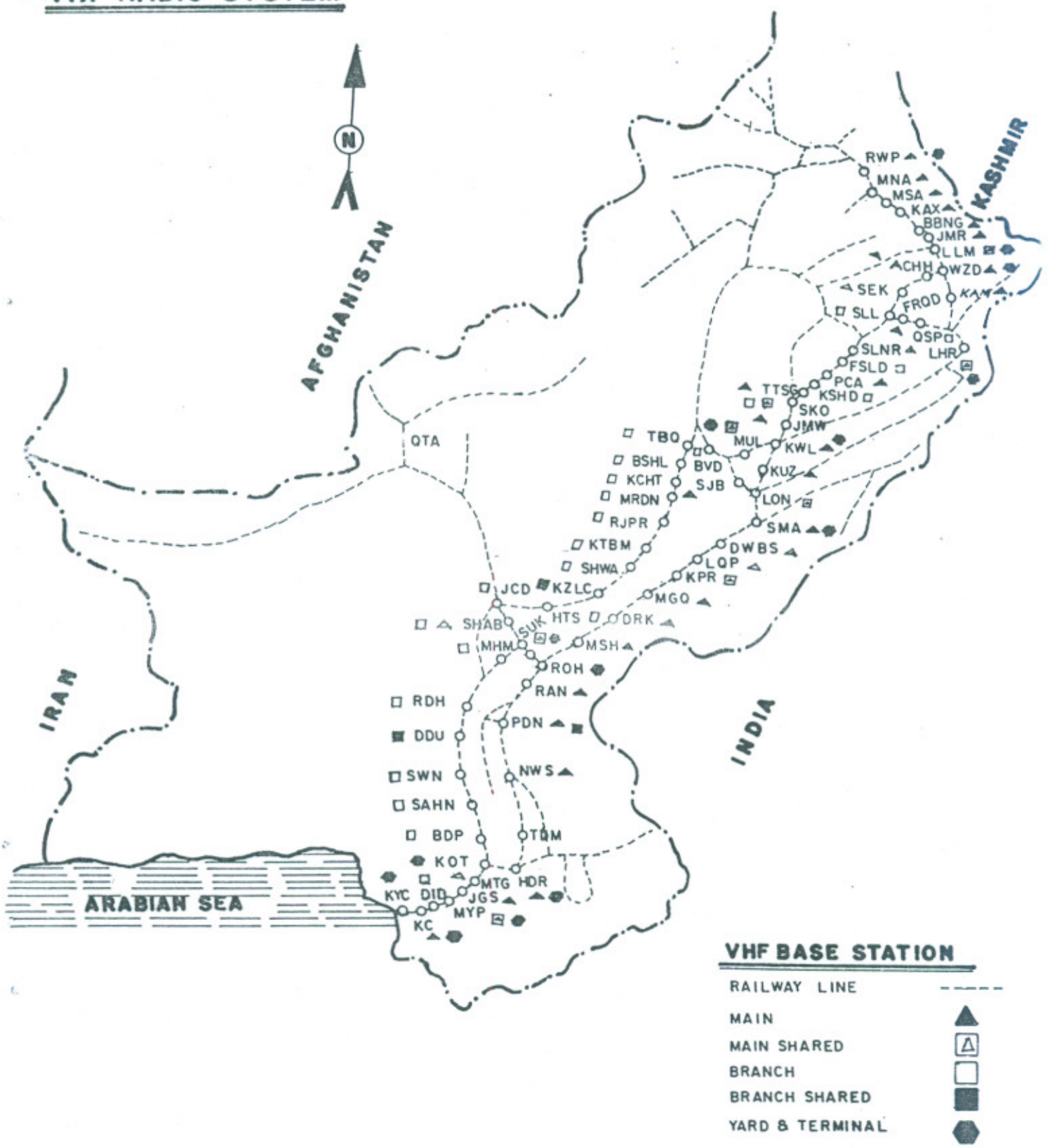
UHF ROAD SYSTEM &

TELEPHONE EXCHANGE



PAKISTAN RAILWAYS

VHF RADIO SYSTEM



VHF BASE STATION

RAILWAY LINE	-----
MAIN	▲
MAIN SHARED	△
BRANCH	□
BRANCH SHARED	■
YARD & TERMINAL	⬢