DEVELOPMENT AND APPLICATION
OF MOBILE COMMUNICATION
IN AFRICA

November 1995
# TABLE OF CONTENTS

**DEVELOPMENT AND APPLICATION OF MOBILE COMMUNICATIONS IN AFRICA**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOREWORD</td>
<td>(iii)</td>
</tr>
<tr>
<td>EXECUTIVE SUMMARY</td>
<td>(v)</td>
</tr>
<tr>
<td>ACRONYMS</td>
<td>(ix)</td>
</tr>
<tr>
<td><strong>I. INTRODUCTION</strong></td>
<td>1</td>
</tr>
<tr>
<td>1.1 Mobile Communication</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Objectives and Scope of the Study</td>
<td>2</td>
</tr>
<tr>
<td><strong>II. DEVELOPMENT OF TELECOMMUNICATIONS IN AFRICA</strong></td>
<td>3</td>
</tr>
<tr>
<td>2.1 Role of Telecommunications in Socio-Economic Development</td>
<td>3</td>
</tr>
<tr>
<td>2.2 Current Status of Telecommunications in Africa</td>
<td>4</td>
</tr>
<tr>
<td>2.2.1 Development of Basic Telecommunication Services</td>
<td>4</td>
</tr>
<tr>
<td>2.2.2 Introduction of New and Value - Added Services</td>
<td>8</td>
</tr>
<tr>
<td>2.2.3 Appropriate Choice and Application of New Technologies</td>
<td>8</td>
</tr>
<tr>
<td><strong>III. GENERAL DEVELOPMENT OF CELLULAR MOBILE COMMUNICATIONS</strong></td>
<td>10</td>
</tr>
<tr>
<td>3.1 History of Cellular Mobile Telephone</td>
<td>10</td>
</tr>
<tr>
<td>3.2 Cellular Mobile Telephone Systems Technology</td>
<td>15</td>
</tr>
<tr>
<td>3.3 Comparison of Major Types of CMT Systems</td>
<td>17</td>
</tr>
<tr>
<td>3.3.1 Advanced Mobile Phone System (AMPS)</td>
<td>18</td>
</tr>
<tr>
<td>3.3.2 Total Access Communication System (TACS)</td>
<td>18</td>
</tr>
<tr>
<td>3.3.3 Nordic Mobile Telephone (NMT)</td>
<td>18</td>
</tr>
<tr>
<td>3.4 Development of GSM</td>
<td>18</td>
</tr>
</tbody>
</table>
IV. INTRODUCTION OF CELLULAR MOBILE TELEPHONE SERVICES IN AFRICA

V. APPLICATION OF CELLULAR COMMUNICATION SYSTEMS

   5.1 General
   5.2 Application as a Cellular Mobile Communication System
   5.3 Radio Access System with Cellular Structure

VI. COMPARISON OF COST AND PERFORMANCE OF WILL AND WIRED NETWORKS

   6.1 Objective
   6.2 Background of the areas selected
       6.2.1 Cost of wired network
       6.2.2 Cost of wireless local loop (WILL)
       6.2.3 Cost Comparisons

VII. CONCLUSIONS AND RECOMMENDATIONS

REFERENCES
FOREWORD

Conscious of the importance of transport and communications in the development of Africa, the African governments, supported by the United Nations and the international community at large, declared special decades for a concerted development of these sectors in Africa. The first such programme, the United Nations Transport and Communications Decade in Africa - UNTACDA - was implemented between 1978-1988. Given the encouraging results of and experience gained from this programme, UNTACDA II was declared to continue with this regional effort in the last decade of this millennium. The development of telecommunications forms a major part of these programmes.

Telecommunications services in Africa are characterized by generally low access, large un-met demand, call-traffic congestion, poor service, limited territorial coverage, user willingness to pay more as well as user pressure to develop own facilities. While these persistent shortfalls may be viewed as weaknesses in the industry, the underdevelopment of the African markets offers exceptional opportunities. Large pent-up demands make attractive markets; major efficiency gains can be achieved quickly through restructuring, improved management and technological innovation.

The telecommunications industry the world over is undergoing major structural changes driven by rapid technological advances as well as market forces. Telecommunications is a fast growing industry by any measure. The cellular telephone, which began barely a decade ago, now has over 30 million customers worldwide. Africa is no exception to these pressures for change. The introduction and application of cellular mobile telecommunications technology amply illustrates the impact of such changes in Africa. It is therefore necessary that pro-active measures be taken by the telecommunications policy-makers in Africa to effectively manage these changes.

This report presents the findings of a study on the introduction and application of cellular mobile communications technology in Africa. It reveals that an increasing number of African countries are embracing this technology and some are adapting it to provide
fixed telecommunications services. With more coordination of the type of systems introduced in neighboring countries in a particular sub-region, the African countries could exploit further the development potential provided by this new technology. Furthermore, cellular technology can be effectively deployed in areas where it is difficult or impossible to deliver services with wireline technologies because of prohibitive construction costs, difficult terrain, or other geographic barriers.

The Economic Commission for Africa is publishing this study with the expectation that its findings and recommendations will provide useful information to the operators and policy-makers in African telecommunications industry for the rapid development of this sector which is vital for Africa's economic and social development in the emerging information age. With the rapid technological advances, Africa has the opportunity to leap-frog the development of its telecommunications from the current nineteenth century systems to those of the twenty-first century. Africa's ability to connect into the fast evolving Global Information Infrastructure (GII) - commonly referred to as the Information Super-Highway or Infobahn - will depend on the commensurate rapid development of its telecommunications infrastructure. Cellular communications technology offers an attractive possibility to Africa to speed up the development of its telecommunications systems. Our challenge is to establish the necessary framework for effective harnessing of technology so as to provide the services which Africa requires for social and economic development and meet the aspirations of our peoples as we enter the twenty-first century.

K.Y. Amoako
Executive Secretary
Economic Commission for Africa
Addis Ababa, Ethiopia
December 1995
Executive Summary

The continuous growth in demand and the ever increasing list of subscribers waiting for services show the inadequacy of telecommunication services in many African countries. All possible technologies which could be cost-effective, appropriate and time saving deserve closer attention to identify possibilities for their applications in order to meet the growing demand for basic telecommunication service, especially in the remote and rural areas.

The objective of this report is to assess current developments in cellular mobile communications in the world in general and in Africa in particular, as a possible alternative approach to meet critical demands and to develop communications in the rural communities. The report presents an overview of the various technologies which could be employed in improving and expanding telecommunication infrastructure and services with particular emphasis on cellular communication as a possible means of meeting the urgent demand in the continent.

In 1994, there were 14 African countries operating cellular mobile telephone systems, with a total number of 278,299 subscribers. In addition, a number of countries including Ethiopia, Botswana, Mali and Malawi have already finalized their plans to introduce the service, while Zimbabwe and Uganda are reported to have introduced the service in 1995. While the planned usage of cellular technology varies from country to country, in most cases it is used to provide mobile communication services. However, there are cases where cellular systems are used as a fixed network in order to provide fast connection to basic telephone services.

The predominant systems in operation are the Advanced Mobile Phone System (AMPS) and the Total Access Communication System (TACS). AMPS, which is the standard adopted in North America, operates in the 800 MHz band while TACS is of European standard and operates in the 900 MHz spectrum. Some of the countries in North Africa have, however, introduced the Nordic Mobile Telephone system (NMT), which operates in the 450 MHz and 900 MHz bands.
Lately, however, several countries have introduced the Global System for Mobile Communication (GSM) system. For example, South Africa has installed GSM system and achieved an unprecedented success by connecting 220,000 subscribers within one year from the date the system was put into service. Similarly, Kenya Posts and Telecommunication Corporation (KPTC) has prepared plans to extend its mobile network using the new GSM technology, with a capacity to serve an additional 50,000 subscribers. Nigeria and Mauritius as well have decided for GSM system for their second CMT networks with capacities to serve 100,000 and 3,000 subscribers, respectively. Furthermore, Zimbabwe and Uganda are also planning to start operating GSM in late 1995, while Malawi and Namibia have committed themselves to GSM based CMT networks.

One characteristic of the cellular mobile telecommunications systems in Africa is that they are being introduced in a very uncoordinated manner, with different systems in adjacent countries. This approach will limit the exploitation of capabilities such as cross-border roaming. Although the data is far from comprehensive, the above examples indicate a trend away from the earlier and currently predominant analogue systems (AMPS and TACS), towards the newer digital GSM systems. In particular, the countries in Southern Africa have all committed to the GSM system and if it is standardized, the potential for cross-border roaming will be created. The migration to the digital CMT systems also have the advantage that the digital systems offer more value-added services, provide better quality of service and improved security.

Another development of significance in the mobile communication market in Africa is the participation of private sector. Out of the 14 countries included in the study private participation was found only in five, namely Ghana, Nigeria, Tanzania, Namibia, and Zaire. Private capital would certainly make important contribution to the development of telecommunications in Africa where demand outstrips capacity. However, effective participation of the private sector will entail, among other things, the establishment of clear private investment codes, and transparent regulatory regimes in the industry.
Cellular technology can also be applied to provide fixed telecommunication services. The wireless local loop or radio access system with cellular structured networks are being considered by a number of African countries to meet demands in the suburban areas and the remote and rural communities. Still further, the phone shop concept which is under implementation in a cellular network environment in South Africa, is another important development for providing access to telecommunication services to rural communities.

In view of the above findings and development of cellular mobile communication network the following recommendations may be made:

**Recommendation 1:** African Administrations should seriously consider the technical and economic merits of radio access or wireless loop systems to reduce constraints faced in their existing network in meeting critical demands for telecommunication services in both the suburban and rural areas.

**Recommendation 2:** Necessary changes need to be made in the regulatory framework to allow and encourage private sector participation in the of cellular mobile communication services in order to enhance fast development of cellular network and also the use of state-of-the-art technologies.

**Recommendation 3:** The phone shop concept deserves serious consideration by telecommunication organizations and all appropriate measures should be taken to encourage their implementation.
Recommendation 4: African countries should include in the terms of conditions and rules for operating value-added and advanced telecommunication services by competing private companies or business groups, a provision by which these companies commit themselves to play a part and contribute to the extent possible towards the development of rural telecommunication services.

Recommendation 5: Each Sub-Region, through its appropriate meetings and conferences, should create a committee to discuss the economic and technical issues regarding the adoption of a single standard of cellular mobile communication system in Africa, and to monitor future development and application of the system.

Recommendation 6: A follow-up action should be taken to organize and establish at sub-regional levels a mechanism for common purchasing of equipment.

Recommendation 7: Each Sub-Region should consider developing the capability for manufacturing components, parts, units and subsystems of cellular mobile communication systems for the countries of the sub-region in order to adopt CMT systems to Africa’s needs.

Recommendation 8: PATU should be given a major role in the coordination and implementation of the above recommendations.

(viii)
<table>
<thead>
<tr>
<th>No.</th>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ADC</td>
<td>American Digital Communication</td>
</tr>
<tr>
<td>2</td>
<td>AMPS</td>
<td>Advanced Mobile Phone System</td>
</tr>
<tr>
<td>3</td>
<td>CMT</td>
<td>Cellular Mobile Telephone</td>
</tr>
<tr>
<td>4</td>
<td>DMU</td>
<td>Display and Metring Unit</td>
</tr>
<tr>
<td>5</td>
<td>FAX</td>
<td>Facsimile</td>
</tr>
<tr>
<td>6</td>
<td>GSM</td>
<td>Global System for Mobile Communication</td>
</tr>
<tr>
<td>7</td>
<td>JDC</td>
<td>Japanese Digital Communication</td>
</tr>
<tr>
<td>8</td>
<td>MAHO</td>
<td>Mobile Assisted Hand-Over</td>
</tr>
<tr>
<td>9</td>
<td>MCHO</td>
<td>Mobile Controlled Hand-Over</td>
</tr>
<tr>
<td>10</td>
<td>MCU</td>
<td>Master Control Unit</td>
</tr>
<tr>
<td>11</td>
<td>MSC</td>
<td>Mobile Switching Centre</td>
</tr>
<tr>
<td>12</td>
<td>NCHO</td>
<td>Network Controlled Hand-Over</td>
</tr>
<tr>
<td>13</td>
<td>NMT</td>
<td>Nordic Mobile Telephone</td>
</tr>
<tr>
<td>14</td>
<td>PCM</td>
<td>Pulse Code Modulation</td>
</tr>
<tr>
<td>15</td>
<td>PCS</td>
<td>Personal Communication Service</td>
</tr>
<tr>
<td>16</td>
<td>RAS</td>
<td>Radio Access System</td>
</tr>
<tr>
<td>17</td>
<td>RBS</td>
<td>Radio Base Station</td>
</tr>
<tr>
<td>18</td>
<td>RSS</td>
<td>Remote Subscriber Stage</td>
</tr>
<tr>
<td>19</td>
<td>RST</td>
<td>Remote Subscriber Terminal</td>
</tr>
<tr>
<td>20</td>
<td>TACS</td>
<td>Total Access Communication System</td>
</tr>
<tr>
<td>21</td>
<td>TDM</td>
<td>Time Division Modulation</td>
</tr>
<tr>
<td>22</td>
<td>UHF</td>
<td>Ultra High Frequency</td>
</tr>
<tr>
<td>23</td>
<td>VHF</td>
<td>Very High Frequency</td>
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</table>
I. INTRODUCTION

1.1 Mobile Communications

1. Mobile communications can broadly be divided into two categories. The first consists of systems which employ earthbound radio transmitting and receiving equipment, with their associated ancillary devices for the transmission and reception of radio signals over a specified coverage area. The system design permits the user to move around in this area and be able to exchange information (voice, FAX, data,) on a continuous basis without interruption. The service coverage area is extended as required through the application of cellular structure and frequency re-use scheme. This system is referred to as cellular mobile communication network.

2. The second category is the mobile satellite service which employs orbital satellites as relay stations for the transmission and reception of radio signals for global coverage. With the appropriate integration to ground station and wired public switched networks, customers are offered capability to communicate with anyone, anywhere in the world.

3. Both the cellular and satellite mobile communications systems have registered impressive progress since the early 1980s. The application of digital technology in the various subsystems provided the capability for high quality and dependable services with improved security and additional features.

4. As regards mobile satellite communications, the achievements by Inmarsat in developing mobile services for ships and aeronautics, and recently the suit-case portable terminal and the land vehicular mobile services, demonstrates the potential of satellites for global mobile communication. The low orbital satellite systems, which are expected to be fully operational in two to three years, will however mark a new era in global mobile communications. Iridium Corporation and Orbital Communication are, for example, pursuing their objectives to provide world-wide commercial services through a constellation of low orbit satellites. Iridium, with its 66 satellites orbiting around the earth at a height of 720 kms, is well poised to offer global two-way satellite mobile communications. Orbital Communication will also place a similar constellation of 36 low orbiting satellites at a height of 960 kms above the earth. Their design parameters, however, permit two-way data communications services to users world wide.
1.2 Objectives and Scope of the Study

5. The continuous growth in demand and the ever increasing list of subscribers waiting for services show the lack of adequate telecommunication services in many African countries. Consequently, all possible technologies which could be cost-effective, appropriate and time saving deserve closer attention to identify possibilities for their applications in order to meet the growing demand for basic telecommunication service, especially in the remote and rural areas. The objective of this report is to assess current developments in cellular mobile communications in the world in general and in Africa in particular, with a view to providing an alternative approach to meet critical demands and to develop communications in the rural communities.

6. The report presents an overview of the various technologies which could be employed in improving and expanding telecommunication infrastructure and services. Among the available technical options, it concentrates on cellular communication as a possible means of meeting the urgent demand in the continent.

7. The report is organized into seven sections. Following the introduction, Section II briefly highlights the current status of the development of telecommunication services and outlines the new technologies being adopted in order to expand and improve networks and services in Africa. The overall world development of cellular mobile telephones, the technologies applied and the different systems used are elaborated under Section III. Section IV concentrates on the introduction of cellular mobile telephones (CMT) in Africa, and the level of private capital investment in the establishment of the systems and operating the networks. The flexibility provided in the cellular structure is explored in Section V, where areas of application of CMT with emphasis on the fixed cellular system are elaborated.

8. Comparative cost analysis has also been included under Section VI to illustrate the advantages of fixed cellular or wireless loop (WILL) in providing basic telecommunication services to areas which are difficult and even sometimes impossible to install wired network, as well as to the remote and rural communities. Finally, the report concludes with recommendations which are considered to be relevant and timely in view of the current level of development of telecommunication infrastructure and services in Africa.
II. DEVELOPMENT OF TELECOMMUNICATIONS IN AFRICA

2.1 Role of Telecommunications in Socio-Economic Development

9. The valuable contributions of good quality telecommunication and telematic services to the socio-economic development have been demonstrated in a number of studies and researches that were undertaken in the 1980s and the early part of the 1990s. Trade, industrial production, agricultural outputs and various social service initiatives attribute their success, among other things, to the availability of efficient telecommunications services.

10. A case study on the use of agricultural machineries demonstrated the effective deployment of scarce resources to increase productivity by cutting down idle time and implementing improved scheduling and planning, thanks to good quality telephone and mobile radio communications. Another study on livestock breeding illustrated how scarce services in the rural community such as that of veterinaries, could be maximized and addressed in a timely and effective manner in the treatment of cattle for various diseases and insect pests. Similarly, for physical transportation, the improvement that can be achieved in scheduling and coordination of pick-ups and deliveries through the use of mobile radio communication is quite significant and has contributed towards increasing productivity. A study carried out in the 1980s by Stanford Institute indicated that judicious application of mobile radio communications in fleet management resulted in increased output per vehicle in the order of 15-25 percent. A number of other cases, declarations and presentations made at international and regional fora could be cited to confirm that telecommunications services are important components in the implementation of economic and social development.

11. Cognisant of this impact towards enhancing socio-economic development, governments, policy makers and operators have taken special interest to invest in telecommunications in order to expand the infrastructure and improve services.

12. While the rest of the world, including those developing countries in Asia and Latin America, has achieved commendable results, Africa has, however, lagged behind in the development of its telecommunications networks and services. For example, in 1992 Africa accounted for only 2 percent of the World's main telephone lines, with the average penetration still remaining below 1 percent. There were only 13 countries in Sub-Saharan Africa with an average penetration of 1 percent and above; the remaining 35 seem to have made no significant progress in the last decade.

1/ Applications in Agriculture, Industry and Commerce, World Communication, 1983

2/ IBID

3/ African Telecommunication Indicators, ITU, 1994
13. While this depicts the status in the development of basic telephone services, the value-added services are basically at the earliest stages of development. Data communication is at its infancy; only a few countries as of 1993 had introduced packet switching in their networks. As for leased lines, Africa accounted for only 0.4 percent of the World connections, while Integrated Services Digital Network (ISDN) services are offered in none of the African countries. FAX services, which seem to have grown at a faster rate as a result of the introduction of digital switching in the network, account for only 0.5 percent of the World’s subscribers.

14. Regarding mobile communications, however, the African countries seem to be in a race to introduce some sort of Cellular Mobile Communications system, probably to satisfy business communities, international organizations and those foreign users who may be in the country for business or pleasure. As of 1994 the number of countries which had introduced cellular communication systems had reached 12, with a total subscriber connection figure of 278,299, the lion’s share being attributed to South Africa (233,000 lines).

2.2 Current Status of Telecommunications in Africa

2.2.1 Development of Basic Telecommunication Services

15. The level of development of basic telecommunication infrastructure and services in Africa is still far behind the world average, and much lower than in the other developing countries in Asia and Latin America. The major contributing factors for such low level of development were capital shortage and the general absence of clear and dynamic policies to guide future development of telecommunications. As a result of delays in taking timely action on the above issues, the rate of development has been unable to match the demands for service which continues to grow at a rapid rate. As of 1992, the waiting lists of subscribers had reached an average of 35 percent of the total demand in Sub-Sahara Africa, and was increasing at an annual rate of nearly 10 percent. Although the rate of increase of wait-listed subscribers in North Africa was slightly lower at 7 percent, the number of potential subscribers which could not be provided with service due to lack of facilities was equally alarming at 57 percent of the total number of subscribers. On the other hand, it was observed that South Africa had been able to steadily reduce the number of wait-listed subscribers at the rate of nearly 7 percent per year, thereby reducing its waiting list to only 3 percent of the demand (Table 1).

16. The other area in which Africa has not shown significant improvement is the utilization of existing facilities. On average, the unused capacity of switching equipment in 1992 was 34 percent in Sub Sahara Africa, (Table 2). This demonstrates the uncoordinated development of the systems and inefficient investment.

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### Table 1

**WAITING LIST FOR MAIN TELEPHONE LINE CONNECTIONS**

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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sub-Sahara Africa</td>
<td>339,584</td>
<td>111,887</td>
<td>9.6</td>
<td>34.8</td>
<td>2,155,229</td>
<td>2,288,300</td>
</tr>
<tr>
<td>North Africa</td>
<td>1,375,740</td>
<td>2,534,102</td>
<td>7</td>
<td>36.5</td>
<td>4,400,451</td>
<td>4,925,000</td>
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<tr>
<td>South Africa</td>
<td>225,321</td>
<td>120,365</td>
<td>-6.7</td>
<td>3.3</td>
<td>3,524,138</td>
<td>3,659,900</td>
</tr>
<tr>
<td>Total for Africa</td>
<td>1,940,645</td>
<td>3,766,354</td>
<td>6.5</td>
<td>27.3</td>
<td>10,079,818</td>
<td>10,873,200</td>
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</tbody>
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Source: ITU: African Telecommunication Indictors, 1994

### Table 2

**STATUS OF SWITCHING CAPACITY IN AFRICA (1992)**

<table>
<thead>
<tr>
<th>COUNTRIES</th>
<th>EXCHANGE CAPACITY (K)</th>
<th>CONNECTED LINE IN % OF CAPACITY</th>
<th>MAIN LINES (DEL)</th>
</tr>
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<tr>
<td></td>
<td></td>
<td></td>
<td>AUTOMATIC (%)</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub-Sahara Africa</td>
<td>2756.9</td>
<td>66</td>
<td>89</td>
</tr>
<tr>
<td>North Africa</td>
<td>5580.0</td>
<td>79</td>
<td>94</td>
</tr>
<tr>
<td>South Africa</td>
<td>4406.8</td>
<td>80</td>
<td>97</td>
</tr>
<tr>
<td>Total Africa</td>
<td>12743.7</td>
<td>76</td>
<td>94</td>
</tr>
</tbody>
</table>

Source: ITU: African Telecommunication Indictors, 1994
17. In 1988 the African countries called for the continuation of a coordinated regional effort for the development of transport and communications up to the year 2000 within the framework of the programme of the Second United Nations Transport and Communications Decade in Africa - UNTACDA II. Specifically for the telecommunications sector, several targets have been established to be attained during the decade (1991-2000), including an average telephone penetration of 0.72 percent by the year 2000. However, based on the recent growth trends in telecommunications development in Sub-Sahara Africa of an average of 4 per cent per year from 1983-1993 (Table 3), it would take another 13 years to attain the penetration targets set in the UNTACDA II programme.

18. In order to increase the rate of development of telecommunications, African Governments, planners and policy makers will have to take bold and concrete steps on certain key issues. These include the establishment of dynamic management which would respond to market demand for basic as well as advanced and value-added services; the creation of the necessary legal framework through which private participation could be encouraged in those areas where the incumbent telecommunication operator cannot adequately meet demands or offer the type of services required due to lack of sufficient capital, among other things. Such measures could have additional advantage of creating an incentive and drive for consideration of new and advanced technologies in order to cope with the urgent demand for basic and advanced telecommunication services, such as mobile communication for fixed network, or digital radio access system and satellite for rural application.
### Table 3

#### GROWTH OF MAIN TELEPHONE LINES (DEL)

1983 - 1992

<table>
<thead>
<tr>
<th>COUNTRIES</th>
<th>MAIN TELEPHONE DEL in (k)</th>
<th>DEL DENSITY</th>
<th></th>
<th></th>
<th>ANNUAL GROWTH RATE %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-Sahara Africa</td>
<td>1,194.5</td>
<td>2,151.5</td>
<td>6.8</td>
<td>0.30</td>
<td>0.43</td>
</tr>
<tr>
<td>North Africa</td>
<td>1,494</td>
<td>4,400.5</td>
<td>12.8</td>
<td>1.56</td>
<td>3.65</td>
</tr>
<tr>
<td>South Africa</td>
<td>2,071.8</td>
<td>3,524.0</td>
<td>6.1</td>
<td>6.87</td>
<td>8.87</td>
</tr>
<tr>
<td>Total Africa</td>
<td>4,760.4</td>
<td>10,076</td>
<td>8.7</td>
<td>0.91</td>
<td>1.52</td>
</tr>
</tbody>
</table>

Source: ITU: African Telecommunication Indicators, 1994
2.2.2 Introduction of New and Value-Added Services

19. As concerns the modernization of the telecommunication infrastructures in Africa, it is observed that some countries in Africa have done relatively well in establishing new and modern facilities which enabled them to provide the information capability required for business, trade and industrial activities. Botswana for instance, has installed a fully digital switching network and has taken bold measures by laying fibre optic cables to support data communication as well as to strengthen backbone transmission system. Similarly, Gambia has taken the decision to install fibre optic transmission network to increase its capability to provide advanced telecommunication services, such as data transmission. Considering the Sub-Saharan Africa as a whole, however, there is a lot more still to be done. The digitalization percentage as of 1992 stood at only 42 percent on the average (Table 2) with the exception of Cape Verde, Djibouti, Mauritius, and Rwanda which have achieved 100 percent digitalization of their switching networks. The combined size of these networks, however, represents only 5.4 percent of the total automatic exchange capacity in sub-Saharan African region as a whole.

20. With regard to the cellular mobile telephone services, African countries have just begun to focus on this technology. While the planned usage of cellular technology varies from country to country, in most cases it is used to provide mobile communication services. However, there are cases where cellular systems are used as a fixed network in order to provide fast connection to basic telephone services. There will be further discussions in subsequent sections on the various mobile systems and applications of cellular mobile communication.

2.2.3 Appropriate Choice and Application of New Technologies

21. Africa’s greatest challenge has been and still remain to develop its telecommunications networks sufficiently to provide telephone services to the rural communities where the majority of the population live and most of the economic activities take place. This would create an environment for the people to increase their participation in the development process in their country and further enhance fair distribution of wealth and assist in curbing the migration of people to urban centres.

22. Single and multi-channel VHF and UHF transmission systems (both analogue and digital generations) have in the past provided valuable contributions to the connection of villages and rural communities to the national networks. Such systems include those with capacity ranging from a few channels, up to 24 and 48 channels covering a span of over 50 kms, and with repeaters up to 80-100 kms depending on the propagation condition. With the development of digital transmission system and the application of Time Division Multiplexing (TDM) technique, far reaching capability has been acquired for addressing the needs for telecommunication services in the rural and remote areas, with scope and quality of no less than those in the urban centres.

23. The point-to-multi-point digital access radio system is capable of providing remote subscriber connection for voice, FAX and low rate data transmission. With a capacity to serve up to 500 subscribers, depending on the traffic load by each subscriber, it can cover
a distance of up to 300 kms with the installation of suitable repeaters. As the system uses solar arrays for power generation, it makes it especially suitable for rural and remote area application. A number of countries in Eastern and Southern Africa, such as Ethiopia, Swaziland and Botswana, can be cited as examples of countries which have adopted the above system for improving their rural communication services.

24. To the above system one can add the application of satellites for providing domestic communication services. With relatively small dish antennae satellites are being increasingly applied in the rural and remote areas for transmission of programmes on community services, as well as to provide data on mining projects, agricultural undertakings and other infrastructural development activities. Vital information through voice, FAX and low rate data transmission can be conveyed at a relatively cheap price using satellite technology.

25. Another new technology contributing to the revolution in telecommunication is the digital switching technology. The associated distributed processing and the possibility for remote location of few subscriber stages of the switching equipment as well as the installation of simple concentrators have greatly simplified the process of establishing networks. One of the major contributions of the digital system is the saving that can be realized by reducing the extent of excavation of cable ditches for the installation of telephone cables by deploying remote subscriber stages (RSS) at strategically located sites. Fibre optics or digital radio links may then be used as junction lines between the parent exchange and the RSS. The last leg of connection from RSS and concentrators will have, however, to be completed through fixed wire network. However, through wireless communication media, such as cellular mobile telephone, even this last leg of wired network can be avoided. This technology is attracting planners as it offers a solution through which the burden of tearing down grounds and pavements and laying subscriber telephone cables can be avoided in order to provide, in most critical and urgent cases, the required connection in the telephone network. Thus cellular mobile communication systems offer an alternative method in the provision of telephone services. Its merit will therefore be treated in some detail in the subsequent sections.
III. GENERAL DEVELOPMENT OF CELLULAR MOBILE COMMUNICATIONS

3.1 History of Cellular Mobile Telephone

26. The early types of land mobile communication systems were characterized by a high power transmitter to cover as much distance as possible, which normally ranges from 30-50 kms, with allowable frequency band at 150 MHz and a capacity not exceeding 20 channels. It provided a mobile telephone service with duplex operation, making use of limited hand-held or portable terminal equipment, and in the majority of cases, the subscriber transceiver units were all vehicular types.

27. Demand for improved quality, greater capacity and additional service features led to the emergence of cellular technology, where efficient utilization of the available frequencies was possible. This is effected by limiting the power of the transmitter employed to radiate in a relatively small area, a cell, and by strategically arranging a number of these cells so as to enable the same frequencies to be used again as often as required depending on traffic and demand for service, i.e re-use of frequencies.

28. The development of the above system took place in the early of 1980s, with North America, Nordic countries and some leading industrialized countries in Western Europe taking the lead. The first commercial cellular mobile telephone service was introduced in the United States in 1983 with the installation of the Advanced Mobile Phone System (AMPS) in Chicago. Nordic countries, with their system NMT-450, took the lead, however, to operate Cellular Mobile Telephone (CMT) in 1981. This was later followed by similar developments in the other European countries (UK, France, Germany, etc.), where another system, Total Access Communication System (TACS) was introduced in the market in 1983. With the development of the above three major systems, the total connection figure by the end of 1989 reached 370,000 subscribers. In the two subsequent years, the demand increased so much that the number of cellular subscribers in the world more than doubled in 1985 and increased by 81 percent in 1986. The fastest growing network was in North America increasing 3.5 times in one year (1984 to 1985) (Table 4).

29. The market continued to grow in the latter part of the 1980s and the early 1990s, mainly due to general acceptance by users of the increased role which cellular mobile telephone could play in business, and particularly in field activities, (i.e. services, engineering and construction, sales, etc.) and increased awareness by managers and supervisors of productivity gains which can be achieved through timely control and management of their activities. The development of portable and hand-held mobile sets with steady decrease in prices has also contributed to growth in demand. Regulatory changes which enabled a number of new service providers to offer their products and services also

## TABLE 4  World Cellular Mobile Communications Market Development: 1982-1986

<table>
<thead>
<tr>
<th>AREA</th>
<th>Subscribers Connected in '000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nordic</td>
<td>120</td>
</tr>
<tr>
<td>Other Europe</td>
<td></td>
</tr>
<tr>
<td>N. America</td>
<td></td>
</tr>
<tr>
<td>Asia &amp; Pacific</td>
<td>20</td>
</tr>
<tr>
<td>Africa</td>
<td></td>
</tr>
<tr>
<td>S. America</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>140</td>
</tr>
</tbody>
</table>

Source: Nieminen, J.V., World Market in M.C., African Service Perspective
played a significant role in lowering equipment cost. The cost reduction enjoyed by consumers in this competitive market can best be explained by the cost analysis made by Herschel Shoslech Associates Ltd. as presented in their article, "Cellular Soars Through 1995". They defined the concept of "full effective cost", which is comprised of three elements:

(a) Monthly cost of the mobile telephone in terms of amortization of rental or lease charges;
(b) Monthly access charges to the network; and
(c) Monthly charges per minute of calls made.

On the assumption that 250 minutes of calls are made during a month, the trend in cost reductions from 1983 was as shown in (Table 5). It is observed that 46 percent of effective cost reduction was possible in just five years from 1983 to 1988.

30. The cost analysis referred to above concerns the cellular market in USA. Liberalization and privatization of the market in Europe and other parts of the world have equally contributed in reducing the cost of cellular services. Thanks to the cost reduction, demand for cellular services was not restricted to the affluent society and business executives, nor to industrial and business activities where CMT had already made an impact; rather, it extended to the general consumer market where the benefits of keeping in touch at any time and any place were recognized. Thus, the number of subscribers to CMT services grew at an impressive average rate of 48.6 percent per year from 1986-1992 during which time the total number of connected mobile phones exceeded 15 million. In the following year alone, between 1992 and 1993, another increase of 45 percent was realized, raising the total connected figure in the world to over 22 million. It is of interest to note, however, that the total number of mobile phones connected in the United States alone was 13 million, which accounts for nearly 60 percent of the world cellular mobile phone market.

6/ Telecommunications Engineering and Management, 1989
### Table 5

**ANNUAL DECLINE IN FULL EFFECTIVE COSTS OF CELLULAR SERVICE (FECSC) ADJUSTED FOR INFLATION, 1983-1988**

<table>
<thead>
<tr>
<th>YEAR</th>
<th>FECSC/MONTH CURRENT DOLLAR</th>
<th>ANNUAL CPI DEFLATOR</th>
<th>FECCS/MONTH 1983 DOLLARS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>229</td>
<td>1.0</td>
<td>229</td>
</tr>
<tr>
<td>1984</td>
<td>192</td>
<td>0.962</td>
<td>185</td>
</tr>
<tr>
<td>1985</td>
<td>172</td>
<td>0.927</td>
<td>159</td>
</tr>
<tr>
<td>1986</td>
<td>163</td>
<td>0.917</td>
<td>149</td>
</tr>
<tr>
<td>1987</td>
<td>154</td>
<td>0.878</td>
<td>135</td>
</tr>
<tr>
<td>1988</td>
<td>146</td>
<td>0.846</td>
<td>124</td>
</tr>
</tbody>
</table>


31. The Advanced Mobile Phone System, which was developed in U.S., dominated the world market, accounting for 62.4 percent of the world’s cellular phones (Figure 1). This was followed by UK’s Total Access Communication System with 14 percent share, and the Nordic Mobile Telephone Systems (NMT 450 and NMT 900) claiming 11.5 percent of the world’s total CMT connections. The Global System for Mobile communications (GSM), now gaining acceptance as one of the world standards, has only tapped a small share of the market, 1.8 percent.

32. While the above generally shows the leaders in the cellular mobile telephone, there was no clear dominating supplier in mobile switches and mobile base stations. The key suppliers of the above equipments were however, Ericsson, Motorola and AT & T 7. In 1995, however, Ericsson is emerging as the dominant supplier for cellular network, but facing strong competition from big companies such as Motorola, Siemens, Alcatel, and AT & T. On the other hand, in the sale of mobile telephones, Ericsson ranked third largest supplier behind Motorola of USA, and Oy Nokia of Finland. 8

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7/ Telecommunications Services, U.S. Industries Outlook, 1994

Fig 1  

WORLD CELLULAR SUBSCRIBERS  
BY SYSTEM TYPE  

MAY 1992 = 15,418,981  

JUNE 1993 TOTAL = 22,376,728  

SOURCE: CELLULAR BUSINESS (5/92 & 6/93) EXCEPT GSM ESTIMATED
3.2. Cellular Mobile Telephone Systems Technology

33. In the preceding section the trends in the development of CMT and the major systems and suppliers were briefly presented. In the following section the major subsystems for operating cellular mobile telephone services and possible areas of their applications are explored.

34. A Cellular Mobile Telephone, in its simplest form, is a system that can provide telephone service in motion through the efficient use of the available frequencies. Most of the available frequencies, however, are allocated to fixed communication and broadcasting services, leaving little freedom in the choice of radio frequencies with sufficient width to meet other demands. The fact that the power of radio signals declines with distance, makes it possible to design radio transmitters to cover a specified locality and with sufficient power output to avoid interference in the neighbouring areas. This allows the same frequencies to be used again, while maintaining the separation distance required to avoid interference.

35. A cluster of small areas, or cells, can be designed where frequency re-use schemes can be planned in order to meet traffic and connection demands in a particular area. The fact that signal strength declines in direct proportion to distance, and together with the frequency re-use scheme combine to overcome the problem of shortage of radio frequencies for CMT. Figure 2b illustrates a configuration where a cluster of seven cells was chosen. Each of the cells in the cluster has its transceiver with the designated frequency band assignment and its share of the total number of channels allocated for the cluster. In the case of narrow band allocation, if "n" is the total number of radio channels available to the cluster, then each cell will be assigned $n/7$ channels. These clusters are repeated as frequently as required to cover the total area to be served. Increase in demand of connection or traffic can be met by cell splitting or through installation of directional radio transmitter antennae to radiate at say 120°, thereby tripling the capacity of the previous cell.

36. The functioning of Cellular Mobile Telephone System can best be explained by tracing a call through the network. Calls are initiated from mobile sets when the hand set is in "off-hook" position. At this instance, special set-up channels designated for common use are "seized" to send messages to the mobile switching centre (MSC) on the readiness to communicate and the necessary data on the called party (Figure 2a). The MSC, which serves partly as a conventional telephone switch, controls all the radio base stations connected to it, and upon receiving request for communication from mobile sets sends out messages to all the radio base stations and locates the called party. At this point the mobile set transmits to its base station an acknowledgement message thereby confirming that both parties are ready to communicate. The mobile switching centre assigns to each of the mobile sets a pair of radio channels for voice communication and releases the special signalling channels used for setting up the calls. The voice channels so designated are used by the customers so long as they are located in the same cell.
FIG 2
MAJOR SUBSYSTEMS
FOR CELLULAR MOBILE
COMMUNICATION
37. The other function of MSC is to monitor the signal strength from the adjacent cells as the mobile user moves around. When confirmation is received that signal strength in the adjacent cell is stronger it sets up a procedure known as "hand-off" or "hand-over", whereby new pairs of radio channels will automatically be selected from the new cell site to enable communication to continue without serious disruption. The time normally required for this change of cell allocation to be carried out is very short, for example 0.05 seconds in the AMPS system, and hardly noticeable by the user.

38. The radio base station as shown in Figure 2a is the second major subsystem in cellular mobile telephone, which basically consists of transceiver, signal conversion and control system. With the assigned radio frequency (RF) and frequency band, it transmits radio signals for reception by all mobile units.

39. The number of available radio channels are far fewer than the number of subscribers to be served. As the likelihood of all channels being "seized" by more than one user at the same time is very remote, the dimensioning of channels is, therefore, based on a grade of service at peak hour traffic. For example, at a grade of service of say 2 percent, and with subscriber traffic load of 0.05 Erlang per subscriber, a ratio of 1:10 (i.e one radio channel for 10 mobile subscribers) would be adequate.

40. The control function of the signal received from a mobile unit is also carried out by the base stations by comparing the special signal transmitted to the mobile units with that of the return signal received from it. This information is fed to MSC to determine "hand-over" procedure.

41. The third subsystem in CMT is the cellular mobile unit which is basically of three types: vehicular, portable and hand-held. It consists of receivers for the radio signals, and a demodulator for the extraction of the audio part from the signal and a transmitter for the transmission of modulated RF signal to base stations. The mobile units also play an important role in conveying to base stations the required information on the quality of signals received. This function is carried out on a continuous basis through the reception of special signals transmitted from the base stations.

3.3. Comparison of Major Types of CMT Systems

42. Because of the development of cellular mobile communications in different countries at different times, the technical features and parameters of the systems so far developed are quite different. A number of systems have appeared in the world market, the main ones include AMPS, TACS and NMT. A brief description of each of these systems would illustrate some of the differences in the design and their possible applications.
3.3.1 Advanced Mobile Phone System (AMPS)

This system, which has gained wide acceptance in North, Central and South America, uses the 800 MHz radio transceiver at the base station. The frequency spectrum ranges from 825 MHz to 845 MHz in the receive mode and 870 MHz to 890 MHz in the transmit mode. With its extended version (i.e. EAMPS), the respective band allocations are 824 MHz to 849 MHz and 869 MHz to 894 MHz for the reception and transmission, respectively. It is an analogue system with capacity up to 416 radio channels.

3.3.2 Total Access Communication System (TACS)

In its allocation in the 900 MHz RF band, it covers the spectrum range from 890 MHz to 905 MHz in the receive mode and 935 MHz to 950 MHz in the transmit mode. The maximum channel capacity is 300, and is widely used in Europe, Japan and China. An extended version of the above technology has been developed making use of additional frequency band from 872 to 888 MHz in receiver and 917 to 933 MHz in transmit modes. It is an analogue system which employs a multiplexing technique of Time Division Multiple Access and Frequency Division Multiple Access (TDMA/FDMA).

3.3.3 Nordic Mobile Telephone (NMT)

This is the system which was developed by Nordic countries and comes in two versions: NMT-450, which operates in the 450 MHz band, and NMT-900 for the 900 MHz band. With maximum channel capacity of 180, the NMT-450 has gained wider application in Nordic countries as well as in Western and Eastern European countries, such as Belgium, France, Austria, Bulgaria, etc. The NMT-900 was designed to carry higher traffic and serve a much greater number of subscribers than NMT-450.

3.4 Development of GSM

All the above cellular systems are based on the analogue system designed to meet the basic operational and service features, which include:

(i) Capability to serve large number of subscribers;
(ii) Efficient use of the radio spectrum;
(iii) Nation-wide availability and compatibility;
(iv) Capability of providing services on vehicular and portable units;
(v) Provision of wired-telephone quality of service; and
(vi) Provision of hand-over capability.

47. Even though the above objectives are met in the design and development of CMT in Europe, America and Asia, the various countries use different radio spectra and modulation techniques with different channel capacities. For these and other reasons, it was not possible for a user to operate his/her mobile unit outside the boundaries of the countries for which the system was standardized. Acknowledging this draw back, the European countries, with unprecedented cooperation, launched as far back as 1982, the development of digital CMT through their regional organization the Conference Europeenne des Postes et Telecommunications (CEPT).

48. The working group established by this organization, Groupe Special Mobile, developed a new digital CMT operating in the 900 MHZ band. The system developed, known as the Global System for Mobile Communication (GSM) is now becoming a standard in all the European countries, and is gaining wide acceptance in other parts of the world. However, the parallel developments of different digital systems of CMT in the United States, the American Digital Communication (ADC) and the Japanese Digital Communication (JDC) operating in the 900 MHz of the radio spectrum, have reduced the truly world wide application of GSM.

49. The world, therefore, seems to operate with three standards, each operating in the areas and zones of their influence. GSM, judging from its wide penetration in Europe, Asia, and Africa would probably be accepted as the standard in the countries of the above continents. The United States, Canada, Central and South America would fall under the influence of ADC, while Japan could be the domain for JDC.\(^9\) While the overall design parameters and features of these systems are similar, one of the main differences in the above systems, however, is the channel frequency band they operate in. GSM uses 25 KHz band width while ADC and JDC employ 10.0 KHZ and 8.3 KHz, respectively. Because of the smaller channel band width allocation, the number of channels that can be made available in ADC and JDC will be larger than in GSM. Such a reduction in channel band width will result in a higher signal-to-interference ratio and would permit a 21-cell cluster configuration as compared to 9-cell cluster possibility in the GSM system.

50. Regardless of the differences mentioned above, the digital CMT systems are designed to

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provide better quality telephone service and additional features associated with ISDN, which, inter alia, include:

(i) Efficiency in the usage of the spectrum;
(ii) International roaming facilities;
(iii) Bearer of data and associated services;
(iv) Short message handling;
(v) Better security and confidentiality;
(vi) Possibility of operating with small hand-held mobile telephone units.

51. Future developments in GSM, ADC and JDC will require the application of systems to be used in much smaller cell sizes than are used at present. In principle it is possible to obtain more capacity per given area by reducing the size of cells. This will lead to micro and pico cell configurations where the number of channels that can be provided over a given area of coverage will greatly increase. For instance, a reduction of cell size by a factor of 10 would yield 100 times the channel capacity increase. Apart from this method, the voice channel coding method could also produce capacity increase. The reduction of the full rate voice channel coding from 13 Kbits/s to 6.5 Kbits/s is followed by roughly doubling the channel capacity.

52. The future therefore favours structuring of smaller cell size clusters to facilitate the Personalized Communication Service (PCS). With relatively greater number of subscribers to be handled in such small cells, the "hand-over" procedure will, however, be more critical. In the earlier analogue system, the network (i.e. MSC, RBS, and associated equipment), conducts the necessary measurements through the base station to decide from which cell the mobile unit should be served. This is known as the Network Controlled Hand-Over (NCHO). A new procedure which could take into account propagation conditions in the user’s environment would be of advantage.

53. This was achieved by distributing some of the logical functions of the network to the mobile units, in order to improve the hand-over capacity of the network. This is done in two ways: in the first one, the mobile units are assigned the task of sending continuously measured signal strength from the adjacent cells to the base station from which it is currently being served. With the additional data obtained from the base station and mobile units on the signal strength and quality of the currently established connection, the network can then make the appropriate

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decision. This procedure, known as Mobile Assisted Hand-Over (MAHO), can be applied in all the three digital CMT systems, i.e. GSM, ADC and IDC. It has the advantage of reducing the need for the network to make measurements in adjacent base stations, as decisions are made basically on the information reported by the mobile units.

54. Further improvement can, however, be achieved if the mobile unit takes over the whole control in the "hand-over". This is what is being done in the Mobile Controlled Hand-Over (MCHO) where, just as in MAHO, all the appropriate measurements are carried out by the mobile unit and the base station, but the final decision for hand-over to the adjacent cell is made by the mobile unit. In this system, assessment of rapid changes in conditions at the mobile site is improved. This procedure is currently applied in the Digital European Cordless Telecommunication, European Standard (DECT), and in Cordless Telephones 3 (CT3), the business cordless system developed by Ericsson.

55. Concerning the application of CMT, the trend indicates increased usage of the digital system for business as well as the general public. Increases in capacity and better quality of service were some of the factors which attracted more subscribers. As of 1993, there were 54 GSM networks established in 36 countries\textsuperscript{11}, with a total of over 403,000 subscribers. The application of smaller cells and the use of MAHO will establish the future base for the development of Personnel Communication Service.

IV. INTRODUCTION OF CELLULAR MOBILE TELEPHONE SERVICES IN AFRICA

56. In 1994, there were 14 African countries operating cellular mobile telephone systems with a total number of 278,299 subscribers. The predominant systems in operation are the Advanced Mobile Phone System (AMPS) and the Total Access Communication System (TACS). AMPS, which is the standard adopted in North America, operates in the 800 MHZ band while TACS is of European standard and operates in the 900 MHz spectrum. Some of the countries in North Africa have, however, introduced the Nordic Mobile Telephone system (NMT), which operate in the 450 MHz and 900 MHz bands (Table 6).

57. Lately, however, several countries have introduced the Global System for Mobile Communication (GSM) system. For example, South Africa has installed GSM system and achieved an unprecedented success by connecting 220,000 subscribers within one year from the date the system was put into service. Similarly, the Kenya Posts and Telecommunication Corporation (KPTC) has prepared plans to extend its mobile network using the new GSM technology, with a capacity to serve an additional 50,000 subscribers. Nigeria and Mauritius as well have decided for GSM system for their second CMT networks with capacities to serve 100,000 and 3,000 subscribers, respectively. Furthermore, Zimbabwe and Uganda are also planning to start operating GSM in late 1995, while Malawi and Namibia have committed themselves to GSM based CMT networks.

58. Although the data is far from comprehensive, the above examples tend to indicate a trend away from the earlier and currently predominant analogue systems (AMPS and TACS) towards the newer digital GSM systems. In particular, the countries in Southern Africa have all committed to the GSM system and if it is standardized, the potential for cross-border roaming will be created.

59. The general picture in the region as a whole is still that of a proliferation of many different systems and operational protocols which do not allow roaming capability. This lack of standardization may be explained in part by the fact that the installation of these systems in Africa are still dependent upon the source of financing, which often derives from the countries supplying the particular system. While the financial assistance is certainly appreciated at the national level, its impact at the regional level is not favourable in that cross-border roaming would not be possible. Furthermore, with different systems operating in the generally small nation-states in the continent, the possibility of cooperative arrangements for joint procurement of equipment is diminished. The logical conclusion one could reach is that CMT is being introduced in Africa purely on the basis of national priority to be able to meet the high demand for telecommunication services.
Table 6

CELLULAR MOBILE TELEPHONE SUBSCRIBERS AND OPERATORS
IN AFRICA: 1994

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>SYSTEM</th>
<th>YEAR INST.</th>
<th>NO. OF SUBS.</th>
<th>EQUIPMENT USED</th>
<th>OPERATORS</th>
<th>OWNER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>900- NMT</td>
<td>1989</td>
<td>3000</td>
<td>NOKIA</td>
<td>PTT</td>
<td>STATE</td>
</tr>
<tr>
<td>Egypt</td>
<td>800 PANASO</td>
<td>1979</td>
<td>2600</td>
<td>MATSUSHITA</td>
<td>ARENTO</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>800 TACS</td>
<td>1989</td>
<td>3000</td>
<td>NA</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>Gabon</td>
<td>800 AMPS</td>
<td>1992</td>
<td>1500</td>
<td>MOTOROLA</td>
<td>PTC</td>
<td>&quot;</td>
</tr>
<tr>
<td>Gambia</td>
<td>900 TACS</td>
<td>1992</td>
<td>430</td>
<td>MOTOROLA</td>
<td>GAMTEL</td>
<td>&quot;</td>
</tr>
<tr>
<td>Ghana</td>
<td>900 TACS</td>
<td>1992</td>
<td>2000</td>
<td>MOTOROLA</td>
<td>MOBITEL</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td>AMPS</td>
<td>1990</td>
<td>NA</td>
<td>AT &amp; T</td>
<td>CELTEL</td>
<td>MILLICOM/CDC</td>
</tr>
<tr>
<td>Kenya</td>
<td>900 ETACS</td>
<td>1993</td>
<td>1169</td>
<td>NEC</td>
<td>KPTC</td>
<td>PRIVATE</td>
</tr>
<tr>
<td>Mauritius</td>
<td>900 ETACS</td>
<td>1989</td>
<td>3700</td>
<td>MOTOROLA</td>
<td>EMTEL</td>
<td>STATE</td>
</tr>
<tr>
<td>Morocco</td>
<td>450 NMT</td>
<td>1987</td>
<td>7000</td>
<td>ERICSSON</td>
<td>PTT</td>
<td>EMTEL/PRIVATE</td>
</tr>
<tr>
<td>Nigeria</td>
<td>900 ETACS</td>
<td>1990</td>
<td>10,000</td>
<td>MOTOROLA</td>
<td>MTS</td>
<td>STATE</td>
</tr>
<tr>
<td>South Africa</td>
<td>C 450</td>
<td>1986</td>
<td>13,000</td>
<td>SIEMENS/ALC</td>
<td>VODACOM</td>
<td>NITEL/DCA</td>
</tr>
<tr>
<td></td>
<td>900 GSM</td>
<td>1994</td>
<td>220,000</td>
<td>MOTOROLA/ERI</td>
<td>VODACOM/MTN</td>
<td>&quot;</td>
</tr>
<tr>
<td>Tanzania</td>
<td>900 TACS</td>
<td>1994</td>
<td>250</td>
<td>MOTOROLA</td>
<td>STATE (MOC)</td>
<td>MILLICOM</td>
</tr>
<tr>
<td>Tunisia</td>
<td>450 NMT</td>
<td>1985</td>
<td>3000</td>
<td>ERICSSON</td>
<td>TELECEL</td>
<td>&quot;</td>
</tr>
<tr>
<td>Zaire</td>
<td>800 AMPS</td>
<td>1988</td>
<td>6500</td>
<td>MOTOROLA</td>
<td>Express Comm.</td>
<td>&quot;</td>
</tr>
<tr>
<td>Angola</td>
<td>800 AMPS</td>
<td>1990</td>
<td>1150</td>
<td>MOTOROLA</td>
<td>ENATEL</td>
<td>STATE</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>278,299</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
60. Another development of significance in the mobile communication market in Africa is the participation of the private sector. Out of the 14 countries included in the study, private sector participation can be found in five, namely:

(i) Ghana: where Mobitel of Ghana has joint venture with Millicom of USA, which holds 80 percent of the share capital.

(ii) Nigeria: Nitel of Nigeria in a joint venture with Digital Corporation of Atlanta, USA, operates ETACS cellular mobile network. A second joint venture arrangement is under way with EMIS to operate a GSM system with a capacity of 100,000.

(iii) Tanzania: The Tanzania Telecommunication Corporation Ltd (TTCL), in a joint venture with Millcom International Cellular (MIC) also plans to extend mobile services to Dar es Salaam, Zanzibar and the other major towns. MIC has 51 percent of the share capital.

(iv) Namibia: Mobile Telecommunication Ltd (MTC) has a joint venture with Telia International and Swedfund holding 26 percent and 23 percent, respectively, and the Namibian Post and Telecommunications Holdings 51 percent of the share capital. MTC operates a GSM cellular mobile network with a capacity to serve 8,000 subscribers.

(v) Zaire: Telcel is a private operating company owned by Zairian Micko Rwayitare, and provides cellular mobile communication service with the analogue 800 AMPS system, having a capacity for 8,000 subscribers. A second company, Express Communications also operates 800 AMPS system.

61. It is evident from the recent entry of the private sector in the development of CMT services in Africa that perhaps more will come in the near future (e.g. Uganda, Zimbabwe). Private capital would certainly make a significant contribution to the development of telecommunications in Africa where the demand for services far outstrips the capacity that the traditional public operators can provide. However, appropriate investment environment must be
created in order to attract private capital into Africa. This will entail, among other things, the establishment of clear private investment codes and transparent regulatory regimes in the industry.

62. Cellular technology can also be applied to provide fixed telecommunication services. For example, Ethiopia and Zambia have plans to install fixed cellular telecommunications systems to provide services in the rural communities of quality no less than that provided in the urban areas. The necessary plans are underway in Kenya to introduce wireless loop in the network. Similarly, in South Africa, the two CMT operators VODACOM and MTN, have already committed to instal a total of 29,000 phone shops in the rural communities using cellular technology. This application of cellular technology will be discussed in detail in Section VI of this report.
V. APPLICATION OF CELLULAR COMMUNICATION SYSTEMS

5.1 General

63. The technological advance in mobile switching equipment, as well as in radio transceivers and mobile terminal units have greatly expanded the scope of application of the cellular mobile communication system beyond its conventional domain of mobile customers into areas where it can complement, or in some cases offer alternative and economical choices for providing fixed telecommunication services. The alternative application in the extension of basic services to remote and rural areas, where conventional wired services would be too expensive and time consuming and in some cases not even practical, deserves serious consideration by the African countries. The ability for quick connection and the response to demands for telephone service in the suburban, remote and rural communities makes cellular technology a viable alternative for providing telecommunication services.

64. The possible applications of cellular communication can essentially be divided in two: the various services it provides under the general CMT coverage with or without the features associated with mobility (such as roaming, hand-over etc...) and the provision of access to basic telecommunication services (telephone, FAX, etc.) to under-served or un-served areas.

5.2 Application as a Cellular Mobile Communication System

65. An article titled "Customers Don’t Have Monopoly on Cellular Service" by Mr. Dale Fox, illustrates the benefits that can be accrued in improved quality of telephone services by providing field staff with cellular mobile terminals to increase their responses to fault clearing, installation, etc^12. He cited the case of Illinois Bell Telephone, a company with a work force of about 2500 technicians and 300 supervising managers, where information from field staff used to flow to the maintenance and operational centres through portable data terminals operating via land-line connections, which were normally accessible at the subscriber’s premises or distribution and connection boxes. The company’s decision to move the supervisors out into the field for better control of field activities, coupled with increased use of the portable data terminals by technicians, created the need for field supervisors and technicians to directly retrieve information on trouble reports, to perform appropriate tests and finalize reports, without the intervention or

assistance of the staff at the maintenance and operation centres.

66. The only alternative available was the use of mobile systems, but decision still had to be made between enhancing the mobile radio communication which the company was already operating then, or the adoption of a new cellular mobile telephone system. After careful consideration of the performance of both systems and its organizational impact, the decision was made to adopt the cellular mobile telephone system. The installed number of cellular mobile terminals in the work force then rose to 1300 of which 300 had data handling capability. The tangible benefits that were derived from the choice of CMT included the reduction of work load of the maintenance and operational centres, and an overall reduction of cost. A less tangible benefit, but equally important from customer relation point of view, was the avoidance of intrusion into private lines.

67. The other area of application of Cellular Mobile Communication which would have relevance to developing countries is the utilization of fixed cellular terminals for providing basic telecommunications services. In the case where cellular mobile telephone service already exists, it would also be possible to provide standard telecommunication services with some modification of the technical and operational features of the cellular mobile communications systems. For example, the charging principle can be reconciled with that applicable to customers connected to the fixed network; the normal mobility features associated with cellular mobile system can be constrained or disabled (i.e. roaming, hand-over, location monitoring etc.), and the subscriber numbering and routing plans can be integrated to reconcile with those in the fixed network.

68. Figure 3 illustrates the basic network architecture for accessing basic telephone service through the fixed cellular terminal. The arrow shows the main elements which constitute a cellular terminal for a single telephone line connection. The cellular network can be based on any of the CMT systems available in the market, i.e. AMPS, TACS or GSM. Fixed terminals can be provided to serve individual customers or they can be grouped in a concentrator to be shared by several subscribers. The latter scheme could reduce the cost of the fixed terminal and would in most cases be adapted to rural areas where the traffic generated by individual subscribers is relatively low.
ACCESS TO PSTN THROUGH FIXED CELLULAR TERMINAL

FIG 3
69. The above system could be of advantage to those telecommunication operators who already have installed cellular network covering wide service areas and are in addition required to offer basic telecommunication services which would otherwise be too expensive or time-consuming. For example, the Spanish public telecommunication operator, Telefonica, initially had procured from Alcatel an analogue system to serve 70,000 fixed cellular terminals. It later expanded this network by another 30,000 units, but this time with the digital version which can operate in the GSM environment.

70. In Eastern Europe, just after the downfall of socialism, the telecommunication operators faced the challenge to quickly integrate their antiquated systems with those in Western Europe. Taking the case of Hungary, for example, in 1989 it was operating with equipment designed in the 1930s. It was not difficult to observe the huge capital outlay it would require to modernize the network to the extent required to meet the high demand. The waiting time was so long, (an average of 12 years, and the estimated unmet demand was in the vicinity of one million) that a local joke circulating then was that "half of Hungary is waiting, while the other half is waiting for dial tone" depicted the status of telecommunication services at that time. The Hungarian Telecommunication Company had then prepared a long-term plan, which would have cost US 5 billion dollars, to increase its network to almost 960,000 lines and to cut the waiting time for connection to one year.

71. In the interim period however, it had to address pressing demands for connection especially resulting from Government's decision to move towards a market economy. This and other prevailing circumstances in the post socialism period led to the formation of a joint venture company, Westel Radiotelefon Kft, between US West and the Hungarian Telecommunication Company to operate a cellular mobile telephone system with a capital of US 10 million dollars, 50 percent of which was to be contributed by US West. The plan was to provide a system with a capacity of 50,000 lines. The system was inaugurated in October 1990 and the targeted connection of 2500 subscribers for the first three months was passed and nearly doubled. The traffic generated by the mobile subscribers was about the same level as that for the fixed locations. The average utilization of air time per subscriber and per month was two to three times that in the US, which was about 200 minutes. Demand for the cellular mobile service grew steadily that Westel had to increase the capacity initially provided. In 1995 the number of connected subscribers reached 47,500. Furthermore, two more operators were licensed to provide cellular mobile service, and the data received from one of them, namely Pannon GSM

13/ Telephone Engineering and Management, Aug. 1989
TRANSCOM/1020
Page 30

Tavkozlesi Rt, shows that 46,000 mobile units were installed as of August 1995. The Hungarian situation clearly demonstrates the contribution that CMT can offer in addressing urgent needs for telecommunication services and bridging the gaps where capacities of the existing network, especially the outside plant, fail to meet demand.

72. The phone-shop concept introduced in South Africa provides another example of the application of CMT technology to provide telecommunications services in remote low density areas. The system is based on a computer managed telecommunication service where a number of telephone lines, say ten, are fixed in a pre-fabricated container or in a room prepared for this purpose, and strategically located for the use of the general public. Each telephone line is provided with an individual display and metering unit (DMU) for monitoring the charges by the caller, and a master control unit (MCU) through which the operator controls calls from each telephone line. The customer has two options for paying: he can pay in advance, in which case the individual meter shows the amount remaining as conversation continues; or he can choose to pay on call completion based on the charges registered for the total duration of the call. If required, the operator can issue receipt to the customer from the printer attached to the MCU. Furthermore, the whole transaction of calls can be produced for each and all lines connected for traffic per auditing period, or per shift.

73. The required ten telephone lines can be provided through two-wire connection to the local exchange or through a radio base station as a fixed cellular subscriber. In the former case, the phone shops are designed to provide service at selected places in the urban areas. In the latter case, the phone shops are dispersed in remote and rural communities served by the CMT network. The two cellular network operators in South Africa, Vodacom and MTN, have already launched a programme to instal 22,000 and 7000 of such units, respectively. Such a system could provide solutions for access to basic telecommunication services to the communities in remote and isolated rural areas.

5.3. Radio Access System with Cellular Structure

74. Despite the demand which far exceeds the supply of telecommunication services in Africa as a whole, the utilization of the installed capacity of switching equipment is on average below 70 percent and yet the waiting lists of subscribers is over 27%. The major constraint to effective utilization of installed capacity is often the lack of local line plants. Extension of line plants is expensive and quite time consuming. The radio access system based on frequency reuse in a cellular structure provides an easy, flexible and fast approach in bridging the last leg
from local switches or remote subscriber stages to the customer. Its application for extension of services needs to be explored.

75. There are two approaches for providing local access telephone by means of radio, or wireless local loop (WILL). The first approach is to provide one radio channel for each two-wire loop per subscriber; while the second method employs concentration factors based on traffic volume, subscribers calling rate and the required grade of service.

76. The basic structure of the first version is shown in Figure 4 where the local switching equipment is connected to the radio base station on the basis of one subscriber number to one radio channel. The subscribers who are provided with fixed transceivers connected to a normal telephone apparatus enjoy the same services and are assigned the same numbering scheme as those subscribers who are connected on two-wire copper lines. The radio base station is normally located within the local exchange, and normal voice cables are used to connect the radio channels to the switching equipment. At a later stage when the network develops and requirement justifies, this same site could be used as one of the sites in CMT network.

77. The extent of coverage by the above system depends on the power of the transceivers in the base station and their antenna gain, as well as on the fixed subscriber radio terminal power and its antenna gain. For instance, a transceiver with 45w. output and antenna height of 80m and gain of 16db can cover an area of 30 kms when the subscribers are provided with a fixed radio subscriber terminal (RST) having an output power of 3w. If, however, a 5m yagi antenna is used to increase its gain to 10db. for the same base station parameters, the radio coverage would be adequate to provide services over a radius of 48kms. If the antenna height of the RST is doubled, then the services can extend over 70 kms radius14.

78. Since there is no concentration factor between the radio channel and the number of subscribers served in the above scheme, the cost of the radio channel per subscriber is relatively high. On the other hand, the system is simple; most of the work involves only the installation of RBS, which can be carried out within a relatively short time.

79. The second version of WILL system introduces a concentration factor which compels subscribers to share the limited resources of radio channels. The extent of this sharing is based

on grades of service considered to be adequate and on the calling rate of the subscribers. It is considered normally acceptable to base the channel requirements on 5 percent grade of service and 50m Erlang traffic per subscriber. Business subscribers could, however, generate far greater traffic which could reach 100m Erlang/subscriber. Figure 5 highlights the basic units of the radio access system referred to above. There are three basic units: the radio base station with its controlling and interface unit, the concentrator or switching interface module as it is referred to by some suppliers, and the subscriber radio terminal (SRT) to which an ordinary telephone, FAX or modem is connected.

80. The function of the radio base station is to provide a pool of radio channels to serve a number of SRTs and to supervise the quality of radio transmission when calls are in progress. The connections between RBS and concentrators are made through digital links (PCM cables or UHF radio) on the basis of one time slot per radio channel. Between the concentrator and the switching equipment, a dedicated time slot is allocated per subscriber, i.e. for each subscriber number a time slot is assigned on a permanent basis. On the path between concentrator and RBS, the available transmission links are for common use by all subscribers. The concentrator, or the switching interface module performs the function of registering the special identity number of SRTs associated with the dedicated time slot for each subscriber, so as to make the final connection to the correct SRT terminals.

81. The spectrum of the radio frequency commonly used for the above radio access system are 380-450 MHZ and 800-1000 MHZ. Although the lower frequency band is often congested with other services, it offers better propagation characteristics suitable for long distance coverage. But for areas which are expected to generate high traffic, the higher frequency band, i.e. 800-1000 MHZ is normally preferred.

82. With cellular structured distribution of the radio base stations and controlling units, it would be possible to develop a network to serve any desired number of subscribers. A network can also be designed on a modular scheme of, say, 1000 subscribers or any other convenient capacity depending on the system to be adopted. For example, based on RAS 1000 (Radio Access System), a network can be designed for 1230 subscribers with a traffic load of 100m Erlang at a grade of service of 0.5 percent. A system offered by Motorola where services to 1000 subscribers can be packaged with a grade of service of 5 percent and 50m Erlang traffic to be generated from each subscriber may also be cited. Working with such modularized units would simplify planning and budgeting and also the installation of radio wireless loop for areas of high or low traffic.
FIG 5
WILL FOR WIDER AREA
VI. COMPARISON OF COST AND PERFORMANCE OF WILL AND WIRED NETWORKS

6.1 Objective

83. In the foregoing sections the various applications of cellular mobile telephones were illustrated. This section focuses on the application of CMT in a fixed network where it can offer cost effective basic telecommunication services to areas where it would be extremely difficult to install wired networks. The time savings that can result is another factor which could influence the choice of fixed cellular mobile services in areas of difficult accessibility as well as to those areas where demand for connections should be met with minimum delay. A comparative study was conducted on the alternatives of wired and fixed cellular mobile networks in an African country.

6.2 Background of the areas selected

84. The selected areas are typically located in the outskirts of a main city, where through the assistance of the government and private initiatives, a large housing project was constructed. Even though plans were drawn for the basic infrastructure, such as access roads, telephones, and other public utility services, either they were not ready by the time the housing projects were completed, or the services provided were not adequate. This was at least the case for telephone services. There were many constraints that would have had to be overcome to provide adequate services to the area, the main ones include:

(i) The difficult terrain in which to install the subscriber cable network to provide reliable connection;

(ii) The absence of subscriber cables and the time it would take to construct the network for immediate connection to customers already waiting for telephone services; and

(iii) The coordination required with other utility organizations and the municipal authority to assign the right-of-way for the cable route which is often very difficult and time consuming and sometimes not even possible to obtain.
85. There are a number of technically feasible alternatives that could be explored to overcome the problems cited above, and fixed cellular mobile telephone is one of the technical solutions that can be applied in a cost-effective manner. As the distribution of subscribers in the area will be somewhat scattered, fixed CMT provides the flexibility required to connect subscribers located within the radio propagation area, thereby eliminating the uncertainty element of the exact locations of potential subscribers.

86. To illustrate cases where CMT could be economically feasible, cost comparisons were carried out between the fixed wired network and a fixed cellular system.

6.2.1 Cost of wired network

87. Figure 6 shows the two areas under consideration; the area designated as A has a very difficult access road, and is separated from the main city area by a big river. The rocky area around the river and the absence of any permanent right-of-way, and the narrow road leading to the bridge makes the construction of any kind of subscriber cable an expensive alternative. Even if decisions were made to proceed with the cable construction, the unavoidable damages and mishandling of the cable plants in the process of the inevitable road improvements and other construction works to be carried out in the future would degrade the quality of the cables and seriously affect the dependability and availability of the services to be provided.

88. The cost of laying the cables especially along the section from the main exchange up to the centre where secondary distributions of the cable network are made, should include the cost of special protective measures to safeguard the cables from any possible damages. Considering the difficult terrain of the area to be covered by the cable network and the expected high incidence of cable breakdown and damage, the alternative to lay copper wire cables on the site would not be a sound engineering choice. The most advisable solution in the long run would therefore be installation of Remote Subscriber Stage (RSS) at the appropriate locations in Area A, and a digital radio junction line link to the local exchange. The other alternative is the installation of a fixed cellular telephone system, if necessary with a directional antenna to cover areas around it. However, the choice to install RSU will require coordinated construction of a building, as well as the installation of switching equipment and local cable network within Area A. The CMT alternative, on the other hand, requires only the installation of the radio base station and switching interface or concentrator, and the connection of subscriber units as requests come.
89. For the area designated as B, where the cable route is not as rugged and difficult as that in A, normal protection measures can be employed for the cables. As the right-of-ways along which the cables are to be laid are not fixed, experience shows that the cables will not escape from damages and interruption during the inevitable road improvement works to be carried out at some future date.

90. The cables to be constructed are assumed to be connected to the new proposed exchange site, where a new switching equipment would be erected to serve the surrounding areas including A and B to serve an estimated 1000 customers requiring immediate connection, and based on 476.2 USD of installation cost per line pair and allowing 20 per cent additional pairs for flexibility of the cable network, the cost of a wired network would be 476.2 x 1200 = 571,400.00 USD

6.2.2. Cost of wireless local loop (WILL)

91. For each of the above areas A and B, a WILL alternative can provide an equally or better service. For the case chosen in this paper the two cells serving each of the areas shown in Figure 6, and the cell sites located within the local switching equipment can provide adequate coverage for basic telecommunication services. There is no blocking structure nor mountains which would adversely affect the propagation conditions. Since the systems are normally designed to cover a radius of 20-25 kms, there would not be any degradation of signal strength to affect communication quality.

92. As the equipment configuration and cost parameters are the same, the costs for each cell are identical. Furthermore, system capacity considered for each cell is 1000 subscribers and the traffic load assumed is 50 m Erlang/subscriber at a grade of service of 5 percent. The cost of equipment per subscriber based on the above assumption is:

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Main equipment (SIM + RBS)</td>
<td>750 per line</td>
</tr>
<tr>
<td>(ii) Fixed subscriber terminal</td>
<td>500</td>
</tr>
<tr>
<td>(iii) Total cost per subscriber</td>
<td>1250</td>
</tr>
<tr>
<td>(iv) Cost for 1000 subscribers</td>
<td>1.25m</td>
</tr>
<tr>
<td>(v) Cost for 1000 subscribers plus labour and transport</td>
<td>1.3m</td>
</tr>
</tbody>
</table>
6.2.3 Cost Comparisons

93. Comparing the investment costs under the two schemes, it is observed that the WILL alternative is two to two-and-half times as expensive as the wired network. But the time it would take to install the new exchange and lay the required subscriber network is quite long. It is estimated that, without taking into consideration the procurement process, at least 1 to 1.5 years would be needed to have the wire-based system ready to connect subscribers. It would require an additional half-year to connect 1000 subscribers. The WILL can, however, be installed in a much shorter time of 3 to 4 months, and the system would then be ready for connection of subscribers.

94. If we consider a time difference of one and half years between the wired network and the WILL option, the revenues that would be generated during the above period would be USD 400 x 1000 x 1.5 (average revenue/sub/yr x No. of sub x No. of yrs) = 600,000 USD. The additional 50 USD connection charge per subscriber would bring the total revenue to 650,000 USD. This amount practically offsets the additional initial investment cost of the wired network, which as already noted above, was estimated to cost 571,400 USD. Investment cost of WILL, less the revenue expected to be generated in the one and half years (i.e. 650,000), nearly matches the cost of the wired network, not counting the social and economic benefits to be derived by meeting the demand for services within the short period.

95. The above comparison is made for the area designated as B in Figure 6. For Area A, the wired network would not be technically feasible for the reasons already brought out above. The WILL alternative is therefore the preferred option to provide telecommunication service to the area. In addition to these targeted areas A and B, possibilities will be created to meet urgent demands in Area C, which is already being served by wired network, but not enough to provide the required connections. In the long run when network extension is implemented, with the erection of more exchanges and construction of additional line plants, the WILL equipment can easily be converted to serve as one cell site equipment for a cellular mobile telephone network of the future.
FIG 6
SKETCH FOR POSSIBLE APPLICATION OF CMT
VII. CONCLUSIONS AND RECOMMENDATIONS

96. It is clear from the above analysis that the development of telecommunications in Africa continues to fall short of the demand for services which continues to increase, partly due to the general awareness of the population about the importance of telecommunications in their daily activities, be they personal, social or business. Cellular communication technology seems to offer an attractive alternative because of the range of services it can offer, especially the mobile aspect, and also for the possibility for much faster installation.

97. The cellular communications technology is making major in-roads into the African telecommunication market. In 1990 there were only six African countries offering cellular mobile telecommunications services, namely, Algeria, Egypt, Morocco, Tunisia, Mauritius, South Africa and Zaire. That number almost doubled to 11 in 1992 and is approaching 20 by the end of 1995. While the early systems are analogue, the more recent ones are nearly all digital, with GSM becoming the preferred standard.

98. Another characteristic of the cellular mobile telecommunications systems in Africa is that they are being introduced in a very uncoordinated manner, with different systems in adjacent countries. This approach will limit the exploitation of capabilities such as cross-border roaming. It is noteworthy, however, that the countries in the Southern Africa region have seen the need for standardization and all seem to have committed to installing the GSM.

99. The migration to the digital CMT systems also has the advantage that the digital systems offer more value-added services, provide better quality of service and improved security.

100. The cellular concept employed in the normal cellular mobile telephone system is increasingly being adopted as a basis for wireless access system to provide basic fixed telecommunication services to suburban and rural communities. The system allows for direct connection of radio channels to the local switching equipment, thereby eliminating the need of mobile switching exchange. It enables the efficient use of frequency through frequency re-use schemes, and of radio channels through sharing mechanisms provided in the design of the system to connect a large number of subscribers depending on the calling rate from customers and the grade of service desired. The major advantages of the cellular application for fixed telecommunications services are:
(i) It enables fast connections to critical areas of demand where the wired network does not have the capacity for additional lines;

(ii) It permits cost effective provision of basic telecommunication services to suburban areas where wired networks would be expensive and time consuming;

(iii) It creates the possibilities for providing basic telecommunication services to areas where terrains and environmental conditions make the wire networks not a viable engineering option; and

(iv) It provides cost effective means to offer the rural community equally good telephone services as those available in urban areas.

101. The application of the radio access system or the wireless loop enables telecommunications operators to provide basic access to telecommunication services. Thus the systems can play an important role in reducing the waiting list, to meet critical connection demands in the urban centres, and address the demands in the rural and suburban areas. It is, therefore, recommended that African Administrations seriously consider the technical and economic merits of radio access or wireless loop system to reduce constraints faced in their existing network in meeting critical demands for telecommunication services in both the suburban and rural areas.

102. One of the factors that had influenced the fast development of cellular communication in the world was the changes made in the regulatory framework, allowing private companies, business groups, and independent operators in the operation of cellular mobile communication services. The competitive atmosphere created thereby benefited the customer as the services provided became cheaper and the quality of service much improved. Accelerated expansion and improvement of services with additional features through the application of digital technology have also been made possible. Some countries in Africa such as South Africa, Ghana, Nigeria etc. had made similar changes in their regulations and have achieved satisfactory results in the expansion of the cellular network. Restructuring the existing telecommunication organizations and limiting their monopolistic role and also introducing competition on the new and advanced telecommunication service would contribute towards the development of telecommunication network and services. It is, therefore, recommended that necessary changes be made in the regulatory framework to allow and encourage private sector participation in the
development of cellular mobile communication services in order to enhance fast development of cellular network and also the use of state-of-the-art technologies.

103. The concept of phone shop based on fixed cellular technology as introduced in South Africa deserves serious consideration by African telecommunication operators. It does not only extend services to rural areas, but also provides opportunities for small scale entrepreneurs to run phone shops as private business. Thus the major telecommunication operators would be promoting entrepreneurship by subcontracting such services to private individuals.

104. The services envisaged under the phone shop concept was the result of negotiations between the government and the two cellular operating companies, where the latter committed part of their resources to the improvement of telecommunication services in the rural communities. This approach, which invites private companies to invest in a relatively less profitable area and yet contribute significantly to the development of the basic telecommunication services, is worth emulating. In principle, therefore, when negotiating for the provision of new and value added services, the competing companies should be requested to contribute towards the development of the telecommunication infrastructure in the rural communities. It is therefore recommended that:

(i) The phone shop concept deserves serious consideration by telecommunication organizations and all appropriate measures should be taken to encourage their implementation;

(ii) African countries should include in the terms of conditions and rules for operating value-added and advanced telecommunication services by competing private companies or business groups, a provision by which these companies commit themselves to play a part and contribute to the extent possible towards the development of rural telecommunication services.

105. The cellular mobile communication systems introduced in Africa were of different types, thus not permitting the use of the same mobile unit in all the African countries. Adoption of a common system at regional and sub-regional level would have positive impact on the development of CMT in Africa. It would permit international roaming and facilitate the preparation and implementation of operational agreements on cross-border traffic. Furthermore, it would establish a single system on which all African operators could cooperate in the development of the type of services most relevant to Africa. In addition, it would create the
basis for establishing the manufacturing of the various units and subsystems in Africa. In consideration of the above points, it is recommended that:

(i) Each sub-region, through its appropriate meetings and conferences, should create a committee to discuss the economic and technical issues regarding the adoption of a single standard of cellular mobile communication system in Africa, and to monitor future development and application of the system;

(ii) A follow-up action should be taken to organize and establish at sub-regional levels the mechanism for common purchasing of equipment;

(iii) Each sub-region should consider developing the capability for manufacturing components, parts, units and subsystems of cellular mobile communication systems for the countries of the sub-region in order to adapt CMT systems to Africa’s needs; and

(iv) PATU should be given a major role in the coordination and implementation of the above recommendations.
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