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Impact of the introduction and utilization of new technologies on the commercial and regulatory environment of telecommunications

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REPORT ON QUESTION 3/1

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Introduction

Developing countries are often faced with many developmental problems in the area of telecommunications. One of the main problems in the telecommunications arena is what telecommunication technologies and systems should be employed. It is a problem that applies to both operators, incumbent and prospective, and administrations.

Operators are usually keen to know what new technologies are available. Once, having learnt about a new technology, an operator may then wonder how the technology can be employed in the marketplace in the country of concern, in order to solve communication problems. A fair amount of understanding of a technology and its main characteristics are required in order to make good marketing decisions.

Likewise, administrations, in contemplating what initiatives to take with regard to a new technology and its applications, need to know its main characteristics, especially in comparison to some other technologies. The question of whether spectrum should be allocated for a technology to be employed is fundamental and usually a crucial one. It requires a certain amount of depth of understanding of the technology, its main purpose, benefits and role in the marketplace.

The potential role and benefits of many new technologies, in the markets of developing countries particularly, is of great importance to both operators and administrations in those countries. Not only may the new technologies enable developing countries to come closer to developed countries in their level of development; it may also enable them to leapfrog over technologies that are now in the process of becoming outdated in developed countries.

This document's purpose is to provide an overview of new telecommunication technologies that are available today and that have the potential of greatly enhancing telecommunications, therefore also business and the economy, in developing countries.

Implementation of these technologies and their success, in economic terms, require entrepreneurship on the part of prospective or existing operators. In discussing certain issues relating to operators and their possible markets, the document aims to provide some food for thought for stimulating entrepreneurial thinking. In discussing selected regulatory issues, the aim is to stimulate a thought process that could contribute to effective regulatory facilitation by administrations. The issues, for a large part, arise from the experiences in countries where the technologies have been implemented or are in the process of being implemented.

Throughout the document, the emphasis is on the more important issues. In no way is it claimed that all the matters which need to be considered, by operators and administrations, in employing a technology in a country are covered.

This document includes by way of examples some specific technologies and applications. The document does not intend to cover all the new technologies being developed. It is suggested that, for this purpose, reference be made to other ITU studies dealing specifically with new technologies. In particular, the ITU-D Study Group 2 is studying this matter, as for example in Questions 1/2, 2/2 and 4/2.

1 Review of the question

The question deals with a rather complex issue which also has a direct impact on the other questions. First of all, one would have to identify, even in broad general outline, the technologies under discussion. There are a number of new technologies involved, including wireless, mobile and global communications. Regarding the impact, one has to assess this upon business environment and regulatory issues. The commercial impact can span from the migration of customers from the existing services to new ones to the lack of adequately trained human resources to deal with the new issues.

On the regulatory front, one has to ensure that the regulator's human resources are able to deal with the issues arising from the introduction of the new technologies. New technologies which bring about new applications pose a number of regulatory issues which, unless effectively handled, will inhibit the growth of the sector.

2 Prerequisites for introduction and utilisation of new technologies and services

Whatever the commercial or regulatory conditions, it should be standard practice that a study is made before any decision is taken for the realisation of a telecommunications programme. This study would deal mainly with the financial and human resources which one has at his disposal to satisfy the service demand and utilisation of new technologies. The most complete study defines the technical and economical feasibility of the project, as well as the technical and technological choices and also the best way to secure funding for the project. In the case of new services, one has to keep in mind two main considerations:

- that the majority of new services use the existing telecommunications infrastructures; and
- the time factor becomes extremely important considering the nature of the needs and the technical evolution.

In the case of new technologies, which would be better installed on new networks than on the existing ones, one has to consider the extremely heavy financial costs. Thus, the necessary prerequisites for the introduction and utilisation of technologies and services are:-

- the existence of funding and the appropriate human resources for the modernisation and maintenance of new installations;
- the taking into consideration of the short- and long-term needs for the political environment and the global strategies necessary for the realisation of the relative studies for the introduction and utilisation of new services and technologies.

2.1 Existence of funding and human resources for the modernisation of the telecommunications infrastructure

The funding needs in most countries remain disproportionate to the financial resources available in the existing conditions for the utilisation of new technologies and services.

New Services

The range of telecommunications services which can be provided for end-users is now extremely broad. At one end, we have the Plain Old Telephone Service (POTS), at the other, interactive video, not to mention the numerous intermediate value-added services, offering features such as mobility. Of course, each of these services can be further subdivided within its own category, according to performance and quality levels offered.

However, the assignment of funds for the development of the basic services yields a very low percentage of turnover when considering the fact that this will satisfy all customer needs (thus, covering only a small part of the population).

In this scenario, various options are to be considered by the public operator:

- co-funding or the creation of joint ventures
- regularisation of the market to accept new operators
- external subsidies.

These ways do not alter much the mechanism of high technicalities to assure the installation and maintenance of new services.

New Technologies

With the introduction and utilisation of these new technologies, we know that, in many countries, most telecommunication networks are obsolete. This makes it necessary that the required investments be more significant given that the countries do not have sufficient resources to modernise their network. Thus, one has to resort to external funding for the modernisation of telecommunication networks. This funding will only be obtained under several conditions and its acceptance is finalised by the signature of a financial agreement, without which the project cannot materialise.

It should be noted that, in the case of new services, human resources are the principal resource necessary for the development and the consequent utilisation of the telecommunication network.

2.2 Taking into consideration the needs in the outline of the strategic plan

Considering the number of new services, the pressing and diversified needs and the magnitude of the technological innovations, it is advisable to include all this in the outline of the strategic plan. As a general rule, one cannot speak of the planning of a telecommunication network without analysing the context in which this network will be built and functions. This is especially true for the networks of low traffic zones, for those with new technologies or using new services. In this context, the economic, financial and technical factors must be carefully considered and it is always advisable to bear in mind the return of the initial investment.

The strategic plan will take into account the following factors:

- The choice of the investments and costs, guarantees, the reimbursement of the initial costs of services, and the identification of the most feasible course of action.
- The taking into consideration of the social interest of the project regarding health, education or the improvement of the quality of life.
- The procurement of better funding and the minimisation of current costs so that there is a rapid amortisation of initial costs.
- The choice of the technology which best integrates with the existing network, which offers several applications, and therefore, can be set up without delay and projects in the future.

The strategic plan should also insist that:

- the tariffs will be a part of the planning and business development process; and
- the regulations in force follow the evolution of the needs and of the demand.

2.3 Factors which influence the willingness and the decision to introduce and use new technologies and services

Operator requirements are by nature different from, and occasionally contradictory to, those of the regulatory bodies or even those of the operator's own customers (be they the service providers or the end users). And requirements vary even more among operators in the competitive environment.

The operator's strategy will differ considerably, depending on whether it is an established operator (a former monopoly) or a new operator. The former will, above all, seek to hold on to a substantial market share while establishing a position in new segments (mobile for example).

The new operator may either take on an established competitor in head-on competition, or establish itself as a distinctive provider of a more attractive service (better price or higher quality), or, alternatively, also focus on new segments.

Similarly, a distinction must be made between developed and developing countries, in which services, access to services, economic development policies and a number of specific environmental factors must also be taken into account.

Apart from financial and regulatory differences, one key differentiating factor between these operator types is their existing telecommunications infrastructure state. Established national PTOs already have a significant quantity of infrastructure commensurate with the state of the country's telecommunications development. On the other hand, newly created operators may have either no existing infrastructure at all (likely if they are to be a dedicated telecommunications provider) or significant infrastructure currently used for other services than telecommunications. Some of this infrastructure may be very effectively reused for telecommunication operations.

The provision of new services is market driven. This is most apparent in a deregulated environment where fear of loss of market share and desire to maximise profits are the major drivers, but is also evident in monopoly, government-owned organisations where impetus is provided by the requirements to satisfy the electorate, the need to provide for large organisations, the desire to maintain the country's status and the fear of deregulation.

The introduction of new technology is not influenced to any great extent by the will of the telecommunications service provider; old technology is, by definition, no longer freely available and if the service provider needs to replace time-expired equipment or to expand its network, it must, by default, buy new technology equipment. This equipment provides the facility for new services.

Below are some factors which influence the willingness and the decision to introduce and use new technologies and services:

- **The current basic infrastructure** (i.e. analogue, digital, part and part, cable, satellite, etc.) – At times an infrastructure which is not *state of the art* gives the opportunity to the operator to leap-frog technology and introduce *state of the art* services, this course of action may have the disadvantage of not giving enough time to the human resources within the operator to grow and develop gradually with the technology as and when it is introduced.
- **Pressure of market demands –** Many times when a demand exists it is quite simple to satisfy that demand. However, a problem arises when the demand cannot be quantified (i.e. when the operator has to generate that demand). In the latter case, it would be advisable to carry out pilot studies to calculate the extent of the project's feasibility.
- **Positive investment appraisal results –** The more the appraisal results are favourable, the more the project will be implemented.
- **Liberalisation of markets** and provision of services in neighbouring countries generate internal pressures – The world is normally divided into major blocks and what a country does has an affect on its neighbouring countries. Therefore, if these countries liberalise their markets, this in itself can stimulate the demand.
- **Awareness, understanding and implications of new technologies** – This is a question of Human Resources and the more sophisticated the knowledge of HR, the greater the awareness, understanding and implications of new technologies.

  Sophisticated knowledge of these technologies will ease their implementation and, with regard to consumer knowledge, this will open the market more easily and generate a demand for the product.
- New technologies provide a means of **fast and/or low cost deployment of services** to places where conventional technologies have not been proven to be feasible. New technologies, e.g. WLL and GMSS, can be a cost-effective means of providing telecommunications services in rural areas, where the conventional wired telecommunications system is not cost-effective.
- Utilisation of modern information technology in support systems is of growing importance as regards the efficiency of human work, quality of service in the broad sense, cost control, etc.

3 Commercial impact of the introduction and utilisation of new technologies and services

New technologies can provide large amounts of affordable, manageable, high quality bandwidth. This enables segments of industry to relocate operations to countries with cheap labour, but to continue to provide service in the home country via telecommunications. This arbitraging of labour rates has a commercial impact in both locations, both in the general economy of the countries concerned and in the opportunities for the telecommunications organisations.

Much has been made of the capabilities of the new technology to provide refile, call-back, etc., and this is indeed a very real threat to the minor players in the telecommunications world. If these processes go unchecked, the small (mainly monopoly, government-owned) service providers could be severely commercially compromised by the major organisations in the USA and Europe. This would adversely affect the introduction of new technologies or the expansion of basic service in the countries concerned.

The technology necessary to provide call-back has been available for many years. What is new are the techniques now being used to provide easier access to the call-back user. The "bombardment" method effectively extends dial tone from the call-back operator's country to the user. It occupies an international circuit almost permanently for each user, but with no revenue accruing to the service provider until an actual call is initiated by the call-back user. The commercial impact on the service provider of these quasi-permanent, unpaid-for, leased circuits is obvious. The grade of service impact on other users is disturbing.

These new technologies cannot just complement the existing systems but can be virtually in competition with existing systems. The most important thing is to introduce these systems to give a wider range to customers and, thus, have the latest technologies.

Governments around the world are being forced to re-evaluate their telecommunications policies in the light of rapid technological advances. In the developing nations, it is increasingly recognised that improved access to communications brings substantial economic benefits, and that sustained development is impossible without an adequate telecommu nications infrastructure. Shortage of capital and a regulatory regime that does not fully support national telecommunications goals are the main barriers to progress in this area.

In most developing countries, the development of the telecommunications infrastructure has often taken a back seat to other national priorities, such as agriculture, health care, roads, etc. Since publication in 1984 of the Report of the Independent Commission for World-wide Telecommunications Development, it is now generally accepted that development of the telecommunications infrastructure is an essential component of national economic development, that it is not so much national wealth which creates an adequate telecommunications infrastructure, as an adequate telecommunications infrastructure which creates national wealth.

For governments facing competing demands to finance vital infrastructure projects, there is a dynamic policy and regulatory tension between, on the one hand, the obligation to provide universal access to basic telecommunications and, on the other, the perceived benefits from privatising the national telecommunications monopoly. In particular, potential investors in what most likely has been a slow-moving government monopoly will want some assurance that the policy and regulatory environment will be conducive to continued telecommunications development.

The imminent availability of GMSS should provide a way forward. GMSS promises telecommunications bandwidth on demand anywhere on earth, so universal service obligations can therefore be largely met through the efforts of GMSS operators. The main hindrance to the GMSS operators is, however, the presence of restrictive national regulation, and, in some cases, an absence of a regulatory framework within which to license GMSS operators. By focusing attention on the need for an open and fair regulatory environment, the benefits to the economically emergent nations can be more effectively realised.

Telecom operators in many countries are concerned that mobile earth stations and GMPCS terminals will bypass local networks and they will derive no revenue from use of such terminals.

However, instead of trying to prevent the use of mobile satellite services, authorities should consider the socio-economic benefits of such use, especially in areas where there are no alternative means of communication. The real challenge for these authorities is not trying to prevent bypass, but rather creating an environment conducive to the availability of such services, one from which their country can extract the maximum possible benefits.

4 Impact on regulation by the introduction and utilisation of new technologies and services

4.1 Introduction

Assessing the impact on regulation by the introduction and utilisation of new technologies and services depends on many factors. These include the regulatory framework of the country, the political and economic policies, the level of telecommunications development, the historical background of how new technologies are incorporated, etc. More specifically, whether the country has an existing monopoly or competitive structure, whether a separate regulatory body exists, and whether regulation is meant to control or to empower the marketplace, have a greater impact on regulations than that of new technologies *per se*.

Where a monopoly structure exists and where the monopoly player acts as regulator as well, then the impact on regulation of the introduction of new technologies will be minimal, if any.

Here it is the monopoly player who decides whether to introduce new technologies, whether it be based on having no other option (unavailability of old technology to maintain their existing networks), or for political reasons of pleasing the electorate (where a government monopoly is involved) or keeping up with the neighbouring countries. In fact, in many of these cases, there are no existing regulations but only policies of the operator which may or may not be published.

Nevertheless, there is still some "regulatory" impact even in the above scenario, if one looks at the impact where 1) convergence is concerned, 2) globalisation of telecommunications and 3) introduction of new applications such as Telemedecine, Electronic Commerce, etc.

New technologies have had the greatest impact, however, in helping to break the "natural monopoly" argument to sustain monopolies. Governments are beginning to decide to introduce new domestic and international players. New technologies here play the role merely as catalysts for the adoption of new policies rather than being the cause of the regulatory impacts in themselves. (Many countries have still chosen to remain a government or private monopoly which will exploit these new technologies to provide new services rather than allowing in new players, having no regulatory impact.)

Where competition is then introduced, however, then the impact on regulations will be the greatest. The impact over the creation of new regulatory frameworks, including new regulatory bodies, can be seen. The transition from government monopoly to a corporatised monopoly, to a private monopoly, to partial competition, to full competition, etc., brings with it its own levels of impact on regulations.

However, some economists believe that later, once full and free competition exists, there will again be a minimal role and impact on regulations. The “invisible hand” of the market place should then take over as the regulator. It has yet to be seen whether such ideal competition can exist in the telecommunications world, given the existence of already giant entities such as Global One, Concert, etc. Some level of antitrust and fair competition laws, on the domestic, regional and international level, may still be required.

In summary, it has been noted that there will be varying computations of regulatory impacts faced by each country, depending on its policy direction, e.g. whether to have monopoly or competition. Therefore, this paper will focus on those common areas that are faced by most countries irrespective of their competition policies, etc., as noted above. These are 1) convergence, 2) globalisation of telecommunications and 3) introduction of new applications such as Telemedecine, Electronic Commerce.

It will be useful to note that, in these instances also, the impact on regulations will not be just for telecommunications regulations, but for other areas of the law such as broadcasting laws, computer laws, investment laws, enforcement laws, competition laws, content laws, etc.

4.2 New Technologies and Services

Several of the contributions submitted to Question 3/1 have discussed in detail many new technologies and services. Although a clear distinction between technology and services was not drawn, the contributions in general spoke about developments to improve existing infrastructure such as Intelligent Networks, ATM, Frame Relay, etc., of new and alternative infrastructure such as fiber optics, cellular networks, VSATs, GMPCS, and of new services enabled by these new technologies, such as E-mail, EDI, video-conferencing, refile, call-back, IDD, etc. Others discussed new applications of these services such as Telemedecine, Distance Education, etc.

As mentioned above, the following section divides these various new technologies and services discussed in the contributions into categories, based on the common areas elaborated above, in order to demonstrate better the clear regulatory impact of each new type of technology and service. In addition to these categories, wireless technologies have also been added as a separate category, given the latter’s own impact on regulations, and the fact that many of the contributions to Question 3/1 also discussed this in detail.

4.2.1 Digitisation/Convergence

The first and most significant impact on regulation can be said to be brought about by digitisation. Digitisation has caused the marriage of the telecommunications industry, the broadcasting industry and the computer industry.

Whether or not we are talking about a government monopoly structure or a competitive environment for telecommunications, these different industries, i.e. telecommunications, broadcasting and computing, have different players (again either government monopolies or competitive providers), different rules and different regulatory bodies. These have now been brought together. Regulations and policies for these industries had been previously treated separately, with separate frameworks and with their own regulatory bodies, if any.

An extension of digitisation allowing for the merger of video, data and voice transmissions has also lead to new applications, such as the ability to trade stocks globally over the telephony network, allow for Distance Education, etc., bringing together a totally different set of industry regulations and regulators into the picture as well. This will be discussed under the next category.

4.2.2 Information Society Applications

New telecommunications technologies have brought about many new applications such as Telemedecine, Telebanking, etc. Each of these applications traditionally has its own area of the law, again with separate regulatory bodies, if any. The effectiveness and application of these laws are being challenged today by new technologies.

More fundamentally, these applications are now taking us through a state of transition from an industrial society, characterised by rigid production and management processes, with the objective to optimise capital utilisation, to a service society where the primary resource is information and knowledge. Access to telecommunications, and thereby information, is becoming the key to gaining a competitive advantage in this new information or service society. Not surprisingly, therefore, new bodies such as the World Trade Organisation (WTO) are becoming involved in telecommunications because of these applications.

NOTE – According to the Harvard Business School writer, Kenichi Ohmae, in his book “The End of the Nation State”, “On old economic maps, the most important cartographic facts had to do with things like the location of raw material deposits, energy sources, navigable rivers, deep water ports, railroad lines, paved roads, i.e. national borders. On today’s map, by contrast, the most salient facts are the footprints cast by TV satellites, the areas covered by radio signals and the geographical reach of newspapers and magazines.”

4.2.3 Globalisation

There are many aspects to the issue of globalisation. One could speak about the globalisation of telecommunications from the perspective of *greater inter-connection* between the different types of telecommunication networks, especially with digitisation. This has allowed for greater international communications and the creation of the Global Information Society. The Internet is probably the best example of the creation of a truly global network. The Internet is a very grass roots network, and as long as a country has some level of basic international connectivity, it cannot cut off the Internet. Its citizens can always dial into a neighbouring country to get its access.

NOTE – Also referred to as the Global Information Infrastructure or the Global Information Economy.

One could also speak about globalisation from the perspective of the various joint ventures and mergers, leading towards the emergence of *mega-carriers and global service providers*, such as Global One, Concert, WorldPartners, Financial Network Association, etc. As countries liberalise their telecommunications markets, these global providers have been able to offer true global connectivity by offering end-to-end managed networks and services. In fact, many own their own global networks, instead of having to lease capacity from others. This is indeed a new phenomenon, as it departs from the old regime where each country provided its own telecommunications networks and services, and international communications was all about interconnectivity and interoperability between various national systems.

An additional perspective, on which the contributions to the Study Group focused most of all, is the development of new satellite technology allowing for *greater global mobility*, such as Very Small Aperture Terminals (VSATs) and Global Mobile Personal Communications by Satellite (GMPCS). GMPCS has been the most remarkable, despite the fact that mobile satellite communications have been in existence since the time of INMARSAT services. What has changed is that the satellites have become more affordable for private entities to own, the handsets have become smaller, cheaper and more user-friendly, thereby creating a new mass market for direct satellite services.

This is different from the past, where GEO satellites were considered very expensive, orbital slots were scarce and frequencies limited, creating some sort of natural monopoly, and satellites were either only launched by nation state monopolies or monopolies working together through organisations such as INTELSAT and INMARSAT. Even the satellite earth stations were expensive to build and antennas were so costly and huge in size that, again, many countries gave their provisioning to a government monopoly. Enforcement of this monopoly was easy as it was difficult to hide an earth station operation, or try to smuggle terminals into the country.

Later, however, mobile satellite systems and VSATs became popular with Multinational Corporations (MNCs), who have global operations and need to create their own networks to locations that are not properly wired. These terminals and the service were, however, still not affordable to all and they were still large enough to be controlled at the operational and customs level. Today, satellite technology has advanced and GEO satellites are already being operated by private entities. Also, the satellite dishes have already become much smaller and more affordable, such as VSATs and some INMARSAT terminals.

GMPCS, on the other hand, are being offered by global operators with portable and mobile user terminals at affordable prices. Taking into account its technical, regulatory and socio-economic nature applicable to the regional and global telecommunity, the first World Telecommunications Policy Forum (WTPF) was convened under the auspices of the ITU and produced five Opinions. In particular, Opinion 4 (GMPCS-MoU) was adopted to facilitate circulation of GMPCS user terminals with detailed arrangements including type approval, licensing, and access to traffic data, together with recommendations on custom duties. At the request of WTPF Opinion 5, the BDT Director established an Expert Group to assist the developing countries by producing a checklist of factors which can be used for granting licences, organizing regional workshops, and studying various impacts of the GMPCS. The tasks of the Expert Group have been recorded in the Report of the BDT Director which were submitted to the World Telecommunication Development Conference, Malta, 1998.

4.2.4 Wireless Communications

Wireless communications *per se* are not new. Many of the points raised for satellite technology also apply here, except that in this category it is being looked at from a domestic and not cross border perspective. Even longer than satellites, radio telecommunications have been around for more than seven decades. Infrastructure costs to put up a microwave dish or radio station were still rather significant, and implementation and running the service were not easy. More importantly, there was such great strategic significance placed on radiocommunication that many countries preferred to have it under a government or private monopoly.

Today, cellular technology and wireless local loop technologies are offering cheaper, quicker and better alternatives to fixed as well as existing wireless technology. Many countries are already using it as a complementary service and while others with poor basic wired telecommunications infrastructure are using it as a basic infrastructure.

The huge gap in telecommunications development in some countries is forcing policy makers' hands to introduce competition where these wireless technologies are concerned. Since the service and handsets have also become more affordable, smaller and more user-friendly, this has also created a new mass market and, with it, new regulatory and policy issues.

4.3 Impact on Regulations

The various country contributions were grouped into certain categories. For each of these categories, the impact on regulation is discussed below.

4.3.1 Digitisation/Convergence

Digitisation has brought together three distinct areas of the law. They are:

a) *Facilities Regulation*

Telecommunications regulation, both domestically and internationally, has primarily been about facilities regulation (regulating the infrastructure itself).

Telecommunications facilities included infrastructure such as fiber optics, satellites, radio, copper wire cabling, etc., basically communication through electromagnetic means. The rules of the game were devised to ensure the smooth implementation of communications. National sovereignty was still an important point for most countries, and therefore telecommunications were controlled within borders either by government monopolies or national companies. Communications between countries would then meet at some halfway point to connect and complete a call.

National and international rules of the game were therefore needed to ensure that calls were completed (such as settlement guidelines). There were other issues, such as communications for safety of life at sea and harmful interference of the air waves. Since satellites used the limited orbital slots for GEO position, international coordination was also necessary. In the past, most of these extensive regulations were found at the ITU, since national monopolies were self-regulated.

Today, with increasing privatisation and competition being introduced, domestic regulatory bodies are being created to perform similar functions, and new domestic regulations concerning facilities regulations are being devised. These rules include spectrum allocation, quality of service standards, type approval of equipment, rights of way, etc. More often than not, these bodies are under the purview of the Ministry of Communications.

In either case, these domestic and international rules related primarily to infrastructure carrying public voice or point to point communications generally available to the public. Private voice networks, data and video, until recently, were treated separately. Point to multipoint networks were treated as broadcasting, while private voice and data were considered as internal communications and therefore unregulated unless there was interconnection with a public network.

b) *Content Regulation for Public Broadcasting*

Content regulation was not applied to telecommunications or common carriers, as telecommunications were traditionally about point-to-point communications, and content was generated by the end user and not the telecommunications company However, broadcasters who used these facilities to do point to multipoint transmissions, regardless of whether they were the creators of the information, were regulated by content laws. The public here was considered as merely passive receivers of the information, often thrust on them unwillingly, and laws were therefore set up to protect the public interest.

This is unlike telecommunications, where the public uses the telecommunications facilities to transmit verbal content that they create (i.e. conversation) and for which the telecommunications carrier, as a mere transmitter, cannot be held liable. Laws such as privacy, libel, copyright, pornography, decency, defamation, etc., existed to ensure a certain level of community standards for society. This was the case, even if the broadcaster was not the generator of the information, but was liable as “republisher”. These rules similarly apply to other non-telecommunications media such as print publications.

In addition, there were separate regulatory bodies regulating this content industry, usually falling within the purview of the Ministry of Information and the Arts. In Singapore, for example, telecommunications regulation falls under the Telecommunications Authority of Singapore (under the Ministry of Transport and Communications), while broadcasting falls under the Singapore Broadcasting authority (under the Ministry of the Information and the Arts).

c) *The Information Technology or Computer Industry Regulations*

This is a relatively unregulated area. Computers were previously stand-alone devices, and therefore, at most, the laws relating to industrial and property rights, with regard to hardware and software, applied here.

Later, distributed computing and smaller PCs were developed, with Local Area Networks (LANs), Wide Area Networks (WANs) and, today, Metropolitan Area Networks (MANs). With these developments, communications were still carried out within a company either located within a building or connected virtually as one. As such, these communications were considered internal and no broadcasting/content regulations applied.

As for the network itself, since it was usually located on the same floor of a building or within the building, it was considered outside the ambit of infrastructure/telecommunications regulations.

Today, digitisation and modems have brought many internal networks virtually together with public networks, and these fine lines may no longer be valid. Those from the computing world would, however, prefer to see deregulation of the telecommunications industry rather than regulation of their industry.

Regulatory impact of the convergence of these three distinct areas of the law

With the digitisation of telecommunications, companies are now using the public network to expand their LANS across streets, cities and states, and their private International Leased Circuits (ILCs) to expand their corporate networks across national borders.

Many countries have, however, chosen to treat these networks as closed user groups, thereby falling outside the ambit of traditional public network and content regulations. Other countries consider them as “value added networks” and license them separately, without allowing for shared use or resale of excess bandwidth to third parties. Others, meanwhile, allow for resale and sharing of these ILCs, which really stretches the definition of a closed user group or value-added networks, especially with Virtual Private Networks (VPNs) and the Internet. Today, in actuality, many companies such as SITA and IBM are offering their corporate networks to third parties, thereby already competing with the traditional telecommunications carriers even within countries which have not yet introduced competition.

Another example of the challenge of convergence on regulations can be seen with the advent of the Internet. Is a user who sends an e-mail broadcast to a mailing list or a newsgroup a broadcaster and therefore be bound by broadcast laws? Will a telephone company that provides a video dial tone or, for that matter, a video on demand service be regulated as a broadcaster? Will a broadcaster who also provides voice and data communications over its network be regulated by telecommunications regulations or broadcast laws, or both?

Convergence has clearly challenged traditional borders between laws. In the US, where convergence and the Internet first appeared, regulators and policy makers are still grappling with convergence issues. Many countries are only now considering allowing cable companies, for example, to provide voice communications, and vice versa. What is clear is that laws in this area need re-examination and redefinition.

Courts and legislators are being confronted by cases of convergence. Recent US cases regarding the potential liability of Internet Service Providers (ISPs) for defamatory material put on the network by their users, and the recent Telecom Law 1996, making them liable for indecent material on their network, have caused concern to ISPs who see themselves as being no different from telecommunications companies, i.e. as mere access providers. As public as the Internet may have become, e-mail is still point to point (as in voice communication, and so content is generated by the user) and web sites are not point to multipoint (the basis of broadcasting laws) but rather multipoint to point. They are not unsolicited but solicited by the user. Because the implications are not clear and convergence has blurred lines between areas of law, answers will not come easy. These lines become even more blurred as users use the Internet for video broadcasting and voice over the Internet.

Internet Service Providers are still resisting being regulated by traditional broadcasting laws (as is the case in countries such as Singapore). Even in the US, the new Telecom Act 1996 tried to make Internet Service Providers liable for pornography over the Internet, which is still being vigorously challenged in the courts, and the debate goes on.

Another big issue is the question of whose jurisdiction these various new technologies will fall under. Domestically, in Singapore, for example, Internet infrastructure is regulated by the Telecommunications Authority of Singapore, while Internet content is regulated by the Singapore Broadcasting Authority. ISPs literally therefore have two licenses from two different agencies for the same activity. Apart from jurisdiction turf battles, the industry is never clear which regulatory body will jump on them at any one time.

The main problem in this area lies in the different basis of the law and the different mentalities to regulations. The computing world was a relatively informal and unregulated world, compared to telecommunications or broadcasting, and they would like to keep it that way. This difference in approaches to regulations is being challenged today on the international front, particularly where the Internet is concerned.

The Internet, which runs over the telephony infrastructure using the TCP/IP protocol, has come to be known as an infrastructure in its own right, given the ubiquitous global connectivity it offers. Unlike the telecommunications world which created the ITU in 1865 to ensure global connectivity, the Internet is a very grassroots effort with little or no formal institutions. Standards over the Internet are created by very informal groupings of volunteers meeting as the Internet Engineering Task Force, and the Internet Society, the closest “international body” for the Internet, is made up of individuals from around the world paying a fee into a non-profit body.

Even IP addresses and domain names, which technically speaking belong to the US government, are monitored by informal or semi-formal bodies made up of individuals or membership organisations, offering their services to keep the Internet running. As scarce resources, IP addresses and, arguably, domain names can be equated to frequencies, orbital slots and numbering schemes in the telecommunications world, yet the future governance structure of the Internet world is still very uncertain.

A strong clash of cultures of people from the telecommunication and business world and that of the Internet and computing world is becoming very apparent. Those from the Internet world want to continue the informal structures, with little or no regulation. They would also prefer to see competition for these scarce resources rather than having any one entity take control and regulate the Internet. The telecommunication and business world, on the other hand, is very concerned about the lack of legitimacy and the informal structures in place today. They feel that this may have worked in the days of an academic and Research and Development Internet, but not for a commercial Internet where big money is involved. Not surprisingly therefore, the efforts by the self-appointed International Ad Hoc Committee to solve the top level domain name problems has differing reactions from differing camps.

The clash of cultures over regulation and regulatory frameworks are only just beginning, both on the national and international fronts. The Internet has merely hastened the debate which should be taking place, in light of convergence. Domestically in the US, cable companies want the right to provide telecommunications services, but they may not want to abide by common carrier regulations, such as rate regulations, etc. Likewise, telecommunications companies are vying to enter the video and broadcasting markets, but may not be ready for the consequences of facing broadcasting laws. Internet service providers in the US are enjoying freedom from many laws as they are considered as value-added providers, and now that they also can and want to provide voice over the Internet, they are also resisting claims by telecommunications companies that they should be bound by common carrier laws, such as quality of service and rate regulation. The debate continues.

4.3.2 Information Society Applications

Many of the regulatory challenges involved in the area of applications of these new technologies have, in some way, been covered by the convergence issue of the Internet. For example, the issue of who will be liable for copyright infringement or defamation over the Internet. These new applications of telecommunications, which support the Information Economy, bring together different areas of the law which may cause domestic, regional, and international laws to conflict. More importantly, they have come to challenge our traditional concepts of regulation.

Traditionally, a lot of these areas of the law have been treated on a territorial basis. For example, doctors are licensed and certified to practice only within a certain city, state, or country. Little has been done to ensure mutual recognition of standards, as very few doctors actually practice outside the place they are certified in. The same is applied to other professional jobs such as lawyers, brokers, teachers, etc., or for other service industries such as financial institutions.

Today, with global telecommunications, many cross-border or cross-state activities are going on all the time. Distance education fills the gap of not enough qualified teachers in some places, and Telemedecine allows doctors across the world to exchange diagnosis and information about patients, etc. The value of these applications is enormous and it has helped propel us into the Information Society. Yet, often the laws of each country have not caught up with these advances. Some of these questions may be asked:

- Is Telemedecine legal?
- Can Electronic Commercial Documents be used as evidence in court?
- Are Tele-Financial Transactions legal?
- Do Copyright Laws apply on the Internet?

Technically speaking, for example, legal advice given over the Internet can be considered illegal in many countries. The laws in some countries may not allow for lawyers to practice law there without being certified in that country. What about virtual banks or credit card transactions over the network? Again, these may violate financial laws in that country. The question then remains of whether the law is stiffling these developments, and should the law be changed or not?

Some of the areas of law affected include:

- fraud;
- security;
- intellectual property;
- financial;
- privacy;
- censorship or decency;
- contract.

These laws have more to do with the nature of the transaction involved and the content, rather than the networks or medium over which the transactions are made. The medium allowing for such transactions to take place anytime, anywhere, to anyone, is what has exacerbated the problems. Even if the laws within that country are strictly enforced, often the perpetrator is outside the country and the regulations are unlikely to be effective.

Some countries are already beginning to address these issues. For example, Singapore amended its Evidence Act to allow for electronic documents to be treated as evidence in court. Others, such as Malaysia, are attempting to legislate cyberlaws to attract multimedia companies to Malaysia. Most countries have not begun to address these issues, as they are focusing on basic infrastructure development, especially if they are still dealing with very basic issues such as a poor telecommunications infrastructure.

The former ITU Standardisation Sector (ITU-T) Study Group 1 has drafted “Suggested guidelines on operational aspects regarding content” with a view to assisting ITU Member administrations to cooperate in order to resolve these issues regarding the regulation of content services, within the framework of national sovereignty. The WTO, under the General Agreement on Tariffs and Trade (GATT) Uruguay Round on Services, did try to raise some cross border professional services issues, but were strongly opposed by lobbyists. The World Intellectual Property Organisation also looked into copyright infringements in an electronic world during the December 1996 Diplomatic Conference.

In deciding which laws to amend, it is important to make the distinction between areas clearly falling within the control of national jurisdictions, and areas where international and regional cooperation or rules may be needed. There is indeed a strong move towards regionalisation and globalisation in the new Global Information Society, and the trend is also more towards soft laws than hard laws.

4.3.3 Globalisation

Greater global interconnectivity

In the first aspect of globalisation, i.e. the greater interconnection of different telecommunication networks, some of the most pressing regulatory impacts can be seen in the area of the Internet. The Internet and other such globally ubiquitous technologies have indeed challenged the traditional basis of laws based on national sovereignty. Even if there may be a chance to locate the offender, the offender is in another jurisdiction where the “crime” may not be considered a “crime”, making it difficult to prosecute. These involve issues of conflicts of law, etc. which are difficult areas of the law in themselves.

For example, although a country may try to control content on the Internet by regulating it, the fact that content is so ubiquitous globally, can be produced anywhere or it can be produced in one place and posted on a website in another place, makes it difficult to control the creation of content. As for the access to content, placing filters at the point of entry into the country is again difficult, as not only are there huge amounts of data passing through the network on a daily basis, but also filtered users can find other ways to access the information. For example, the user can dial into a neighbouring country which does not control the Internet in order to access the information.

Creation of global/mega carriers

The second aspect of globalisation, the creation of global service providers and mega carriers, involves concerns that these carriers fall outside the ambit of any single regulatory system. Often, the provider may have but a virtual presence in any one country, and its country of incorporation may have taken a hands-off approach to regulating it as a Multinational Corporation. Many regional bodies such as the European Commission are attempting to apply national and regional antitrust laws on these bodies (while others are calling for global antitrust laws to be developed under the World Trade Organisation) but, until there is a global antitrust body, these entities can never fully be regulated.

Global technologies

Some of the general regulatory and policy issues which have been developed in the Expert Group (Opinion 5) under the ITU Development Sector cover national sovereignty, licensing criteria and policies, frequency spectrum availability, as well as issues related to the assurance of fair competition in the new global marketplace.

One advantage of GMPCS systems is their ability to provide global or regional coverage regardless of geographic or topographic obstacles. This advantage raises questions about traditional national security and sovereignty concerns. Security-related concerns can be placed into four broad categories: assistance to law enforcement authorities, national security concerns, legal interception, and policies on encryption of radio signals. These security concerns can be ensured in accordance with the Law Enforcement and Security Agencies in each country that govern national telecommunications operators including GMPCS. In addition, GMPCS are or will be technically capable of national routing, location determination, legal interception, positioning and monitoring of calls. These technical functionalities will allow the national governments to ensure national security and sovereignty, especially in the context of unauthorized use.

Most of all, licensing has been the traditional policy instrument for regulating technological expansion and ensuring competition in the telecommunications sector. No unified global policy on licensing criteria exist to date, especially for the GMPCS. However, licences for radio-based communications have traditionally been requested for providing service and frequency use, by various national governments. Licensing itself can represent the most effective way of regulating the development of a competitive telecommunications market to some extent.

Taking into account the new dimension of GMPCS, licensing requirements can be differentiated in accordance with the segments: e.g. space, ground, and users.

Space segment licences are granted by the single home country, which submits the appropriate notification to the ITU in accordance with the Radio Regulations. This creates an effective way of balancing the needs of a government to monitor and manage its use of the radio spectrum, and the needs of GMPCS and other satellite operators to get spectrum assignments for the respective systems.

Ground segment can be defined as a part of an operating network that operates from a country's territory, generally referred to as gateways or earth stations. Earth stations are the link between one or more terrestrial networks and the satellite. Such licences, however, need to be granted only by countries in which an operator is building and operating the gateway. In such cases, the relevant government may want to take into account a system's use of the local infrastructure, or the interconnection between the gateway and the public network. Most of GMPCS systems plan to have such ground facilities in limited countries (e.g. 10-100).

In case of **user segment**, most national governments need to issue the applicable licences for provision of GMPCS services in their territory. It is highly recommended to ensure fair competition among various GMPCS systems based on light-handed, transparent, and non-discriminatory rules and regulations. Licensing use of GMPCS terminals is another essential component of providing global services. It is important that user terminals be licensed in a way that does not require every user to register or obtain a licence for their individual terminal; to do so would make GMPCS impractical. For this reason, GMPCS operators, service providers, manufacturers and governments alike have agreed within the framework of the ITU that the most effective way to manage the circulation of terminals is to grant "blanket" or "class" licences. In doing so, a government allows that all terminals with an agreed-upon mark can be brought into that country's territory and used. Such licences take into account the use of frequencies in which the terminals operate and include authorization for the terminal equipment itself. For customs purposes, user terminals may be considered among a traveller's personal effects.

Opinion No. 4, on the preparation of a Memorandum of Understanding (MoU) to facilitate the free circulation of GMPCS terminals, as well as the GMPCS Group of Experts dealing with Opinion No. 5, on the implementation of GMPCS in developing countries, are analysing and discussing many of the above-mentioned issues, and the output of their deliberations was reported by the end of 1997.

The ITU, as exercised on the GMPCS issues, has been actively trying to adapt to the new world of privatization and globalization by allowing sector members or private sectors to participate in its activities. Although this is a good first step, much more thought and work are required to look at the long-term implications and its relevance to the real world.

4.3.4 Wireless Communications

National Spectrum allocation and assignment

Wireless communications (both terrestrial and satellite) can certainly help developing countries in particular to lessen the gap in their telecommunications development. Without appropriate frequency allocations, however, a nation loses the opportunity to develop this new technology.

In countries with a monopoly structure and where the monopoly is self-regulated, the issue is merely whether the frequency has been allocated to that country, and whether the monopoly provider (also countries without a regulator) decides to use that frequency. If it is already in use, the operator may decide to terminate the other service and start a new one, or if not, it will decide how to use it efficiently and not cause harmful interference to its other services. In short, there is no regulatory impact, just a decision by a monopoly operator on how to manage its own spectrum usage.

In Morocco, because of the separation of operational and regulatory functions, even the government monopoly has to acquire these frequencies from the government. Here a decision is made by the regulator, but very little other regulatory impact is seen.

In a competitive environment and where a government regulator is involved, each new technology introduced will require the regulator to allocate and manage spectrum. For this, the regulator will have to devise spectrum allocation and management policies to decide who gets the spectrum, etc., to ensure fair and transparent opportunity for all. As for the methods and policies, some countries may decide to use public auction to allocate to the highest bidder while others on a best qualified tender basis. Here, regulatory impacts can be seen as the market competes for scarce resources and the regulator plays a key role to ensure the growth of the market.

Spectrum allocation for global services

While national administrations are subject to the ITU Radio Regulations, the issue of how regional and global systems will be affected by spectrum needs will have to be addressed on a regional and global basis. With the recent privatisation and competition in satellite systems, and particularly the development of the GMPCS system, the ITU's method of frequency and orbital slot registrations of "first come first served", is severely under attack. The goodwill approach of accommodation and coordination of new systems with existing ones may not work in a private, competitive world.

Even World Radio Conferences (WRC) to allocate frequencies for global services become very heated, and after the frequencies are allocated, there may be one regulator in the world licensing these services, thereby acting as the *de facto* regulator of the world.

Global mobile/wireless communications have indeed caused the greatest national and international regulatory challenges.

4.3.5 Other General Issues

Where a country decides to introduce competition, then there are several regulatory impacts. Of course, these impacts are similar whether mobile is the cause of competition, or whether a country starts by introducing value-added service competition first.

Need to separate the operator functions of the government from the regulatory functions

The transition from a monopoly-based government telecommunications environment to a corporatised monopoly, to a private monopoly, to full or partial competition with domestic and/or international competition, requires institutional arrangements to ensure that government policies can be implemented. Although these arrangements will vary widely from one country to another, the process must be objective, transparent and non-discriminatory.

Clearly, this can only be achieved by separating service provider and regulatory functions, which may therefore involve the creation of an autonomous regulatory body or government agencies which are at arm's length from the service provider functions (this is usually coupled initially with the corporatising of the government monopoly).

Need to have clear network and service licensing procedures

Licensing becomes more important in a liberalised environment and is normally applicable only to the service provision or network operator market sectors. The main decisions are: which services should be liberalised, whether there should be a limit to the number of licenses and what are the conditions imposed on the licensees (e.g. universal service, quality of service, etc.)

Licensing procedures are, of course, largely determined by the legal and policy framework of the respective country. Some countries choose to adopt the "first come first served" approach, while others, the selective licensing approach. The latter is one where the regulator intends to license only one or a few operators, and preference may be given to applicants who have proposed or are able to demonstrate technical, economic or social advantages. Another method is the preferential licensing method. For example, cable TV companies may be licensed to provide additional telecommunications facilities and services, while a public telecommunications operator may be prohibited from entering the entertainment sector, at least for a limited period.

There is a debate going on regarding the licences/authorisation required for GMPCS systems. The national sovereignty of countries has to be fully respected. On the other hand, through some form of regional or global harmonization of laws, practical ways and means should be identified so that this process will not be so cumbersome as to impede the progress of this type of technology.

Need to rethink type approvals and licensing procedures in a global environment

Many of the national type approval and licensing of terminals standards and laws of the past were based on purely national services. ITU Radio Regulations RR2020, for example, states that no transmitting station may be operated without a license. However, where global services are concerned, this would mean that separate licenses would have to be obtained for every terminal used in every different country.

As for terminal type approval, adopting global standards, mutual recognition, etc., are some ways forward to avoid bureaucratic hassles. The CEPT countries have already developed recommendations to facilitate cross border and/or use of mobile transmitters/receivers by visitors. More specifically, the CEPT believes that it is desirable for its members to have common regulations at their disposal concerning the type approval, the marking, the free circulation and use of mobile earth stations. See also WTPF Opinion No. 4 and the MOU on free circulation of terminals.

Network Interconnection

New entrants to the telecommunications market, whether providing network services or equipment, will need to interface with the incumbent network in order to effectively enter a new market. To avoid, also, pockets of new services, there may be the necessity to ensure interconnectivity between the new networks. Regulatory policies controlling interconnection arrangements between the new entrants and with the established operator(s) will have to be developed. Some regulators have chosen to take a very active role in interconnection agreements while others, for reasons of lack of resources only, step in as arbitrators. Other issues faced by the regulator include issues regarding numbering portability and open standards.

Pricing

To avoid price wars between the new entrants and the established operator, and to ensure non-predatory pricing by the established operator, regulatory policies regarding pricing will have to be established to ensure competition. Either cost-based pricing or a cap on rate of return are some of the methods adopted by countries globally. The actual system adopted will depend again on the policies of the country involved.

Tariff structures and the introduction of new technology and services are linked in two ways. The first arises from the fact that many of the commercially important services involve either repackaging of existing services with attractive pricing or discount mechanisms or other marketing price attractions. The second is whether the pricing policies provide the necessary incentives for the operator to introduce new technologies and services.

Universal Service

Many of these new technologies and services, such a GMPCS, WLL, cellular, VSATs, etc., provide great opportunities for countries to provide universal service. However, just leaving it up to the market place alone is often not enough. These new entrants may only want to serve lucrative sectors of the market. Therefore, having relevant universal service policies in the regulations or license conditions may be necessary to ensure that it happens. This has been successfully implemented in Mexico.

From the operators' perspective, these new technologies have changed the cost structures so drastically that it is no longer as unaffordable to provide universal service as before. To them, the key issue would be whether the country adopts regulatory policies that allow for the introduction of these new technologies, thereby ensuring universal service. GMPCS operators in the ITU Forum agreed to voluntary principles to ensure global availability and affordability of their service. Such industry agreed-upon policies will help add weight to country policies to open up to global services and competition, and, when substantiated with national universal service policies (whether in the license contract or in the regulations), will help ensure the success of these polices, provided, of course, that they are not onerous.

4.4 Observations

4.4.1 Digitisation/Convergence

There are no clear solutions to these convergence issues, and to a large extent it will take a body of case laws, a series of complaints and incidences, etc., before new laws can be clearly defined and adopted.

Many countries should, however, take the first step by making the separation along the lines of infrastructure versus content, rather than the traditional telecommunications, broadcast and ITR lines. These also involve the creation of new regulatory bodies and laws along these lines, for example, a Communications Authority and Information/Content Authority, or merging existing ones into a single regulator. Malaysia is the only country studied that was actively creating cyberlaws to encourage the growth of cyber industries.

Whatever regulatory bodies or laws created, it is useful to keep in mind that laws have traditionally been reactive rather than proactive, and often for a good reason. Future problems and difficulties are not easy to predict, and being too proactive could mean stifling new technologies or industries. Also, countries who are still dealing with very basic issues, such as poor infrastructure, may not be ready to deal with convergence regulations.

Countries should, nevertheless, keep in mind that laws in these areas need re-examination and refinement, as they may already stifle industry as they currently stand. The situation today demands that lawyers, regulators and policy makers look at these issues with open minds.

4.4.2 Information Society Applications

Many of the above recommendations on convergence apply here too, except here it applies to other areas of the law than those covering just telecommunications, broadcasting and Information Technology.

Countries should re-examine copyright laws, medical professional laws, legal professional laws, commercial laws, etc. Here, it is important to keep in mind that first and foremost, each country has to define for itself what its country policies are before considering the necessary changes to the law. For example, a country which wants to promote Telemedicine should then consider how to modify its existing laws, otherwise, technically, doctors from outside their jurisdiction cannot give medical advice without authorisation. This will of course have to be balanced by ensuring laws to protect client confidentiality, etc. There will be some balancing between differing goals in determining the necessary laws.

Another example can be seen in the recent WIPO conference directed at amending the copyright laws to apply to the electronic medium. Here each country has to carefully balance the rights of copyright holders over this new medium versus not putting an onerous burden on transmission providers such as Internet Service Providers (ISPs) to be liable for the infringing material. The initial proposal was to put strict liability on Internet Service Providers, and this would have certainly stifled the industry. Not only are ISPs not usually the generators of content, but they have little or no control over the information the end users put on the Internet. WIPO has now left to individual governments the decision of whether to make ISPs liable, and it will become important for each country to determine the necessary balance according to its own national needs.

4.4.3 Globalisation

For the issue of greater global connectivity and the Internet, countries should study Internet governance and current policies, in determining how they want to regulate such global technologies. It is crucial that the telecommunications world try to understand the Internet world, and vice versa as the time has come to make crucial decisions on the survival of such technologies (for example, IP addresses becoming scarce resources and issues regarding allocation and management become key). Likewise, where jurisdictional and sovereignty issues here are concerned, close regional and international cooperation will be key to suppressing commercial fraud, hacking, etc., on the Internet.

For issues regarding mega carriers, countries should actively cooperate regionally and internationally to study the implications of this globalisation. It may be necessary to consider adopting national, regional or international antitrust laws to avoid the creation of oligopolies.

For issues regarding sovereignty, countries should re-examine whether merely asserting one’s right to national sovereignty will work in today’s global society and economy.

It is recommended that working out reasonable solutions, “soft law” solutions, with industry will be the step in the right direction.

Since there is no pan-national body to which these entities are accountable, countries will have to coordinate with each other and with the providers to ensure that their interests are not compromised. At the ITU WTPF, for example, countries worked out a compromise with providers that they be given access to the providers’ traffic database so that they can determine if there has in fact been unauthorised access. Without this cooperation, and merely passing strong laws, denying access will only make bypass more tempting.

Participation versus Bypass

GMPCS has been promoted as a technology that can enhance a country’s telecommunications access as well as traffic, rather than as bypass. This service may still be more expensive than fixed-based services, and users may wish to use it only where there are no local facilities. The real challenge for policy makers and regulatory authorities is not trying to prevent bypass, but rather maximising the availability of these services. They can, for example, consider alternative ways of making new revenue, such as:

- License fees
- Fees charged by accounting authorities, billing organisations
- Rental of mobile earth stations or GMPCS equipment
- Revenues from traffic which would not have otherwise taken place
- Investment in the MSS or GMPCS operator
- Providing value-added services such as One-stop shop service provision, etc.

Where these new services are to be promoted as global services, then national and international regulations will have to be reconsidered and amended accordingly. Some measures that countries should consider to encourage the spread of GMPCS services are, for example:

Free Circulation of Terminals

Harmonising their type approval and licensing of terminal equipment by mobile users. There was a recommendation in one of the contributions to the Study Group that countries look to the CEPT recommendations on free circulation of terminal equipment for guidance.

Meanwhile, ITU Radio Regulations 2020, requiring each earth station to be licensed, should be re-examined in light of the small and numerous terminal equipment used as “earth stations” and to avoid unnecessary cumbersome licensing and approvals in so many diverse countries around the world.

Customs Duties

There appears to be different customs duty around the world on mobile earth stations. The recommendations made in the contributions to this Study Group point towards calling for an elimination or reduction of these customs duties to a reasonable amount.

Accounting Authority

As mobile users travel from country to country, there has to be a mechanism in place to ensure the payment of bills, etc. Until recently, this payment mechanism has been the Accounting Authority (AA). Reference in this context is to be made to ITU-T Study Group 3 Recommendation D.90 which deals with “Charging, Billing, International Accounting and Settlement in the Maritime Mobile Service”.

Service Provider Concept

It was also recommended, in the Study Group contributions, that existing AA and Routing Organisations could become a service provider offering not just accounting and billing services, but in future act as a one stop shop and derive revenues from the traffic they bring under an agreement with one or more land earth station operators.

Universal Service

It is recommended that countries work with these global service providers to ensure universal service and affordability, either through contractual agreements or MOUs, or through licensing and regulations. These should be considered if that is the goal of the country.

4.4.4 Wireless Communications

Spectrum allocation and management will be the key issue here, irrespective of whether it is the monopoly who provides the service or competition is introduced. Without an allocation, implementation of new technologies will be delayed. Where there is competition, clear spectrum allocation laws are required to ensure equal opportunity among new entrants. Spectrum management laws are needed to avoid overcrowding, harmful interference and inefficient use of these limited resources.

In a competitive environment, Mexico has chosen under its new law to allocate frequency through a transparent and fair procedure of auctions. Other countries may choose selective allocations based on technical, economic and social indicators.

Countries should study models used by other countries and determine what works best in each country's environment. In any case, what will be key is skilled personnel to manage the procedures and understand new technologies. Sometimes, choices will have to be made in the light of limited resources, and it is crucial that personnel involved are able to make needed judgements. Training and experience will be crucial.

As for international allocations and management of frequencies, the system currently used within the ITU is under debate. Will the cooperative method of frequency registrations and the coordination process of orbital slot allocations still work in a very competitive and multibillion dollar industry? Will world conferences which allocate badly needed frequencies to provide global services be too slow a process? Once allocated, who will be the "regulator" of these frequencies?

Countries should consider examining these and other similar questions within the ITU in determining the future regime for global services offered competitively through private operators.

4.4.5 Other General Issues

The main regulatory issue confronting countries today is how, when and for which market segments to introduce competition. As was pointed out earlier, this usually has more to do with economic, social or political reasons, although new technology does have a strong role to play as a catalyst for these decisions.

When considering whether to introduce competition, it is important that each country makes clear the goals it is trying to achieve, and then it can decide which sectors to liberalise, if any, and whether only domestic and/or foreign competition is to be allowed. Countries should study experiences of other countries in making such decisions.

Once a decision to open up to competition is made, the next key step would be to separate the regulatory and operational functions of government. This again can be done through corporatising the operational arm, or through privatisation. The type of regulatory body (i.e. whether a Minister, a government arm, a statutory body or an independent autonomous unit) will largely depend on the legislative and political history of the country involved.

Each model will have to be adapted to fit a country's specific needs.

The next step will be to put rules and regulations in place to ensure fair competition. These will include clear licensing procedures, network interconnection rules, open standards, pricing, etc. What will be key will be transparency and non-discrimination, etc. (i.e. rules to which countries may have agreed within the WTO). The industry has clearly shown that the introduction of competition comes together with reregulation – often more regulation than before to ensure a level playing field, especially where a dominant carrier exists.

There are many more regulatory impact questions that can be discussed, but when one looks at the issues from the perspective of the question of this Study Group, then it is important to focus and narrow down these issues. The question is, after all, "The impact of the introduction and utilisation of new technologies on the regulatory environment of telecommunications". The answers will largely depend on the existing industry environment (i.e. whether it is a monopoly or there is competition, what is the regulatory structure in place, are there published regulations and polices, and whether there is a separate regulatory body independent of the regulator, etc.).

As was previously indicated, where there is no separate regulator and there is a monopoly provider acting as the self-regulator, then the introduction of new technologies will have minimal impact, except where convergence, new applications, globalisation of technology and services, etc., are concerned. Each new technology will be introduced based on the commercial, political or economic reason decided by the operator, with little or no regulatory impact.

Where there is a separate regulator, regardless of whether or not full or partial competition exists, then there will be greater regulatory impact depending again on the factors within that country.

Some concluding remarks follow.

4.4.5.1 Purpose of regulation?

Firstly, apart from determining the current industry and regulatory environment in place before answering such a question, it will be useful to determine what the purpose of regulation in any particular country is. This will largely depend on whether the regulator sees himself as a patron, as a proactive remover of obstacles or as one taking an arm's length approach. Does the regulator want to police, mediate or empower the industry?

NOTE – "Good regulations and, indeed, good regulators should be unobstructive. In many sports, the good referee is the one who controls the game well and manages to stay inconspicuous in the process. Conversely, the bad referee, in becoming the focus of attention, rarely controls the game to the satisfaction of anybody, except perhaps himself." Bernard Cullen, Cullen International.

4.4.5.2 What is national sovereignty in today's telecom world of privatisation, competition, global liberalisation, and technology that defies borders? Is it so sacrosanct?

It is after all a concept under Public International Law that coincides with the rise of nationalism. Before nationalism took a firm hold, telecommunications were provided in many countries by private entities. In fact, the 1865 ITU Treaty allowed private entities to become members of the ITU. It was only much later that the idea of national sovereignty was enshrined within the ITU. Today, increasing globalisation of societies, of economies, etc., is challenging traditional concepts of nation states.

In telecommunications, the market has already been finding ways to overcome national sovereignty and provide end-to-end services through alliances such as Concert, Global One, etc. Technologies such as the Internet and GMPCS are also challenging our notions of regulations based on national sovereignty. Also cross-border economic activity and well informed citizenry are not going to allow border limitations to stop them.

In short, the time has come to:

- relook national regulations in the context of convergence, globalisation and the New Information Economy
- continue to adapt and amend existing ones (such as the ITU is doing by introducing small "m" status, although it may have to consider going beyond this) or create new types of international and regional organisations (existing ones still based on nations sovereignty), and to
- adopt "soft laws" with industry participation where hard laws seem inadequate.

These are only some of the action items required to establish more appropriate global rules and organisations which will truly support a Global Information Society and to better complement national regulations. These and other pressing issues are all catalysed by the introduction of new technologies and services.

5 Possible ways forward

Telephone customers are continually seeking higher quality and more sophisticated services as well as enhanced ease of use in both developed countries and developing countries. These trends have been helped along by requests for telephone services comparable to those available in other countries. Many countries are now introducing Intelligent Network (IN) systems to meet customer demands quickly and economically.

Meanwhile, cellular systems and digital cordless systems are being spotlighted in developing countries as WLL systems for the provision of universal telephone services.

However, there is no easy answer as regards the way forward. One can only show what effect certain approaches will have under certain conditions. What action is then actually taken can only be decided in each given situation.

First of all, it should be noted that the concept "New systems" should always be seen in relation to a country's stage of development. A definition of this concept in an industrial country will vary greatly from a definition in a developing country.

However, the focus is on mobile communications. Before a mobile radio service can be offered at all, mobile radio networks containing the elements of other telecommunications networks must be set up. Such elements are, for instance, the public telephone network, radio relay links and (after the abolition/in the absence of monopolies) the network elements of other licensed carriers.

To this extent, then, we can certainly regard mobile communications and the mobile radio networks as overlay networks, on the one hand, yet, on the other, as new systems too.

By overlay networks, we generally understand an optical fibre cable network superimposed on the "ordinary" network, which enables the use of many new services.

5.1 Radio Paging Systems

A radio-paging system historically has been a one-way wireless selective signalling (messaging) system without speech and designed as an extension of the telephone network. It allows continuous accessibility to someone away from the wired communications network. In its most basic form, the person carries a palm-sized device (the pager) which is given an identification number. The calling party inputs this number, usually through the public telephone network, to the paging system, which then signals the pager to alert the called party.

Today's paging systems offer much more than the basic system described above. A paging subscriber can be alerted anytime and at almost any place, as coverage can be extended easily, even across national borders. Useful features incorporated into modern pagers include a variety of alerting methods. For example, features using vibration, flashing lights, musical alerts and different beep tones are used. Group call, which is useful for emergency rescue at appropriate locations or times is another feature one finds in modern pagers. Alpha-numeric pagers also enable important information and data, for example, business and financial news, to be constantly updated and monitored.

A paging system makes efficient use of the radio spectrum, as compared to some other systems, enabling it to provide inexpensive functions that, to a large extent, can satisfy the communication demands of somebody on the move. This has contributed to a steady expansion of the paging industry in recent years. The introduction of complementary products, e.g. pocket-sized cellular phones, cordless telephones and multi-functional "communicators", will inevitably spur the paging industry to provide more value-added services and improved pager design in the future. There will be more new applications of paging, like the sending of e-mail, voice mail, faxes or other useful information, to a pager. Pagers also will offer better features and take on more attractive, innovative forms.

Although introduced relatively late in some European countries, paging is growing at a steady pace as an alternative solution to daily communications needs. Entrepreneurs in fast-developing countries provide paging services in practically every city and major township.

5.1.1 Benefits of using a conventional pager

Because a pager is a device which is used to keep the user in touch with others, the benefits of using one are far and wide. Some of these are:

Freedom

Carrying a pager can give a person the freedom of walking out of the office or of going home without leaving an itinerary or telling anyone where he/she is going. There need not be any fear of not being able to be contacted.

Reduced stress

A pager can prevent irritation, frustration, stress and sheer annoyance. Very frequently, one feels upset by such little things as missing a call, a changed appointment or an urgent request. A pager helps avoid such unnecessary sources of agitation.

Increased competitive edge

In a competitive business environment, using pagers helps to keep a company one stop ahead of the competition. It assures one's customers that they can reach out for business or professional assistance at any time, thereby projecting a "customer care" image. Carrying a pager will ensure that one will not miss a critical message that could mean a successful deal or another major opportunity. On the road and away from the phone, answering machine or voice mail, business people are afforded constant contact by means of a pager.

Peace of mind

For parents, it can be sheer frustration or even a nightmare when their children's whereabouts are not known. Parents carrying a pager are always within reach by their children, and vice versa. Pagers provide immediate contact and peace of mind. For the chronically ill, a pager by the bedside could turn out to be a life saver as a reminder to take medication.

Improved productivity

A pager is one of the most cost-effective and reliable tools for productivity improvement. It saves money by reducing wasted travelling costs. It earns intangible profits by making one's customers happy and it saves valuable time. Wasting or losing time is often a triple loss – lost time could mean loss of money, loss of control and loss of confidence. Reducing or avoiding lost time is therefore worth far more than just the time alone.

5.1.2 Summary of pager types and their advantages

Table 1 summarises the advantages of the different types of pagers.

TABLE 1

Pager types and their advantages

Paper Types	Type of Use	Advantages
Tone-only	Pager alerts user, user takes predetermined action, such as calling a predetermined phone number.	• Simple to use • Very large channel capacity • People can be alerted to act when they are "on the go"
Numeric Display	Pager alerts user and displays numeric message; user calls phone number displayed	• Flexible, user can be instructed to call any phone number • In silent mode, message does not disturb others in quiet environments • Works in noisy environments • Message read privately • Message displayed and stored • Less chance of missing or of misunderstanding message • Reduces doubt, errors, confusion • Message is saved for future use • Large channel capacity
Alpha-numeric and ideographic display	Pager alerts user and displays test message; user can then take necessary action	• Same as numeric display, plus user receives complete, accurate test message, not just a number • Eliminates doubt, confusion, errors • Eliminates need for phone call to get message, and phone tag • User can screen messages and make better action decisions
Tone and voice	Pager alerts user, then delivers short (10-20 seconds) voice message; user can then take necessary action	• User gets voice message with alert • Eliminates need to make phone call to get message • User gets message with page • Voice is most natural way to communicate messages • Voice is easiest for message sender to use • May identify voice of sender • Voice tone can convey urgency
Stores voice	Pager silently alerts and stores voice messages for recall at user's convenience	• User gets all advantages of voice plus silent alert • Message storage for private listening to messages • Message can be reviewed later if received in a noisy or quiet environment

5.1.3 Paging today and its future

The future points to pagers offering more features, better capabilities and taking on new forms. There will be wider, more innovative applications of paging, many achieved through combining paging technology with other technologies.

The paging market is also diversifying into low-cost, simpler consumer paging products and services, on the one hand, with higher-cost regional, national and international services and messaging and data transfer services, on the other hand.

Listed below are examples of relatively new and more innovative applications of paging for information and data transfer. Most of these are applied already, although still on a scale much smaller than what is envisaged for the future. Also given are some other significant developments in paging.

5.1.3.1 Numeric paging

The majority of pagers are presently used for the purpose of contacting someone on the move and leaving simple messages. The most popular type of pager used for this application is the numeric pager which displays the telephone number to call back after alerting the paging subscriber (the person who carries the mobile paging unit). The numeric information may be entered using audio-frequency digits, such as can be provided by a DTMF-based telephone. Numeric pagers are used in very innovative ways as a communication device, using numeric codes for a variety of messages in environments where telephones are not readily available. Good examples of this can be found in parts of China.

5.1.3.2 Alpha-numeric paging

Alpha-numeric pagers are able to receive alpha-numeric information or data. However, apart from already being fairly extensively used for messages, this capacity is largely under-utilised, even in developed countries. However, there are valid reasons for this situation. Firstly, a device by which a caller can directly input alpha-numeric messages is not commonly available at a reasonable price. Either a personal computer with a modem, or another custom-type device connected to the public switched telephone network, is required to enable a caller to enter alpha-numeric paging information directly. The former is costly and not widely available while the latter does not yet exist in an affordable form. As a consequence, the majority of callers have to suffer the inconvenience of going through an operator to input their messages. That is time-consuming, labour-intensive and lacks privacy. Also, even if the input device were to be inexpensive and commonly available, it would still not be as simple to operate as the telephone instrument (in order for a paging caller input device to be a success, it needs to be at least as simple to operate as a standard telephone). The industry therefore awaits the development of a voice-recognition device which will enable callers to send alpha-numeric pages without the transcription process by the caller himself/herself, or an operator. Another disadvantage of the alpha-numeric pager used on its own is that, mainly because of its size, the amount of information or data that can be displayed is limited. Despite these disadvantages, however, alpha-numeric paging has a definite and indispensable role in many environments. With improved data transmission rate and better pagers, the trend towards the widespread use of alpha-numeric paging is inevitable. This, in turn, will bring about more data and messaging services.

5.1.3.3 New signalling protocols

To cope with increasing competition and demand for quality up-market services, new transmission techniques and new signalling protocols have been developed. These offer increased data transmission rates (information transmission rates) and improved reception reliability and coverage. One such protocol, FLEX™, has already found wide acceptance on a global scale and is expected to be the most popular *de facto* standard for a long time to come.

5.1.3.4 One-way data communication

One likely trend to take place in the near future is that paging operators will offer advanced one-way data communication services, such as point-to-point and point-to-multipoint data transfers. Downloading spreadsheets to a computer or a group of computers is a good example. The computers could be at fixed locations or could be portable units carried by professionals and business people on the move. In this role of data communication to a computer, the pager then essentially becomes a wireless modem, without the ordinary functions of a normal pocket pager. The implication of this trend is that pagers will become an optional feature of computer systems.

One-way data communication over a paging network in a mobile environment has a competitive advantage over conventional two-way communication systems, such as cellular mobile radio systems. Because of lower network operating costs, partly due to less expensive infrastructure, the price of services to the user can be very competitive. In addition, the low-cost of subscriber units, as compared to two-way devices, makes the total cost to the user very competitive. One-way data communication is therefore sure to find its niche in the market, especially with the advent of more software development to drive the data and information transmission services.

One application for one-way data communication is wireless electronic mail. In wireless e-mail, messages are sent through the paging network to a pager integrated into a small portable computer (e.g. a palmtop computer). So, instead of sending e-mail to a location, it is sent directly to a person's computer, by means of the built-in paging receiver. Paging receivers of this type therefore constitute a wireless modem in the computer. Receivers for this type of application already exist. A nation-wide information network which permits the use of such wireless modems already exist. A nation-wide information network which permits the use of such wireless modems has already been introduced in the USA.

It is expected that the growth in this area will be tremendous in the next few years, especially with the trend towards decentralised corporate organisations. Also to be seen are the introduction of small radio modems to fit into laptop and pen-based computers.

Mobile data communications provided by a paging network can, in the same way as described above, be used to send faxes directly to the paging subscriber. Similarly, sales and pricing information, customers' file information, stock quotes, news headlines, weather forecasts and any other important information can be updated constantly and remotely. A travelling executive's calendar built into a laptop or notebook computer can be kept updated remotely by the office. The wireless data link can also be used to turn devices on and off, be it a data collection instrument, a light, a pump, a gate, an alarm or an advertising panel.

New protocols for computer communication have also been developed.

The mobile data communications application will elevate the service level of paging operators to a new height. They will no longer be in the paging business, but in the mobile data and mobile information services businesses.

It appears that the use of paging systems to transmit information and data, in amounts large and small, offers the greatest potential for the expansion of the paging industry, also in developed countries. It promises wider, newer and more useful applications of paging at a very low cost.

5.1.3.5 Two-way alpha-numeric messaging

The traditional definition of paging as only a one-way communication process is being revised. Paging is in the process of shedding its role of using the subscriber unit as a listening device only. Newly developed pagers, using the protocol called ReFLEX™, are now offering high-speed two-way messaging. Functions include automatic acknowledgement, by the messaging unit, that a message has been received and acknowledgement by the user that he/she has seen the message. User response is by means of simple keystrokes.

For this type of two-way messaging functionality, pagers are expected to compete aggressively with other two-way technologies, such as mobile cellular technologies, including Personal Communication Networks (PCN). Two-way messaging is cheaper, mainly because, using mobile communication technologies, longer transmission ranges to the base-station receiver site – therefore larger coverage areas – can be achieved. This is due to the very narrow bandwidth used for the messaging unit's reply signal, which results in a relatively high spectral power density.

The feature whereby the messaging unit confirms the receipt of each message without any subscriber action has four important advantages:

- When the unit successfully receives a message, it informs the system that it has done so. The system then immediately removes the message from the transmission (broadcast) queue, making room for other messages.

- If part of the transmitted message was not correctly received, the unit tells the system which parts of the message (known as the data packets) need to be retransmitted (rebroadcast). That obviates the retransmission of the entire message. This feature provides maximum efficiency in the amount of transmission time message required, on average. In some one-way systems, the system is programmed to never retransmit the message, because the system never knows if there is an error, thus resulting in missed and erroneous messages. Alternatively, the system may be programmed to retransmit all messages a set number of times, thus wasting valuable transmission time if the original transmission was successful. With the increasing popularity of long messages, such as alpha-numeric and voice messages, this feature becomes critical. The amount of data packets in a single message can climb into the hundreds and the system can easily become overloaded if messages are unnecessarily repeated.

- After the system has received confirmation of successful delivery, it can inform the caller of the transmission's completion. This leads to greater satisfaction on the part of the caller and the user.

- The most important advantage is that all messages are guaranteed to be delivered. If a message cannot be delivered (because, for instance, the subscriber's messaging unit is turned off), the system holds the message until the messaging unit reregisters its status and location. The message is then sent.

Although two-way messaging systems have many advantages, as compared to one-way paging systems and other types of communication systems, they may have the disadvantage of being expensive. This is an aspect not to be overlooked by prospective operators in developing countries, especially for rural applications. Two-way messaging systems are relatively expensive, due to the added complexity introduced by the reverse (inbound) transmission. To obtain coverage over large rural expanses of land will hardly be practical. In part, this is due to the frequency bands used. The frequencies used by systems on the market, at the time that this document was compiled, were in the 900 MHz band, *viz.* 940-941 MHz for subscriber unit receive (outbound) and 901-902 MHz for subscriber unit transmit (inbound). (Manufacturing was being considered at 280 MHz for subscriber unit transmit, for certain markets, but that had not yet materialised.) In the 900 MHz band, the geographic coverage obtained is much less than that for a conventional paging system operating at VHF, for instance – assuming equal effective isotropically radiated power. This is due to the smaller degree to which diffraction helps the wave at this frequency to reach behind obstacles, such as hills. A relatively high density of fixed stations would be required in order to get continuous coverage at 900 MHz. Another reason for a high density of base stations is that the transmitted power on the mobile paging unit does not allow ranges as large as in the receive mode. A two-way messaging system for rural areas will therefore be expensive. At best therefore, a two-way messaging system operating at 900 MHz will be suitable only for urban environments.

5.1.3.6 Voice Messaging

Voice messaging systems have recently become available in the USA. The personal messaging unit is in the FLEX™ family of products and uses the InFLEXion™ protocol. It has the ability to receive digitally encoded voice messages. Up to about 20 messages, with a total time of four minutes, can be received and stored for playback at a convenient time. The receipt of the message can be acknowledged, as the subscriber has the ability to do that by means of pressing some keys.

Voice messaging is one of the major applications of two-way messaging. Basically, voice messaging repeats the spoken word of the caller to the subscriber, through the messaging unit. That can be responded to by means of a simple acknowledgement message in data format.

Two-way voice messaging functions as a telephone answering machine on the belt. It incorporates all the features of an answering machine, such as message storage and playback. Also, the voice messaging unit offers low audio volume for private listening or higher volume for hands-free public listening.

Should the unit's memory be full of messages, it has the capability to let the infrastructure network know that. The network will then keep a new message until such time that the unit informs it that memory is available.

To leave a voice message, the subscriber's phone number is dialled, exactly as with a conventional answering machine. A recorded message will ask the caller to leave his/her message. From there on, the process of getting the message to the subscriber is automatic.

Voice messaging using the InFLEXion™ protocol should not be confused with analogue operator-assisted, selective or non-selective voice paging. The voice is digitally encoded, which allows much greater functionality, including storage and retrieval at both the control centre terminal and subscriber unit. There is also no degradation in quality as a result of storage and transmission.

Voice messaging includes the following benefits:

- It eliminates operator bureaus normally required for alpha-numeric messaging. The caller's message is stored directly in the controller terminal from where it is forwarded to the subscriber's messaging unit. This reduces the operational costs normally associated with alpha-numeric paging.
- A sense of message urgency can be conveyed, since the message is actually the caller's voice. In general, voice messaging provides a higher level of communication than numeric paging.
- In many cases, a voice message does not require a return call because more detail can be conveyed in the message.
- Language independence is achieved because the message flows from the caller to the subscriber and therefore translation is not required.

Although voice messaging may be expensive initially, because the technology is new, prospective operators in developing countries should think of innovative ways of perhaps using it cost-effectively. Voice messaging has one distinct advantage, as compared to all other forms of paging, for developing countries: the most unskilled and uneducated people can be taught how to use it and from there on they can use it as effectively as anybody else – simply because voice, and not written characters, is the medium of communication.

Administrations need to take into account that, at the time this document was compiled, the only bands for which equipment was available for subscriber unit receive was 930-931 MHz and 940-941 MHz. The band used for subscriber unit transmit was 901-902 MHz, which is the same as the band used by two-way alpha-numeric messaging. However, manufacturing was being considered for 280 MHz as well, for subscriber unit transmit.

5.1.3.7 Visual appeal and integration of paging units with other personal effects

Pagers are designed to look visually appealing and trendy, as it is recognised that there is a large potential market segment other than the business community. Pagers are offered to consumers for their personal use, which include young people out and about. They fulfil the role of a social connection among friends, students, family members and colleagues. Pagers are integrated into belts, pens, watches, key chains, jewellery, credit cards and calculators. They are more attractive when offered with extras such as musical alerts. Improvements in battery life have removed restrictions in the physical size and weight of pagers.

5.1.3.8 Integration of pagers with portable telephones and other portable equipment

Pagers integrated into cellular phones and second generation cordless telephones have already been developed and marketed. There is likely to be more widespread usage of these devices in future. The alpha-numeric pager in a cellular phone offers the possibility of screening an incoming call, allowing the user to determine if, when and where he/she should return the call. Integrated into cordless telephone handsets, pagers enhance their usefulness as they effectively add the capacity of receiving incoming calls on these phones when out of range of the base station.

Pagers are also being integrated into palm-top and pen-based computers, to form small radio-based modems. When a pager is integrated into a palm-top computer, the shortcoming of having limited display capacity when a pager is used on its own is overcome. It also opens up a host of new application possibilities, some of which are described later.

5.1.3.9 Multiple-frequency auto-scanning pagers

Looking into the future, one should see more pagers with a high degree of sophistication, such as those which can operate on more than one frequency, using auto-scanning receivers. Pagers having this function will be useful for roaming between paging systems that do not operate on the same frequency in the FLEX™ protocol and have been implemented in China, Korea and Japan.

At the moment, most of the European paging systems cover mainly local areas or one country at a time. The paging service provider, Euromessage, however, provides coverage in the UK, France, Germany, Italy and Switzerland. The new pan-European paging system called ERMES will provide roaming coverage in most of Europe in future. Roaming can, today, take place between the USA and several cities in Asia. However, none of the systems used today have the capability to provide true international roaming. This is mainly because non-standard frequencies are used. The use of non-standard frequencies is a problem not easily solved and will remain so for many years to come.

The development of auto-scanning pagers could effectively solve the roaming problem, despite the use of non-standard frequencies, and is bound to be seen in future.

5.1.3.10 Paging infrastructure developments

The trend is moving in the direction of systems in which auto-access and operator-assistance are integrated. There is also a trend towards high-speed signalling. This will give the best of both worlds. This trend is brought about by modernisation of the telephone systems in most countries, the onset of new technologies which make better use of air-time, the hunger for more information and the demand for more and better services by the general public. Integrated auto-access/operator-assisted systems on their own serve the demands and needs of the paging subscriber much better.

High speed signalling was born out of the market requirement for higher capacity to cope with the demand for alpha-numeric and data transmission services. The limited channel capacity of the existing commonly used systems poses a bottleneck to such revenue opportunities. The new FLEX^{TM} high speed paging code provides the answer to this requirement, without the need for operators to invest heavily in upgrading their existing systems. More information on FLEX^{TM} can be found in Appendix A.

5.1.3.11 New applications and services

Mobile data and information services will definitely become a reality in many developed markets. Other new services proposed by operators in the USA include enhanced one-way services such as low- and high-resolution graphics, video, electronic mail, facsimile, digitised voice, the ability to encrypt messages and acknowledgement of reception of the message.

Market statistics show that more people are using pagers as a cost-effective and reliable communication device. There is a definite trend whereby users move up from numeric to alpha-numeric services. Information providers are increasingly looking at data broadcasting to pagers as more and more people are using paging systems to transfer data to their remote computers. With the use of pagers being integrated more and more into people's daily lives, they will be greeted with a host of new and exciting applications.

Alpha-numeric paging as an alternative to the telephone

Alpha-numeric pagers have made a significant impact in many parts of the world, such as in Europe. In emerging markets where telephone penetration is relatively low, alpha-numeric paging offers an excellent alternative to telephones. This is an aspect of importance to administrations and prospective operators in developing countries. One obstacle for future fast growth is the lack of an input device. However, alpha-numeric sales will pick up as soon as consumers reach the point where they understand the benefits of alpha-numeric pagers and accept the cost. Rationalisation of alpha-numeric pager pricing will obviously expedite acceptance by consumers.

Alpha-numeric paging for information broadcasting

With alpha-numeric transcription, a service in which voice messages are typed out and transmitted to alpha-numeric pagers, the need for a convenient input device is eliminated. Markets where alpha-numeric services are enjoying good penetration, like UK and Spain, are offering operator-assisted alpha-numeric services. While start-up costs may be high, service providers can easily work out the long-term figures and find the margins acceptable. With alpha-numeric pagers, operators can provide services such as news headlines, sports scores, betting services, weather and stock market updates. This can be done by means of group calls which can sometimes be transmitted at off-peak traffic hours, at a relatively low cost.

The following types of information can be broadcast using alpha-numeric paging:

- Lottery results and sports news
- Traffic information, such as locations with road works, traffic jams and accidents and information on alternative routes
- Weather forecasts, high and low tide, full moon, and fishing information
- Alarms and reminders, such as wake-up calls, medical alarms and birthdays
- Sales promotion, such as discount sales, movie schedules and new products
- Financial news, such as exchange rates, stock movements and other business news
- Local, national and international news headlines

- Stock market news, such as the hourly summary, index, gainers, losers and volume
- Flight information, i.e. aircraft arrival and departure schedules
- Ships in port, shipping schedules, container arrival status and berthing information.

Paging as an aid for universal telephone access

In some developing countries, the idea has been raised that paging could complement public telephones, especially in rural areas. A public telephone has the disadvantage that incoming calls usually cannot be taken because the called party is absent. Paging can solve this problem. A pager can alert the called party that a call would be coming in for him/her at a certain time. He/she can then make his/her way to the public phone to be in time for the call.

Calls to rural areas are usually from relatives or friends. It is relatively easy to work out a protocol for, say, a numeric pager to handle a variety of call alerts. The numeric code can contain information as to who the caller is, who needs to be spoken to and at what time. A numeric pager would be the first choice, as it is reasonably inexpensive.

If every household or closely spaced group of households were in possession of a pager, universal access could greatly benefit, in a tangible, practicable and cost-effective way.

5.1.3.12 Reliability aspects

Some manufacturers of paging units have significant quality standards to ensure reliability of their products. Every pager is put through rigorous accelerated life testing (ALT). ALT stands for the highest possible standard of quality and operating reliability. It stimulates five years of use and incorporates a variety of extreme conditions that the pager may be exposed to. We know of a manufacturer who literally freezes, boils, shakes, bakes and hits its pagers. The pager is also dropped on a concrete floor. Only if it still works after this treatment will it qualify for leaving the factory. A manufacturer who exposes its pagers to ALT usually includes a certification to that effect with each pager.

With pagers increasingly being sold in relatively unsophisticated markets, in terms of the user’s ability to protect the pager from water, dust, mechanical shock and high and low temperature, it is anticipated that there will be no relaxation in the above standards.

5.1.3.13 Paging versus PCS and PCN

Personal Communications Networks (PCN) and PCS (Personal Communications Systems) are networks that allow mass communications between users who, in general, are mobile. In the last two years, interest in these networks have increased tremendously. PCS and PCN are currently attracting a lot of attention. There is a lot of emphasis on developing pocket-sized portable phones and multifunctional personal communicators. It is a question of what implications that may have for the future of simple pagers. A related question is: How are paging systems differentiated from these systems, if at all?

Paging networks can be regarded as being closely related to a PCS or PCN network. However, whereas the latter are two-way networks, conventional paging is in one direction only. This presents a major difference, with a radical influence on both the functionality and cost of systems.

It is likely that the future is bright for paging for the following reasons. Paging technology is relatively simple, of low cost, but nevertheless effective. A large variety of users’ needs can therefore be satisfied at much lower cost than with the above-mentioned more sophisticated two-way telephony systems. Due to their lower complexity and smaller power requirements, pagers will always be smaller and lighter than telephony devices. Much longer battery life is also a distinguishing factor.

5.1.4 Markets and marketing outlets

5.1.4.1 Retail distribution of pages

Previously, pagers were available in most developed-country markets from outlets maintained by paging operators themselves. These mainly target business users: business services, health care, construction, sales/marketing, transportation, delivery services and real-estate industries. Demands in such traditional segments of the markets are becoming saturated in many developed countries. Unless new segments or new services are developed, the industry will approach maturity quickly.

Personal use by consumers is the key segment which operators can exploit to gain higher penetration rates, especially in metropolitan markets. With marketing programs to promote higher consumer awareness of pagers and their benefits to consumers, service providers will be able to tap into the potential mass markets and enjoy the returns.

To promote increased awareness, paging products are being made available where people normally shop. Further retail distribution strategies are being developed by some service providers as an effective channel to reach consumers in mass markets with large numbers of potential new customers. In addition, retail is generally a relatively low-cost operation because of commission structures, the ability to move inventory and strong market pull. This, in turn, offers a low-cost solution to consumers, a necessary condition to attract personal users.

Pagers will be increasingly distributed through retail outlets of merchandising chains to enable tapping into the developing consumer paging market. Pagers are now available in a variety of colours and form, factors which appeal to people aged 14 to 45 and who would like to stay in touch with family and friends. Pagers will become as common as a walkman radio, a camera, and other consumer electronic products. In some countries, pagers are now available through mail order houses and even from vending machines.

Retail distribution is the key to increasing market penetration and consumer awareness. It will continue to play the most important role in the paging industry.

5.1.4.2 Global market opportunities

With more than 50 million paging subscribers world-wide, the major paging markets in the world, many of them in Europe, continue to expand rapidly. Emerging markets with huge population bases such as China are growing very rapidly, although penetration rates are still relatively low. The main reason for this high growth is the backlog in telephones. In China, for instance, pagers, especially numeric pagers, are used in innovative ways to overcome the scarcity of telephones.

Western Europe, with four million subscribers, is under-penetrated, compared to other developed markets. However, given the initiatives by the industry to also address the consumer market, this is expected to change in future.

Finally, the developing markets in Eastern Europe, the Middle East and Africa offer great opportunities for the future. In many of these markets, there has been a sudden awakening as to the benefits that can be obtained by paging. One of these is the communication problems that can be overcome as a result of not having access to a telephone. In addition, there is the complementary role that paging can play in providing universal telephone access, in both urban and rural communities.

5.1.4.3 Private paging systems

In developed countries, as well as some developing countries, there has been strong growth in private paging systems in recent years. Private paging systems are usually meant for on-site use where there is a lot of movement of personnel. It is of major benefit, in many instances, to the effectiveness of the operation of the organisation. Organisations which typically make use of on-site private paging systems are hospitals, mines, large industry and farming concerns.

5.1.5 Regulatory Aspects

5.1.5.1 General aspects

Administrations and operators should take note of the complementary role that paging could play in making universal telephone access successful.

There should also be an awareness that paging can be a cost-effective means of providing information, of various kinds, to the population. This can be done at much less capital outlay and cost than with many other types of system.

Administrations would be well-advised to leave the choice of technology and signalling protocol standard to the operator. It should be noted that the FLEX™ protocol, for instance, although developed by a (leading) pager manufacturer, is open to any manufacturer, for employment in its products. (This protocol, described in Appendix A, is already employed by a number of manufacturers.) The FLEX™ standard has already become the *de facto* paging standard for large parts of the globe. Products utilising this standard are bound to be attractively priced, due to the high volumes produced and the competition in the marketplace.

In making allocations of RF spectrum for paging, administrations should be aware of the various factors that should be taken into account. The choice of frequency can determine the geographic area coverage by a base station. It can have a serious effect on the price of pagers as well, depending on the volumes that are produced at the particular frequency.

It should be noted that, even in the developed world, no standards, as yet, exist for true international roaming. Europe is attempting to implement a standard for roaming in terms of ERMES, at least in those countries that form part of the European community. However, it will take some years before this ideal is accomplished. Even then, roaming will not be possible, using ERMES, on, by far, the greatest part of the globe.

5.1.5.2 Regulatory aspects of high-speed paging and advanced messaging using the FLEX™ protocol

Spectrum allocation

In order to understand the spectrum allocation issues for high-speed paging and advanced messaging that uses the FLEX™ family of protocols (see Appendix A), it is necessary to look at the history of developments in the USA.

In the United States, the Federal Communications Commission (FCC) has created a new industry in wireless communications by licensing a new service known as Narrowband PCS. The FCC defines Narrowband PCS as a family of mobile services that includes advanced voice paging, data messaging, and both one-and two-way messaging on a nation-wide and regional basis. The FCC has licensed Narrowband PCS in the 901-902, 930-931, and 940-941 MHz bands. A total of 3 MHz of spectrum was allocated in these bands. The FCC opened 2 MHz of this spectrum immediately and 1 MHz was reserved for future expansion.

A critical aspect of the US frequency allocation was the designation of the 901-902 MHz inbound (or return) channels as quiet bands (separating it from services with high-powered transmitters). This gives manufacturers the ability to supply low-powered, low-cost and small-sized subscriber units. The preferred separation between the outbound and inbound channels is 29 MHz, with a minimum separation of 20 MHz. Eleven frequencies were assigned on a nation-wide basis:

- Five 50 kHz channels in the 940-941 MHz band, paired with 50 kHz channels in the 901-902 MHz band
- Three 50 kHz channels in the 930-931 MHz band, paired with 12.5 kHz channels in the 901-902 MHz band
- Three 50 kHz unpaired channels in the 940-941 MHz band

Six frequencies were assigned on a regional basis, for five regions:

- Two 50 kHz channels in the 940-941 MHz band, paired with 50 kHz channels in the 901-902 MHz band
- Four 50 kHz channels in the 930-931 MHz band, paired with 12.5 kHz channels in the 901-902 MHz band

The authorised bandwidth of Narrowband PCS channels is 10 kHz for 12.5 kHz channels and 45 kHz for 50 kHz channels. For aggregated adjacent channels, e.g. two or three 50 kHz outbound channels, a maximum authorised bandwidth of 5 kHz less than the total aggregated channel width is permitted.

The industry responded to the above FCC initiatives by developing new narrow-deviation messaging devices that permit a greater use of the available spectrum than has been the case in traditional one-way paging.

The above information on the allocation of spectrum at 900 MHz shows the complexities involved. Administrations in developing countries should take note that allocation in the 900 MHz may be difficult if GSM cellular systems are deployed or planned to be deployed. However, the price advantages to be obtained from the large volumes of pagers produced for the US market warrant serious consideration of the 900 MHz band by administrations, should they see a need for this type of system in their countries. Administrations should also check what the position is in the Far East at the time that they become interested in making an allocation. It is possible that at that time China and other Far East countries will have allocated a band at around 280 MHz for the outbound transmission. It is a band that has traditionally been used for paging in that part of the world and solves the problem of the lack of suitable spectrum in the 900 MHz band. The economies-of-scale in production that China's consumption will command will be of great benefit to any country that uses the same frequency band.

At the time this document was compiled, Brazil, Canada and Mexico were in the process of making similar allocations as the US.

Administrations should consider the allocation of nation-wide spectrum in the 900 MHz band. The VHF band also has reasonably high manufacturing volumes, especially around 155 MHz.

Channel widths of 50 kHz are required at 900 MHz for one-way paging and for the outbound leg for two-way messaging. For two-way messaging, 12.5 kHz channel width is required for the inbound leg. At VHF, the channel width for one-way paging needs to be 25 kHz.

Nation-wide channels are useful from the point of view of providing a roaming capability.

Administrations should also consider the nation-wide allocation of one to four frequencies for private paging systems, i.e. for organisations who need paging for internal, on-site use.

Licensing of operators

The spectrum allocated for Narrowband PCS, in the United States, was divided into nation-wide channels, regional channels, major trading area channels and basic trading area channels.

In July 1994, an auction was conducted of licences for the nation-wide channels. The auction was for two 50 kHz unpaired licences, five 50 kHz paired licences and three 50 kHz/12.5 kHz paired licences. After 47 rounds of auction, the six winning companies had pledged over $ 650,000,000 for the ten licences.

In October and November, 1994, an auction was conducted of licences for regional channels. The auction was for a total of 30 licences: two 50 kHz/50 kHz paired channels and four 50 kHz/12.5 kHz paired channels in each of five regions. After 105 rounds, the nine winning bids totalled over $ 488,000,000 for the thirty licences.

Auctions are scheduled for 1996 for major trading and basic trading area channels.

It is common to license operators of paging systems who provide paging services to the public. Operators of private paging systems also usually require a licence, at least for the use of the spectrum.

Spectrum efficiency

Two-way protocols provide the best transmitter management, and thus the largest subscriber capacity, for wide-area coverage through the use of automatic registration and locator services. The system does not track the precise transmitter area, or cell, where the subscriber currently is located, but an area encompassing a number of cells called a zone. This allows the same frequency channels in separate zones to be used simultaneously for different messages. Transmission usage is economised to the maximum level because only the transmitters in the zone of the unit's physical location are used. In one-way systems, all transmitters broadcast every message because the system never knows where the unit is located. All other transmitters in the two-way system can be devoted to other messages, thus giving the entire system peak efficiency and the capacity for many more messages and subscribers.

In FLEXion voice-paging, systems track the individual transmitter, permitting re-use based on seven sub-channel frequencies within a 50 kHz channel. This creates a cellular-like system design where an individual transmitter site can be active and broadcasting on a given sub-channel while an adjacent transmitter is active and broadcasting on a different sub-channel. Additionally, transmitters that are properly spaced can be operating on the same frequency, transmitting different messages at the same time.

Type approval

Other than the infrastructure equipment for paging and two-way pager units, specifically, it is usually not necessary to have type approval. One-way pagers are passive devices that do not have a high likelihood of causing interference to other systems.

5.1.5.3 Systems aspects of paging

Paging systems need to be well-designed in order to be successful. Various approaches may be followed, depending on the situation. Information about coverage, simulcasting and network paging is given in Appendix C.

5.2 Conventional PMR Systems

A conventional private mobile radio (PMR) system, often called two-way radio, is defined as a class of professional user system that operates in the so-called open channel mode. In practice, the transmitter is activated by the user, who simply presses a button and talks. Usually the talker will be heard by any user that has a compatible radio that is tuned to the same RF channel. The simplest example of such a system is two or more handheld radios working in the simplex mode, i.e. using one frequency on which all radios transmit and receive.

A more advanced PMR system is used in cases where it is not appropriate or convenient for all users of the radios to hear every message that is transmitted by a user. Two methods are commonly employed to solve this problem. One is called selective calling and uses a burst of up to five audible tones to indicate the identity of the intended recipient of the message. The other is called the continuous tone controlled signalling system (CTCSS) or private line (PL) and makes use of a series of sub-audible tones, between 67 Hz and 250 Hz, transmitted continuously with the speech.

Only those radios programmed to respond to the code that is transmitted at the time will provide an audio output. On all other radios receiving the same message, the audio will be muted. As a consequence, only those users belonging to the group whose radios use a common tone will be able to talk to one another. All groups using the same frequency but other tones can therefore operate independently from each other. However, while a member of one group is transmitting, another group cannot use the frequency.

Selective calling also has the advantage of low-speed data transmission. Any one of a number of pre-defined codes may be transmitted to the dispatcher (the central person who selects the intended recipients of messages). At the dispatcher site, the transmitted code will be translated into a message readable on a screen. The advantage of this data transmission facility is that it is a very efficient form of transmitting information. A message like “on my way to the next delivery point” may take less than a second.

In cases where an organisation has a large number of users who are organised into a number of groups, one RF channel may not be sufficient to handle all the traffic. The user may therefore be assigned more than one channel by the country’s administration. The channels can then be divided between the groups and, if needed, the members of groups can switch to other channels at certain points.

Although there are other variants of the above systems and methods, they all involve a large degree of manual control. The larger the number of users become on a frequency or a set of frequencies, the more complicated and time-wasting does this control become. It is for this reason that systems have been developed that will enable the sharing of channels in an automated way.

5.2.1 Applications and benefits of conventional PMR

PMR offers users, whose businesses largely involve out-of-the-office activities, an economic form of wireless communications. It is especially suitable for the frequent exchange of messages between stationary and mobile associates of the same business group.

Studies have shown that sectors such as transportation, construction, technical services, agriculture, distribution and sales, municipal services, etc., can improve their productivity levels by 15 to 30% by using two-way radio.

The most common criteria that studies in the past have utilised to evaluate two-way radio contributions are:

- Improvement in the organisation’s overall operational efficiency
- Increase in effective working hours
- Growth in business measurable outputs
- Enhanced quality in workers’ performance

- Better utilisation of vehicle fleets (less travel per task)
- Reduction in fuel consumption and fleet maintenance costs
- Growing customer satisfaction and long-term loyalty

In addition to direct benefits to the PMR users themselves, their customers also obtain benefits. A faulty machine in a factory which can be restored much faster, simply because the radio-equipped technician could respond earlier to the service call, is a good example.

The many benefits derived from the PMR's extensive use are of major importance from the perspective of a country's economy. Reductions in fuel consumption, coupled with the increasing productivity of businesses and organisations in the country, all contribute to economic progress.

There are a large variety of conventional PMR-type radios on the market. These range from handled or belt-worn portable radios, to those fitted in vehicles. Some radios have special features, such as intrinsic safety, required in environments where there are flammable liquids (for example, in the petrochemical industry) or explosive gases (for example, in coal mines).

5.2.2 Short-range business radio: a new type of PMR

A new type of low-power (PMR) two-way radio has recently been developed and has been introduced in some countries. The technology employed provides a cheap and simple form of short-range two-way radiocommunication for speech, mainly for on-site business activities. Communication is provided by small, lightweight, low-power, rechargeable hand-held two-way radios that are simple and easy to use. The maximum transmitter output power is 2W and the range is typically a few hundred metres to two kilometres, depending on propagation conditions. The modulation used is F3E, F2D, F1D (frequency modulation with ± 5 kHz deviation).

A user's radios operate in the simplex mode on one UHF channel. The channel is selected by the user, by means of buttons on the outside of the radio. The user selects the channel from a number of channels that are programmed into the radio by the factory. A channel is shared by different users. Privacy is enhanced, although not guaranteed, by a private-line (PL) code. The number of PL codes depends on the number of frequency channels. A total of 15 unique combinations of frequency channels and PL codes is possible. Therefore, the more frequency channels there are, the fewer PL codes are available. Only radios using the same frequency channel and PL code can communicate with one another.

The service provides the user with the flexibility to use his/her radios for short-range speech communication anywhere in a country, without needing to give notice to the administration or to await a channel assignment. No infrastructure, such as a repeater, is required.

Due to the nature of the service using this type of radio, the low power and the absence of repeaters, the capacity of the service is massive. About 40 000 users per frequency channel can be accommodated in a major metropolitan area.

The radios can be manufactured to operate in the UHF band, at 430-450 MHz or 450-470 MHz, or in the VHF band at 154-174 MHz.

5.2.2.1 Standards and specifications

Technical characteristics and test conditions conform to the ETSI standard ETS300-086. It furthermore meets the EIA RS-316B standard for resistance to shock, vibration, dust and humidity and the IP54 standard for sealing.

The radio meets the standard FCC technical requirement. Construction to IP52/EIA RS-316 allows the radio to be used in a range of environments. Radios from a number of suppliers that employ the same PL code are inter-operable.

5.2.2.2 Market aspects

The radio satisfies many needs in large and small businesses where on-site communication is required. Due to the radio being about half the price of a conventional radio, the service serves the needs of businesses in relatively underprivileged communities, as well as those in the informal business sector. It effectively contributes to any kind of social upliftment programme. The service has the following benefits to a vast range of businesses:

- It provides a simple means for on-site portable communication for small and medium-sized enterprises.
- It gives near-instantaneous access to on-site portable communication suddenly required.

- It provides on-site portable communication at a much lower cost than previously possible.
- It leads to increased business efficiency, especially in businesses that otherwise are not able to afford radiocommunication.
- It increases the range of radio types for business use.
- It is the ideal solution for many applications not requiring large range.

The following countries have already implemented the short-range business radio service: USA, Denmark, Czech Republic, Poland, Switzerland, Ukraine, Belarus, the UK and South Africa. Many other European countries are also considering introducing this service.

It is estimated that the penetration of the radio in a developing country could reach 0.1% to 1% in a five-year period. For a country with a population of 20 million, that represents 20 000 to 200 000 radios.

5.2.2.3 Regulatory Aspects

Nature of the service

The service is a secondary service. It requires no frequency co-ordination or planning by the administration. The channels therefore need to be allocated for exclusive use by the service on a country-wide or regional basis and need to be shared by all licensees. The channels may be busy and unusable at particular locations and times and the licensee has to be made fully aware of that at the time of licensing. The licensee or prospective licensee also needs to be made aware that no protection can be demanded from interference by other radios of the same type and which operate on any of the frequencies allocated to the service. The licensee or prospective licensee needs to understand that the service is therefore not suitable for the user who needs to be certain that he/she can communicate at all times.

Streamlined licensing procedure

The successful marketing of the radios critically depends on the user being able to operate the radios immediately after purchase. Any delays in the issuing of the licence seriously hamper the sale of radios. In order to facilitate the prompt acquisition of the radio by the licensee, the administration needs to follow one of several possible approaches: the licence should be issued promptly, i.e. on the same day as the purchase, but not later than a day after that; the licence can be waived; the licence can be prepaid by the manufacturer or the licensee can be allowed to operate the radio for a limited period, until such a time as the licence has been issued.

Spectrum utilisation efficiency

The service provides efficient use of the spectrum. The spectrum is used much more efficiently than with higher-power radios due to the ability to re-use frequencies at much smaller separation distances. The spectrum is also used efficiently because there is a great amount of sharing of a channel, partly due to the convenience of not hearing a user on the same frequency channel that is using a different private-line code. The estimated penetration of 0.1% to 1% provides an extremely efficient way of utilising the few frequencies allocated to the service. One is likely to also see a migration of users of other conventional PMR systems to this radio service and the consequent freeing of spectrum for other, more professional uses.

Spectrum requirements

Ideally, five simplex frequencies are required for itinerant use, preferably nation-wide. Failing a nation-wide allocation, the allocation should be for a sizeable region within the country. Should five frequencies not be possible, fewer will also be workable, at least in the first few years. The channels should each have a bandwidth of 12.5 kHz at UHF and 25 kHz at VHF. They can be adjacent to one another or can be spread over a 20 MHz portion of the band. The 20 MHz portion should be in either one of the following bands: 450-470 MHz, 430-470 MHz or 154-174 MHz, in order of priority.

Type approval

It is recommended that administrations accept the ETSI standard ETS300-086, as far as the technical characteristics to which the radio needs to conform are concerned. It is furthermore recommended that, in order to not unnecessarily delay the introduction of the radio into the country under the jurisdiction of the administration, test reports from reputable European test houses be accepted. Alternatively, administrations may find it acceptable to type approve the radio on the basis of it having been type approved by a leading European administration.

Conventional PMR, like any other form of radiocommunication, is dependent on the availability of radio frequencies within the electromagnetic spectrum. Administrations usually license frequencies directly to users who operate their own conventional PMR radio systems.

Conventional PMR systems operate in a number of bands at VHF and UHF. When allocating spectrum, administrations will be well-advised to note for which bands radios are manufactured in large volumes and by a reasonable number of manufacturers. A common mistake is to make spectrum allocations for radios that do not operate on commonly used frequencies and which may only be available from few suppliers. The penalties in terms of the cost to users may be high, due to the lack of economy-of-scale benefits. There is also the risk of production coming to an end unexpectedly, with a resultant problem of spare-part availability.

Allocations that employ a channel spacing of 12.5 kHz are wise, in terms of the shortages of spectrum that may easily arise.

As much sharing as possible should be encouraged, by means of, for instance, community repeater systems. Simplex frequencies should, as far as possible, be used for radios used in limited geographic areas not requiring repeaters. In this case also, consideration should be given to sharing the frequency amongst various groups, even groups not belonging to the same organisation.

5.3 Trunked Radio Systems

This section briefly describes the different markets, technologies, features and benefits of trunked radio systems. It gives the reader a brief overview of different aspects without going into too much detail.

5.3.1 What is a trunked radio system?

A trunked land mobile radio system is a multi-channel system with automatic channel selection, particularly referring to dispatch systems. This is explained in what follows.

In traditional non-trunked radiocommunication systems, i.e. conventional PMR systems, different groups of users operate on separate frequencies (or radio channels). A user in a group needing to communicate with another user (or users) in the group may find that the channel is busy, because other users in the group are using it. Consequently, the user needs to wait for the channel to become available. In this situation, it often happens that the channel of another group operating in the same area is vacant. However, the user cannot access this channel, simply because it belongs to another group. He also does not know that it is vacant. In essence, therefore, while one group is experiencing a lack of spectrum to communicate, the other is experiencing an over-supply. Because the latter group does not need the spectrum at that particular moment, the spectrum is wasted.

If there exists a way by which the one group's channel, when not needed, could be made available to the other group and vice versa, both groups will be better off. They both will be able to get more air-time, simply because they share channels. Should automatic dynamic assignment of channels be done so as to provide any one of the two channels to a user requiring a channel, provided it is vacant, sharing will be effective and spectrum will be saved. This is the principle on which two-way radio trunking is based.

In two-way radiocommunication (or PMR), trunking is therefore the automatic and dynamic assignment of channels, from a number of pre-allocated channels, among a number of radio users. The number of users is usually much greater that the number of channels. Trunking is therefore the sharing, in an automated way, of a number of channels among a significantly large number of users. (Trunking, of course, can theoretically also be done manually, by means of a human operator that instructs users what channel to switch to. However, as well as the cost of manpower, it has the obvious disadvantages of a lack of speed, human error and the impossibility of handling a large number of channels and users effectively.)

The same principle as in two-way radio trunking is used in the public switched telephone network. If a telephone call is made to a subscriber in another city, the call is carried by an arbitrary line. The caller does not have to select the line; it is selected automatically by the system. All the caller has to do is to request a line, by dialling. The city exchange will automatically assign a free line to the caller. When the conversation is over the caller hangs up and the line is then released for other users. The system therefore handles the assignment of a relatively limited number of lines among a large number of subscribers.

In radio trunking, when a call to another user, or group of users, is requested, the system assigns a free channel for the call. When the conversation is terminated, the channel is released for other users. This assignment of channels is done dynamically buy a computer-based controller in the system and the user is not even aware of it.

In a trunked radiocommunication system, the system's built-in intelligence, by means of computer technology, takes care of assigning channels to users. Users therefore do not have to worry which channel is free, but can concentrate on the communication that has to be carried out.

Trunking in radio systems became feasible with the introduction of the microprocessor that made it possible to bring enough computing power into mobile and portable radios, as well as the controller of the trunking system. The controller is the housekeeper of all activity within the system. It receives the request for communication, processes it and establishes the contact between users.

5.3.2 Features and characteristics of trunked systems

Trunked systems are available in all frequency bands popular for two-way radiocommunication, such as VHF, UHF, the 800 MHz band and the 900 MHz band.

In trunking, the following applies, as compared to a system where every user group has only one dedicated channel:

- Because a number of channels are available to a potential user, the probability of finding a vacant channel immediately on request is increased. Likewise, the waiting time for a vacant channel is decreased. This, of course, is of major benefit to users.
- On average, every channel is occupied for a larger proportion of total time. This is because the probability of the channel being needed at any point in time is increased, because of the larger number of users. As a consequence, fewer channels will be needed for all the users' traffic, simply because each channel now carries more traffic, on average. For users where the use of the spectrum comes at a price, this, of course, has financial benefits. For the country, this has the benefit to saving RF spectrum that could now be made available to another group of users, on another trunking system. Alternatively, the spectrum could be used for a totally different application.

Trunking technology therefore leads to the efficient use of frequencies and is to be welcomed by administrations and operators.

Trunked systems allow users to communicate via mobile, portable and fixed equipment, offering them features which are very useful and sometimes indispensable for people who work in teams.

Because computer technology is used in radio trunking systems, a number of useful features can relatively easily be provided. Some of these are:

- quick access time to a radio channel;
- a dispatch facility, i.e. the ability to talk to more than one user simultaneously;
- encryption of the voice signal, thence complete privacy;
- high-user density, i.e. a large number of users per square km;
- specific coverage characteristics, e.g. wide area, single site and ribbon-type systems;
- telephone interconnect capability;
- different priority levels for different users, for example, priority access for special users at peak times;
- high reliability of communication, i.e. low-system down times;
- a private call capability.

All the above can be achieved at a very reasonable price per user, as compared to conventional PMR systems.

A trunked land mobile radio system allows a very cost-effective way of sharing a number of radio channels by a large number of radio users through a common infrastructure. It may be of use to a large organisation, who could operate its own private system. Also, a number of medium-sized organisations could share a trunking system amongst themselves, for private use. Apart from being used for private purposes, a trunked system can be used to provide a service to the general public, including small businesses. In this case, the concept is often referred to as public access mobile radio (PAMR) or shared mobile radio (SMR).

5.3.2.1 Technologies and protocols

In order to make the trunking control terminal and the individual mobile and portable radios talk to one another, a common language is used. Communication between the units is made by exchanging sets of information, much like telegrams. The language used in the telegrams is called the trunking protocol. Several trunking protocols are in use today. Some of these have been put forward by regulatory authorities, and some by the manufacturers of trunked radiocommunication systems.

The authority-based protocols are usually "open" *de jure* protocols, available for employment by any manufacturer. The protocols developed by system manufacturers are often proprietary and not for use by other manufacturers. However, manufacturers will sometimes, for the sake of popularising a protocol, make it available to other manufacturers as well, usually at the payment of a fee. Manufacturer-developed proprietary protocols can, due to general popularity, become *de facto* protocols.

An example of an open protocol is the UK standard MPT1327, which has been adopted in some other countries as well. However, countries who have adopted MPT1327, much as countries who have adopted other standards, do not always adhere perfectly to the original standard. Variations are often introduced, which may hamper compatibility between systems. In practice, this may mean that some manufacturers' mobile subscriber units may not be able to operate on the infrastructure installed.

5.3.2.2 Technologies categorised by channel selection method

Trunking system technologies can broadly be categorised by the type of channel selection and modulation method. These are:

- Scanning systems (pseudo trunking, without control channel).
- Analogue trunking (with control channel).
- Digital trunking (with control channel).
- Scanning trunking systems.

In these systems, the subscriber radio scans the channels for an available channel in order to make a conversation. It is ideal for single-site systems with two to three channels. However, a disadvantage is that it has a long access time.

A scanning system could be a starting point for an operator who later wants to migrate to a trunking system with a dedicated control channel.

Systems with dedicated control channel

This type of system consists of a couple of duplex base stations and a trunking controller. One of the channels of the system acts as a control channel. This channel is the main communication pipeline for the housekeeping of the communication between the subscriber radios and the trunking system base stations.

The access time for this type of system is much lower than in a scanning system. Furthermore, additional features, like enhanced access control, are offered.

All the channels other than the control channel are called traffic channels. The traffic channels are only used if there is a communication requirement from a user in the system. When a conversation ends, the traffic channel is released and is available for other users of the system.

This type of system could be an analogue or a digital system.

Based on theoretical traffic calculations, about 50 to 100% more users can be loaded on the same number of channels as compared to a conventional PMR (non-trunked) system.

5.3.2.3 Technologies categorised by modulation method

Analogue trunking

Examples of analogue trunking systems are those which conform to the MPT1327 and APCO-16 protocols. APCO-16 is a wide-ranging standard that includes the system protocol. It was developed by the Associated Public-Safety Communications Officers, Inc. (APCO), in the USA. MPT1327 was developed in the UK. MPT1327 and APCO-16 complaint systems use frequency division multiple access (FDMA).

Analogue systems, generally speaking, are in the process of falling behind in terms of features that are now becoming available on digital systems. However, analogue technologies have many of the features mentioned in section 5.3.2. They are in widespread use and will be the preferred system with many operators, also because of price, for a long time to come. Some analogue technologies lend themselves to being upgraded to digital technologies, an important advantage for operators who want to buy an analogue system but who would later like to switch to a digital technology.

Digital trunking

What is commonly referred to as *digital trunking systems* are systems that make use of digital modulation and which essentially employs TDMA. Two of the latest developments in digital trunking are iDEN and TETRA. The name iDEN stands for integrated Digital Enhanced Networking, a standard developed in North America and in the process of being accepted in Europe as well. TETRA is a standard that has been developed by the European Telecommunications Standards Institute (ETSI), in conjunction with some of the larger radio system manufacturers and prospective users.

Digital modulation provides a good way of reducing the effective channel bandwidth. In the case of TETRA, for instance, the data transmission rate is 36 kbit/s in a 25 kHz bandwidth, while in the case of iDEN it is 64 kbit/s in 25 kHz. As a result, four and six speech channels, respectively, can be carried on a simple 25 kHz channel.

Digital modulation schemes make use of error correction techniques and, as a result, the quality of speech is maintained over the whole of the system's service area.

Another advantage of digital systems is the greater amount of ease with which a variety of information types can be carried, including facsimile and data.

More information on digital transmission technology can be found in Appendix D, section 8.

TETRA is a standard that is likely to become a true pan-European open standard that will possibly also find application outside of Europe, in ITU Region 1. In the initial stages of its development, it is aimed at public-safety applications, mainly those of the police, fire-fighting, and medical rescue. In later phases, it is also likely to be employed in civilian systems, including public access mobile radio systems (PAMR).

The TETRA standard defines a number of interfaces [4]. These are:

- The trunked mode air interface between mobile stations (MS) and the Switching and Management Infrastructure (SwMI), which comprises the base stations, switches and controllers.
- The direct mode air interface, for direct communication between MS without involving the SwMI.
- The inter-system interface between two TETRA SwMIs.
- An interface for connecting a network management terminal.
- The interface to a line-connected terminal, which has the same features and functions as a MS but is connected to the SwMI by a landline, rather than by radio.
- The terminal equipment interface between a MS and an external data device, such as a printer or video camera.
- The interface between the SwMI and other networks, such as the public telephone network, public data networks and PABX networks.

TETRA will initially operate in the band 380-400 MHz, for public safety. The band 410-430 MHz is likely to be used for civilian private use and PAMR.

More information about TETRA is given in Appendix D.

The iDEN standard is a standard developed by Motorola and is licensed to other manufacturers. An iDEN system allows an operator the ability to offer a number of integrated services from a single subscriber unit. These include: enhanced dispatch services for group communications, full-duplex feature-robust telephone interconnect with roaming capabilities, message mail and data for dial-up facsimile usage. The iDEN technology is extremely flexible in its networking capabilities and can serve both regional and nation-wide applications. An interesting feature of iDEN's frequency use is that its frequency channels (of 25 kHz) do not have to be adjacent to each other. Channels can be spread over the full width of the 15 MHz wide band.

Another trunking protocol that is digital is APCO-25.

5.3.3 Other aspects of trunked systems

5.3.3.1 Spectrum utilisation efficiency

Radio trunking is spectrum efficient. Two factors make a major contribution to the spectrum efficiency. Firstly, all radio users share all channels in the system. Secondly, no channel stays unused when a need for communication exists. The trunking controller immediately allocates free channels when requested. More users can therefore be loaded on the system. More users per channel means less demand for new channels. By optimising the use of the spectrum, more users can be allowed on the system and be provided an increased level of service. For this reason, in many countries, administrations have ruled that new spectrum allocations for PMR be restricted to trunking.

Public access mobile radio systems (public trunking systems) also provide an affordable good quality solution for small and medium-sized businesses who may find it difficult to own and operate private two-way (conventional PMR) radio systems.

5.3.3.2 Privacy

With trunked radiocommunication systems, users hear only the conversation intended for them because they have exclusive use of the channel. At all other times, their radios are silent. Since communication in a trunked radiocommunication system happens on an arbitrary channel selected by the system, it becomes difficult for unauthorised users to monitor the voice communication of a particular group of users. The degree of privacy can be even further enhanced on a trunked system by adding digital voice encryption, if that is supported by the system architecture.

5.3.3.3 System reliability

If a channel in a conventional system breaks down, the users on that channel are prevented from communication, unless they all decide to proceed on a different channel. This may not be easy to do. This situation never occurs in a trunked radio system. When a repeater station falls out, the trunking controller registers the fall-out and does not use the repeater until it has been repaired or the disturbance has disappeared. Since channels are allocated as needed, and no user group is dependent on any one channel for communications, the failure of a single channel is usually not noticed by the user.

5.3.4 Markets

The main markets in which radio trunking systems can be used are:

- Public-safety sector (police, fire brigade, government administration, ambulance, security, border guard).
- Commercial (taxis, sales, services, delivery, agriculture).
- Industry (major industries, such as metal processing, engineering, automotive manufacturing, mining).
- Transport (airlines, airports, railways, transit, shipping, harbours).
- Utilities (water, gas, electricity).
- Oil and gas industry (exploration, transport and refineries).

In order to implement a PAMR system, there is a need for an operator who can invest in the design, development and maintenance of the system infrastructure and who can offer effective and affordable radiocommunication services to many individual users. In the case of PAMR, the cost of the infrastructure, system operation, maintenance and technical support is therefore incurred by the operator. Users (subscribers) have to pay only for the subscriber equipment and the operator’s periodic service charges. Such a cost structure fosters demand for and popularity of the service, by lowering the financial and administrative entry barriers. Existing radio users and new users, who otherwise would not be able to afford radiocommunication, could easily become subscribers.

PAMR services can be utilised by various user sectors. Some of these sectors are:

- Construction.
- Passenger transportation.

- Cargo/freight transportation.
- Business services.
- Farming services.
- Delivery services.
- Security services.
- Health services.
- Repair & maintenance services.
- Banking.
- Insurance.
- Manufacturing operations.
- Sales organisation.

Trunked PMR systems have become popular, in recent years, in developed countries. In Europe, for instance, the subscriber base reached about 300 000 users towards the end of 1995. There are many developing countries in which trunked radio systems could be used cost-effectively.

Table 2 shows how typical features match typical markets. A bigger circle means a better fit.

TABLE 2

Features versus markets

	Dispatch	Encryp-tion	Access Time	Reliabi-lity/Re-dundancy	High Density	Wide Area	Ribbon Type Systems	Tel. Intercon-nector	Diff. Priority Levels	Invest-ment
Public Safety	**◯**			**◯**	**◯**		○	○	◯	○
Commercial PAMR	○	○	○	○	**◯**	○	○	◯	○	**◯**
Industry	○	○		○	**◯**	○	○	○	○	○
Transport inc. Oil/Gas	○	○	○	○	○		**◯**	**◯**	○	○
Utilities	○	○	○	○	○	○	○	○	○	○
Oil/Gas Exploration & Refineries	○	○	○	○	○	○	○	○	○	○

Table 3 shows the likelihood of finding certain features with the various types of PMR system.

TABLE 3

Features versus type of PMR system

	Dispatch	Encryp-tion	Access Time	Reliabi-lity/Re-dundancy	High Density	Wide Area	Ribbon Type Systems	Tel. Intercon-nector	Diff. Priority Levels	Invest-ment
Conventional Systems	◯	○	◯	○	○	○	○	○	○	◯
Scanning Systems	○	○	○	○	○	◯	◯	○	○	◯
Analogue Trunking	◯	○	◯	◯	◯	◯	○	◯	◯	○
Digital Trunking	◯	◯	◯	◯	◯	◯	○	◯	◯	○
Cellular/ GSM	○	◯	○	◯	◯	◯	○	◯	○	○

Table 4 shows what type of PMR system fits what market the best.

TABLE 4

Market versus type of system

	Conventional System	Scanning System	Analogue Trunking	Digital Trunking	Cellular/ GSM
Public Safety	○	○	◯	◯	○
Commercial/ SSMRS	○	○	○	○	○
Industry	○	○	◯	○	○
Transport inc. Oil/Gas	○	◯	○	○	○
Utilities	○	○	◯	○	○
Oil/Gas Exploration & Refineries	○	○	◯	○	○

It is obvious that no single system can cover all markets, nor all features.

The question may be asked as to how the markets for cellular mobile telephony and PAMR differ. While cellular mobile services are targeted to the general public and are relatively expensive to use, PAMR is only for businesses and other organisations. It provides them with quick and efficient communication at an affordable price. This is an aspect which is of great importance for business and other organisations in developing economies.

5.3.5 Regulatory aspects

General

The availability of an operator-managed trunked PAMR network (or networks) is advantageous to both operators and administrations. The collection of licence fees from users utilising a shared network service is the responsibility of the operator and not that of the administration, as in the case of conventional PMR. The administration is therefore spared all the efforts associated with handling such fees. Instead of dealing with every end user individually, the administration will have to deal with only the system operator. The latter is charged periodically for the use of assigned frequencies.

It is inadvisable for administrations to prescribe the technology or protocols to be used by any trunking operator, whether it be a private or public operator (PAMR). Competitive forces in the marketplace provide enough of an incentive to choose an appropriate technology or protocol. The converse, i.e. to let the administration choose the technology, puts an unnecessary obligation on the administration and leads to situations where the administration may be blamed for the ineffectiveness or inefficiencies of the operator. Following many attempts in the past, administrations should attend to the following issues, discussed in some detail in the subsections to follow.

- Efficient use of the spectrum.
- Spectrum allocation.
- Frequency coordination.
- Encouraging competition.
- Type approval.
- Licensing conditions.
- Efficient use of the spectrum.

Frequencies are a limited natural resource and should be used efficiently and economically. Measures that can be utilised to use the spectrum efficiently are the following:

- Administrations should encourage the use of trunking systems in the case of large users of two-way radio systems. In cases where a user requires more than three channels, serious consideration should be given to a trunking system with a dedicated control channel. Spectrum-saving benefits can already be obtained with as little as three channels.
- Conventional systems should be allowed only in areas where the user density is lower then about 50 radios per site (i.e. within coverage area of one radio base station). In areas where the density is higher, trunking should be strongly encouraged.
- The channel spacing should be as small as possible, but the number of traffic channels should be taken into account. Some systems are more efficient using 25 kHz than others using 12.5 kHz. Where a choice of channel spacing is possible operators should be encouraged to use 12.5 kHz, provided it is spectrum efficient to do so. This is a channel spacing widely used. The administration should not define the protocol to be used on the control channel. It should be left to the operators.
- For areas where enough users exist to justify a trunking system, but where no single user or company can justify a system for only its own use, consideration should be given to allowing either a closed user group, consisting of various organisations, or an independent public service network operator, to operate a trunking system. The operator in the latter case would sell his services to the users. Such a system, called a shared mobile radio system (SMRS) in some countries and a public access mobile radio system (PAMR) in others, is highly desirable. Users therefore do not have to invest in their own infrastructure and spectrum. The public system operator is paid a monthly fee, related to the depreciation cost on the capital outlay of the system, plus a fee per call, more or less related to other operating costs that the operator may have. This approach usually leads to costs which are less than the costs involved in operating a self-owned system. The fundamental reason for the savings is that the system and RF spectrum are essentially much more effectively utilised than what would be the case for the combination of privately owned systems.

The licence costs for the PAMR operators should be kept reasonably low. It should be realised that it is not business of the same scale as with mobile cellular telephony. If the licence fee is too high, the PAMR business will not be profitable enough for the operator.

Spectrum allocation

In order for trunking operations to be economically viable, frequency bands widely used, preferably on a global scale, should be allocated. Such allocations make operating licences more attractive and guarantee that operators have a continuous supply of competitively priced infrastructure and subscriber equipment. This leads to competitive pricing for the trunking services provided to end-users.

Bands that are popular are:

- The VHF bands 136 to 174 MHz and 146 to 174 MHz, with 12.5 or 25 kHz channel spacing. These bands are popular for systems using the APCO-16 and MPT1327 protocols.
- The UHF bands 806 to 824.9875 MHz, paired with 851 to 869.9875 MHz, with 25 kHz channel spacing. These bands are popular for systems using the APCO-16 protocol and are likely to be used for the APCO-25 protocol in future.
- The UHF bands 403 to 450 MHz. These bands are popular for the MPT1327 protocol.
- The VHF band 308 to 390 kHz, paired with 390 to 400 MHz, with 25 kHz channel spacing. The band has been set aside in Europe for digital trunking systems. It will mainly be used by TETRA.
- The band 806 to 821 MHz, paired with the band 851-866 MHz and the band 1453 to 1465 MHz, paired with 1 501 to 1 513 MHz. These bands are popular for the integrated digital enhanced networking system (iDEN).

Encouraging competition

A competitive environment increases the marketing activities of the different suppliers and operators. The marketing activities increases the number of users and the increasing number of users reduces the prices. This chain of effects has, all over the world, been found to have a positive impact on the economy, also with respect to telecommunication services, such as PAMR.

Type approval

Type approval regulations are key to the success of radiocommunication in a country. When a country develops its own rules and laws for type approval, it should consider taking over the regulations from renowned standards bodies, such as ETSI. The reason for that is that the parameters are already defined and most of the radios and systems around the world are complaint with these regulations. That enables fast market development.

Another issue is the actual testing of the equipment. In many countries, accredited test-houses are allowed to make the measurements for the authorities. In other countries, the measurement results are accepted by administrations. A third type of country issues certificates based on licences given in other countries.

For the development of a country, it is important that type approval with respect to trunked radio systems takes place smoothly and does not cause undue delays.

5.4 Cellular Public Land Mobile Telecommunication Systems

Public land mobile cellular telecommunication (telephone) systems can, in generic terms, be defined as land mobile systems for public correspondence via radio stations connected to the public switched telephone network.

One of the most important characteristics of any mobile cellular telephone system is that of *multiple access*, meaning that multiple, simultaneous users can be supported. In other words, a number of users share a common pool of traffic channels in each cell and any user can be allowed access to any channel by the system. (Each user is not always assigned to the same channel in a cell.) A channel can be thought of as merely a portion of the limited radio spectrum which is temporarily allocated for a user’s phone cell. A multiple access method is, in essence, a method of dividing the RF spectrum into traffic channels and assigning the channels to simultaneous users of the system. (In the sense in which we use the term *RF spectrum* here, the dimensions of both frequency and time are included.)

Mobile cellular technologies have come as the saving grace for urban telecommunications in developing countries. They provide a form of telecommunication that not only solves the ubiquitous lack of telephones in residences, businesses and other concerns but also ensures mobility for the user that, in the majority of cases, is of the same standard available in the most developed of countries.

Mobile cellular systems are relatively expensive for fixed telephony and cannot be regarded as the optimum solution for this application. However, apart from providing a mobile telephone service to businesses and other well-to-do private users, cellular technologies can be a means whereby a limited number of public telephones may be made available in areas where phones do not exist. Nevertheless, it must be realised that there are penalties in using a mobile system for fixed applications, i.e. for what essentially amounts to a wireless-local-loop application.

5.4.1 The analogue technologies

Analogue cellular technologies are based on frequency modulation (FM) techniques. The speech to be transmitted is used to modulate the carrier frequency causing it to be varied in frequency. Most analogue cellular systems use FM for speech and frequency shift keying (FSK) for data. In analogue cellular systems a traffic channel is usually carried by one radio frequency. All analogue cellular systems use the frequency division multiple access (FDMA) technique.

For the greater part, the technologies for the other analogue cellular standards are very similar to the AMPS standard described below; in fact, the majority are variants of AMPS. The major differences lie in the frequency bands in which the various standards are implemented. Among the other major analogue cellular standards are the Total Access Communication System (TACS), the Extended Total Access Communication System (E-TACS), the Japanese Total Access Communication System (J-TACS) and Narrow-Band Total Access Communication System (N-TACS), the Austrian Total Access Communication System (A-TACS), the Universal Total Access Communication System (U-TACS) and the Nordic System (NMT).

A short description of each of the analogue cellular technologies is given below.

Advanced Mobile Phone System (AMPS)

The AMPS air interface is specified by the American National Standards Institute (ANSI), Electronic Industries Association (EIA) and Telecommunications Industry Association (TIA). The current version is known as EIA/TIA-553.

The AMPS frequency ranges are:

- A band: 826-836 MHz for base-station receive and 870-880 MHz for base-station transmit.
- B band: 836-845 for base-station receive and 880-890 for base-station transmit.
- A-band extension: 824-826 MHz for base-station receive and 868-870 MHz for base-station transmit, plus 845-846.5 MHz for base-station receive and 890-891.5 MHz for base-station transmit.
- B-band extension: 846.5-849 MHz for base-station receive and 891.5-894.4 MHz for base-station transmit.

The base station transmit and receive bands are separated by 45 MHz. The channel spacing is 30 kHz and typically each operator within a geographical area is allocated half the available channels (416) for control and voice. In the US, the B-band frequencies are reserved for the wireline operator and the A-band frequencies for the non-wireline operator. The extended bands, referred to as Extended AMPS (E-AMPS) channels, were added after the commercial introduction of AMPS.

There are two classifications of AMPS channels. Control channels are used by the base station and mobile station to exchange information relating to call set-up. Twenty-one channels are reserved in both bands for the implementation of control channels. Mobile stations always monitor the control channels when not in the conversation state and lock to the strongest of these to acquire paging and overhead information. The traffic channels (TCH) are used by the base station and mobile station to bear information on the conversation of a call.

Link continuity between the base station and mobile station in a TCH is accomplished via the Supervisory Audio Tone (SAT) signal. Signalling between the base station and mobile station takes place through either the signalling tone (ST) or the 10 kbit/s FSK data signalling.

Total Access Communication System (TACS)

The Total Access Communication System (TACS) is a system using 15 MHz of RF spectrum. It is used in Europe, some parts of Asia, the Middle East and Africa. Channel spacing is 25 kHz and the duplex frequencies spacing is 45 MHz. The frequency range for the channel is:

Base receive/mobile transmit: 890.0125-904.9875 MHz

Base transmit/mobile receive: 935.0125-949.9875 MHz

The total number of voice channels is 558 and the number of signalling channels is 42.

Extended Total Access Communication System (E-TACS)

E-TACS adds additional 16 MHz of spectrum to the conventional TACS system and is considered an extension of TACS No additional signalling channels are provided. However, 640 voice channels are allocated – 320 for Band A and 320 for band B. Transmit and receive frequencies are separated by 45 MHz.

Channel spacing is 25 kHz and the duplex frequency spacing is 45 MHz. The frequency range for the channel is:

Base receive/mobile transmit: 872.0125-887.9875 MHz

Base transmit/mobile receive: 917.0125-932.4975 MHz

The total number of new voice channels is 640 and the total number of voice channels (TACS and E-TACS combined) is 1198.

Japanese Total Access Communication System (J-TACS) and Narrow-Band Total Access Communication System (N-TACS)

The Japanese Total Access Communication System (J-TACS) and Narrow-Band Total Access Communication System (N-TACS) are systems for a singular frequency band. Channels are not separated into separate bands in these systems. The overall band occupies 10 MHz of spectrum. This allows a total of 800 channels. Both systems are currently used by Japan. The original specification, J-TACS, uses only the even-numbered channels. Only when the Japanese employed the narrow specification, N-TACS, did the odd channels come into use.

The channel spacing is 25 kHz and the duplex frequency spacing is 55 MHz. The frequency range for voice and signalling channels is:

Base receive/mobile transmit: 915.025-924.475 MHz

Base transmit/mobile receive: 860.025-869.975 MHz

For N-TACS there are 752 voice channels and for J-TACS there are 376. N-TACS has 48 signalling channels and J-TACS has 24.

As can be seen from the frequency ranges given above, J-TACS and N-TACS cell sites receive in the upper leg and transmit in the lower leg of the allocated spectrum. Conversely, AMPS and TACS cell sites transmit in the upper leg and receive in the lower leg. As a result, J-TACS and N-TACS subscriber units cannot be used in TACS and AMPS systems. The same is also true of the subscriber units of the TACS and AMPS systems – they cannot be used in the J-TACS/N-TACS systems.

Austrian Total Access Communication System (A-TACS)

The Austrian Total Access Communication System (A-TACS) consists of repackaged TACS equipment used exclusively in Austria. It uses the same RF spectrum and channel selection as TACS voice channels. The frequency spectrum is divided into two bands, with each channel separated by 25 kHz. Up to 600 voice channels are available.

Universal Total Access Communication System (U-TACS)

The Universal Total Access Communication System (U-TACS) is used in Europe, some parts of Asia, the Middle East, China and parts of Africa. U-TACS has a 15 MHz frequency spectrum and uses 25 kHz channel spacing, providing up to 920 channels. The U-TACS frequency spectrum and channel allocation is the same as the combined TACS/E-TACS system, with the exception of the lower 8 MHz of the spectrum. With 8 MHz less of the spectrum. With 8 MHz less spectrum, U-TACS has 320 fewer channels.

Nordic Mobile Telephone (NMT)

The Standard Nordic System (NMT) is designed to operate within the 400-470 MHz band, although a version was also developed for the 900 MHz band. NMT was developed in the late 1970s and was operational before other cellular systems were implemented. This system operates in a manner similar to the latter, more conventional cellular systems and is used by Iceland, Sweden, Finland, Switzerland and Netherlands. A modified version is also used by Denmark.

5.4.2 Digital Technologies

The most popular digital technologies are GSM, DCS1800 and DS-CDMA and will be discussed here.

Global System for Mobile communication (GSM)

Due to the rapid growth in Europe of analogue cellular telephone systems in the 1980s and the incompatibility among the systems in different countries, there was the need for a better solution. In 1982, the Conference of European Posts and Telegraphs (CEPT) formed a study group called the Group Special Mobile (GSM) to study and develop a pan-European public land mobile system. The acronym GSM was later changed to Global System for Mobile communication.

The cellular multiple access method that was developed, known as Global System for Mobile communication (GSM), is a combination of Time Division Multiple Access and Frequency Division Multiple Access (TDMA/FDMA). The FDMA part involves the division of the nominal 25 MHz bandwidth (the maximum bandwidth) into 124 carrier frequencies, spaced 200 kHz apart. One or more carrier frequencies, depending on capacity requirements, are assigned to each base station. Each of these carrier frequencies is then divided in time, using TDMA scheme. The fundamental unit of time in this TDMA scheme is called a burst period. There are two major channel categories, traffic channels (TCH) and control channels (CCH). These channels are further broken down according to their function.

In addition to these full-rate TCGs, half-rate TCHs have also been defined, although they are not yet implemented. Half-rate TCHs will effectively double the capacity of a system once half-rate speech coders are specified (i.e. speech coding at around 7 kbit/s, instead of 13 kbit/s).

GSM operates in the band 890-915 MHz for the uplink (mobile station to base station) and 935-960 MHz for the downlink (base station to mobile station). Also reserved for GSM is the top 10 MHz of each band referred to as the spectrum for the Extended Global System for Mobile communication (E-GSM).

Amongst the benefits of GSM are the improvement of the following characteristics over analogue systems:

- Range of services, e.g. ISDN related services.
- Quality of the service and security.
- Support for international roaming.
- Ability to support handheld terminals.
- Rf spectrum utilisation efficiency.
- Network aspects.
- Cost aspects.

GSM is a technology that has reached a high level of maturity, while new features are continually being added.

Digital Cellular System 1800 (DCS1800)

The specification for DCS1800 (Digital Cellular System 1800), which is a higher frequency (1800 MHz) variant of GSM, was completed in 1991. DCS1800 systems are aimed for use in urban areas to meet the high capacity requirement in those areas. DCS1800 operates in the band 1 710-1 785 MHz for the uplink (mobile station to base station) and 1 805-1 880 MHz for the downlink (base station to mobile station). These are bands that have been allocated by various countries in ITU in Region 1, for Personal Communication Systems (PCN).

DCS1800 systems have basically the same benefits and features as GSM systems.

Direct-Sequence Code Division Multiple Access (DS-CDMA)

DS-CDMA for cellular application is specified by the Telecommunications Industry Association (TIA) in the USA as IS-95. The TIA published IS-95 in 1993. FDMA (used in traditional analogue systems) and TDMA (used in GSM) are examples of multiple-access technologies akin to DS-CDMA. In analogue cellular systems, each subscriber terminal (mobile station) is assigned a specific frequency channel (typically 25 kHz) that may be available at the time. In a TDMA system (e.g. a GSM system) each subscriber terminal is assigned an available time-slot within a frequency channel that is somewhat wider than a FDMA frequency channel (200 kHz in the case of GSM). In the case of CDMA, each subscriber terminal in use is assigned a channel in the form of a unique digital code, rather than a separate frequency channel or a time-slot. This code consists of a binary sequence of zeros and ones and is pseudo-random. It, together with the bitstream that contains the voice information of the user, becomes a signal that constitutes an element of the composite signal that modulates the transmitter carrier directly, hence the term *direct sequence*. The composite modulation signal, in the case of the base-station, consists of the signals of all the simultaneous users.

The pseudo-random code is present at both the transmitting and receiving stations and in that sense effectively constitutes a traffic channel. At the receive end, the information that constitutes the voice signal of a user and which is scrambled amongst the signals of all the simultaneous multiple users is accessed (demodulated) using the unique pseudo-random code. These unique codes – one for each subscriber terminal in use at the time – therefore serve as vehicles for *dividing,* into *multiple* channels, the information contained in the *multiple* signals of all the simultaneous users, and for *accessing* the channel for each user at the receive end, hence the term *code division multiple access (CDMA).*

In terms of the IS-95 specification, the CDMA carrier has a bandwidth of 1.23 MHz. This is a very wide band as compared to the bandwidth used on analogue systems (typically 25 kHz) or even GSM (200 kHz). The information in the voice signal of every simultaneous mobile station user is carried over the whole of the 1.23 MHz bandwidth – as a result of the carrier being modulated by the unique pseudo-random code – hence the term *spread-spectrum modulation* that is sometimes used. Many conversations, up to 18, can take place on one carrier.

CDMA cellular systems are currently offered in at least three different frequency bands, as shown below:

824-849 MHz (Base-station receive)	869-894 MHz (Base-station transmit)
872-915 MHz (Base-station receive)	917-960 MHz (Base-station transmit)
1 850-1 910 MHz (Base-station receive)	1 930-1 990 MHz (Base-station transmit)

As compared to analogue and other digital cellular technologies, DS-CDMA offers a number of benefits to cellular operators. These are:

- Capacity increases in comparison to other technologies, for instance, in certain cases 8 to 10 times that of an AMPS analogue system and 4 to 5 times that of other digital cellular systems.
- Large coverage area.
- Improved call quality, with better and more consistent sound as compared to some other systems.
- Simplified system planning through the use of the same frequency in every sector of every cell site.
- Enhanced privacy.
- Improved coverage, allowing for the possibility of fewer cell sites.
- Increased talk time for portables.
- An ability to trade off coverage, traffic channel capacity and voice quality against one another.
- A smaller requirement for RF spectrum.
- CDMA is better suited for high-density applications, due to large capacity and the ability to handle multipath propagation.

5.4.3 Using a mobile cellular system in a fixed-telephony role

One of the penalties of using a mobile cellular system in a role where it provides a fixed telephony service, such as with public telephones, is that the grade of service of the mobile system deteriorates. Depending on the capacity of the particular cell that serves the public phones, the number of public telephones, the traffic patterns on the public phones and the volume of mobile traffic, the mobile system will experience a certain amount of blockage. In one particular example, *viz.* on a GSM system in one country, it was found that the blocking ratio (i.e. the proportion of uncompleted calls) of cells in the mobile service deteriorated to about 10% (from 2%) after the introduction of approximately ten public telephones per cell. The commensurate blocking ratio for calls on the public phones were somewhat higher – about 20%.

The problem is that public telephones, especially in highly populated areas, can carry a lot of traffic. It is not uncommon for a public telephone to be almost permanently occupied during daylight hours. One public phone may therefore easily carry as much traffic, during an eight hour period, as 100 to 200 mobile phone calls. A public phone may therefore place an exceptional loading on a cell, effectively tying up a traffic channel permanently. When a number of public phones are served by the same cell, too little capacity may be left for the cell to provide an acceptable service. It can, of course, be argued that, under such circumstances, the system should be re-dimensioned to provide more capacity – i.e. more cells should be provided, or the cell could be sectored, for instance. However, such changes can only be made at huge service costs or have to be absorbed by the operator. Neither of these options are attractive. As a consequence, the option of letting the mobile service deteriorate, while at the same time operating a below-standard public telephone service, has to be seriously considered.

The blocking ratio figures of 10% for the mobile service and 20% for the public telephone service are the approximate thresholds of what can be tolerated in terms of degradation, in the grade of service, for the two services, as these figures are obtained with approximately the maximum number of phones that can be accommodated per cell.

A total of ten public telephones per cell represents a fairly low density of public telephones that is probably not sufficient in the majority of cases.

To provide a public fixed telephone service using the infrastructure of a mobile cellular service is therefore not a satisfactory solution, at least with the majority of cellular technologies. The majority of cellular technologies are not able to provide a true public fixed telephone service that is able to accommodate normal traffic demands in urban areas. At best, a mobile cellular system should be employed only temporarily to give relief in areas where there is no public fixed service.

It is concluded that, for a fully-fledged public telephone service, unless a technology is used that can provide large traffic capacity, the mobile cellular service and the fixed service should rather make use of different infrastructures.

5.4.4 Market aspects

The cellular telephone industry has enjoyed phenomenal growth since its inception in 1983. A widely accepted prediction in 1985 held that the total number of cellular subscribers might reach as many as 900 000 by the year 2000. This prediction was vastly exceeded. In fact, by the end of 1994, there were well over 20 million subscribers in the United States alone and approximately 50 million world-wide. Recent annual subscriber growth rates have been as high as 40% and it is believed that this growth rate could continue through the rest of the 1990s.

In order to meet the increasing demand for service, new digital cellular telephone systems have continually been introduced since the advent of the first systems. The first half of the 1990s saw some spectacular new technological developments, of which DS-CDMA and GSM were the most prominent.

The growth of GSM networks has also been phenomenal. GSM has proven to be an excellent choice for many operators, especially in Europe. GSM and DCS1800 networks are currently planned or deployed in a number of countries around the world, e.g. in Europe, the Middle East, the Far East, Africa, South America, Australia, etc.

DS-CDMA came at a much later stage than GSM, but seems to be growing equally fast, especially in the Far East and North and South America. In North America, a large part of the total installed base of mobile cellular systems is analogue. However, that is changing fast, due to the popularity of DS-CDMA for new systems and for upgrading the capacity on existing systems. Operators wanting to upgrade the capacity of their analogue systems have the option of gradually phasing in CDMA, while phasing out the analogue system. The change is made by swapping small portions of the RF spectrum between the two systems in a systematic, step-by-step way.

As today’s cellular operators in developed countries move to adopt new technologies in their systems, they often demand the following:

- Increased capacity within their existing spectrum allocation and easy deployment of any technology it takes to get them that capacity increase.
- Higher capacities and lower system design costs (plus lower infrastructure costs) which will lead to a lower cost per subscriber.

- A lower cost per subscriber, combined with new subscriber features, which will help the operators to increase their market penetration.
- An increased market penetration, which will lead to an increase in number of subscribers and a system which offers support for that increased capacity.
- High quality calls must be maintained during the change or migration to any new digital technology.

Prospective operators in developing countries should take note of the above demands by operators in developed countries. The latter operators have gone through a learning experience that can be of great use. Prospective operators would be well-advised to thoroughly consider their long-term needs before deciding on a cellular technology. For instance, it may be attractive to opt for a technology that has been in service for a large number of years. Such a technology may be cheaper. However, should the operator's requirements be close to those detailed above, it should seriously consider one of the later generations of cellular technologies, preferably a digital technology, such as DA-CDMA or GSM. The DS-CDMA technology is most suitable for countries that have a need for a digital cellular system with state-of-the-art features and qualities and who are perhaps contemplating using the system for both mobile cellular and wireless-local-loop applications.

Analogue technologies are in the process of becoming replaced by digital technologies. The latter offer much better features and a roaming capability. Support and maintenance for analogue technologies may deteriorate in the not too distant future as they are phased out in developed countries.

For countries that want to move into the information age, data transmission capabilities should be a key issue. Digital cellular technologies offer a lot of scope for data transmission services and pave the way for bringing the information age into the mobile environment. Data transmission services are very often non-existent in developing countries, also for fixed applications. The introduction of a digital cellular system may therefore, in part, be a solution for this problem as well.

CDMA offers some definite advantages over GSM and should not be overlooked as an attractive new-generation technology, even in countries that already have GSM. CDMA's most important advantages for developing countries are its greater geographical coverage and larger capacity (hence few cell sites and a large number of users per cell site). These factors become very important where consideration is given to combining mobile cellular services with wireless local-loop services on the same infrastructure. This is because the large capacity and coverage capabilities will enable the handling of large numbers of mobile and fixed subscribers.

5.4.5 Regulatory aspects

Operator licences

It is common for the administration of a country to require a licence for the installation and operation of a cellular mobile system, other than a licence for only the use of RF spectrum. The requirements for eligibility to obtain a licence and the conditions stipulated in the licence vary from country to country. The reasons for the licensing of operators also vary, but are often given as one or more of the following:

- to ensure interconnection and interoperability with PSTNs and other networks (including other cellular networks);
- to ensure that mutual interference between the cellular system and other systems is limited;
- to enforce roll-out at a rate which the administration deems appropriate;
- to enforce the fulfilment of social and other cross-subsidisation obligations;
- to collect fees from the operator for the use of the RF spectrum;
- to control the degree of competition.

The reasons given usually relate to the political and economic philosophies in the country. For instance, countries more oriented towards economic freedom and a genuinely competitive environment will usually refrain from laying down social obligations of an involuntary nature. Such countries will also leave it to the operator to determine the roll-out rate. (Usually such countries will allow more than one operator, so that the competition between the operators will provide the incentive for fast roll-out.) In these countries, there will also be less of a tendency to prescribe technical standards and other specifications, as that is adequately taken care of by competitive forces. A good example of a country that has a minimum of conditions and prescriptions is Hong Kong. In Hong Kong, there are a number of cellular operators and with technologies that include AMPS, TACS, GSM and CDMA. Competition is fierce, with operators offering good prices and a large variety in quality and range of services. In some developing countries, such as South Africa, competition has been limited to two operators. Even this limited competition has had a dramatic impact in the roll-out rate and the growth rate in the subscriber base - to more than half a million in less than two years. The advantages of competition in this country have been so marked that consideration is being given to licensing even more operators. Administrations should take note of the many advantages that a minimum of regulatory interference and a competitive environment brings. Serious consideration should be given to not restricting competition by limiting the number of operators.

One reason, from a regulatory point of view, of sharing infrastructure between a mobile service and a public telephone service is to use revenue obtained from the mobile service to subsidise the public telephone service. However, this has a penalty. It puts a constraint on the development of both services. The operator needs to maintain a certain ratio between mobile service users and fixed-service users in order to remain profitable. The public telephones may therefore have to be limited from this point of view. Also, the provision of the fixed services consumes capital that could have been used for the greater geographical roll-out of the mobile services, for example, on the fringes of an urban area and on main routes.

Type approval

During the licensing process, it is customary for administrations to consider type approval. Type approval is the process whereby the specification of the equipment to be installed is reviewed by the appropriate authorities to ascertain that the equipment meets minimum standards, usually with the emphasis on the prevention of harmful interference. This is done by either reviewing the specification provided by the equipment vendor or physically conducting a test in the laboratory to verify equipment specification, e.g. RF emission tests.

In the case of GSM subscriber units, many countries do not require type approval to be done in-country. Rather, the list of type-approved mobile stations as per the GSM Memorandum of Understanding (MoU) Association is accepted as the document that determines whether a unit meets the type approval standard. Units listed meet an ETSI specification that all manufactures and prime countries in the MoU Association agree to. There is no inherent need to test a unit anywhere else once it has been enlisted by the MoU Association.

The above MoU-related type approval process is a well streamlined process and causes a minimum of problems to all parties concerned. It is strongly recommended for all countries considering GSM systems.

Standard specifications

There are various specifications covering the different cellular technologies around the world, issued by standard bodies in various countries. The well-known standards are mostly produced by standards bodies in the USA, Europe and Japan. Only those standards relating to the digital technologies of GSM and DS-CDMA are briefly discussed here.

In the case of GSM, the responsibility for the GSM standards were transferred to the European Telecommunications Standards Institute (ETSI) in 1989. Phase I of the GSM specifications was published in 1990. Phase II of the GSM recommendation was published in 1995 and is a fully-fledged version of the GSM standard with some additional supplementary services.

In the case of CDMA, there are various TIA specifications covering different interfaces, depending on the specific frequency band. IS-95 is the specification for the 800 MHz range system. It was approved, in July 1993, by the TIA subcommittee TR-45.5, whose function it is to develop spread-spectrum digital cellular standards. The other specifications are either approved or in the process of being approved. The goal is that, eventually, all CDMA specifications will be open standards.

As far as possible administrations are advised to let market forces – i.e. the prospective operators – choose the technologies and standards that are to be employed. History has proven that attempts by administrations to choose the winning technologies, even in developed countries, often lead to failure.

Operators should take note that it is advisable to employ a standard specification that is open, i.e. a specification that is complied with, or which is planned to be complied with, by more than one manufacturer. In this regard, it should be noted that both GSM and DS-CDMA comply with well-known open standards.

Spectrum

Administrations have the responsibility of ensuring that spectrum is allocated to meet the needs of their countries. It can be emphatically stated that no country can afford not to make spectrum available for cellular mobile systems. The economic benefits of these systems for business, government and private use have been proven beyond any doubt. In many instances, a cellular system will provide the only form of communication in urban areas, especially in countries which have a low telephone penetration rate.

In allocating spectrum and assigning it to operators, consideration should be given to the fact that some technologies are more spectrum-efficient than others. A CDMA system, for instance, will, in certain cases, use about one-ninth of the spectrum that an AMPS system uses and about one quarter of the spectrum that a GSM system uses – for the same number of users. Where spectrum is in short supply – and more often than not it is – administrations should seriously consider allocating spectrum for the more spectrum-efficient technologies and assigning it to operators who use efficient technologies. Of course, there are sometimes other considerations that have to be taken into account as well. Administrations of developing countries should take great care not to blindly follow the same trends as developed countries just because they may happen to fall in the same ITU region. Very often, these trends come about as a result of the particular circumstances in the developed countries and which do not apply to the country concerned.

Some of the newer technologies, such as CDMA, offer the advantage of requiring fewer cell sites than other technologies to cover the same geographic area. This may be the case, even in urban areas, due to higher traffic channel capacities.

5.5 Wireless-Local-Loop Telephone Systems

Providing new telephone subscribers with traditional local loop telephone services based on copper wire can be costly. These services can also be slow and difficult to implement. Maintenance costs due to weathering and theft are often a major problem. Another disadvantage of the wired local loop is that the exact locations of existing or future customers must be known before network planning can begin.

In rural areas, especially, the cost of providing a telephone service is high. In some remote locations, potential subscribers may be difficult or even impossible to reach.

In urban areas, the high and often difficult-to-foresee growth limits the ability to plan the outside plant network properly.

All these problems can be solved using a wireless-local-loop solution. However, the degree to which they are solved will depend on the circumstances and the particular technology employed.

The wireless local loop (WLL) can be a very flexible and cost-effective alternative to the wired local loop. Wireless-local-loop systems, as they are based on communication by means of radio waves, enable a telephone service for new subscribers to be installed quickly and cost-effectively.

Some WLL technologies are a spin-off from mobile cellular technologies and have architectures similar to that of the mobile technologies. In many instances, the system component is identical to that of the mobile technology. This has some very definite advantages. The production volumes that the mobile cellular applications command bring about an economy of scale in production that, for the foreseeable future, could not be achieved by WLL applications alone. The WLL operator and the telephone user therefore have a cost advantage if the operator buys a system that uses a technology that is closely related to a mobile cellular technology.

5.5.1 Benefits of WLL

Some of the benefits of WLL are the following:

- Unlike a conventional wired telephone network, the cost of a wireless local loop to a subscriber is not dependent on the length of the loop to be installed or the type of terrain. There is therefore a cost-saving on installation.
- The speed with which services are provided means that operating revenues can begin to be generated immediately.
- Whether it is used as a temporary or permanent network, a wireless-local-loop system is highly flexible. Some WLL systems, *viz*. those for which a range of cell types exist and which use industry-standard technologies, work equally well in serving the needs of users in various environments. Dense urban areas, small towns and fast-growing suburbs, as well as rural areas with widely-dispersed subscribers, are equally well served.

- In the case of densely populated cities, WLL can also provide a convenient and cost-effective solution to the provision of a temporary service until a conventional wired telephone network can be restored or completed.

- A WLL network can be connected easily to any existing landline telephone exchange which supports wired subscriber loops. For each radio subscriber unit, the exchange provides the same type of connection that it provides for wired telephone subscribers. The system is completely transparent to the user and there is no need for a special telephone numbering plan.

In summary, WLL offers major benefits to an operator who needs to provide telephone services quickly, economically, efficiently and without the complication of additional installation of wirelines. In addition to solving immediate requirements for standard telephone services, a WLL network can form the basis for a future mobile telephone network, provided the correct technology is chosen.

5.5.2 Important issues for operators

System attributes

The following are attributes of WLL systems and technologies of which operators should take note:

- Flexibility in base-station antenna configurations and patterns for optimum capacity and quality of service in the telephone network.

- For high-capacity urban networks, sector-type cell configuration which is suitable for WLL networks that need to service the required number of subscribers and which minimises the amount of spectrum required for the network.

- For widely dispersed rural networks, large cells that provide maximum geographic coverage. There should be an awareness that some WLL technologies offer greater ranges (distances) than others. In rural areas, with a relatively low density of subscribers and/or public telephones, one may not be limited by the capacity of a cell site. The number of cell sites that then need to be deployed will depend solely on the geographic area to be covered. Technologies that give large ranges and hence greater coverage area per cell site offer major cost advantages, with respect to both capital outlay, maintenance and backhaul.

- As in the case of mobile cellular systems, the higher traffic channel capacities of some technologies may, in the case of high-density urban areas, also make some technologies more beneficial than others. The higher capacities per cell site cause fewer cell sites to be used.

- Systems that do not require more spectrum than is available (from the administration) for the required number of subscribers (also considering future growth), and systems that make efficient use of the radio spectrum, are desirable. Depending on the specific technology used, the number of subscribers that can be supported may be large or small. Systems making use of CDMA, for instance, will support 10 to 20 times the number of users, as compared to some other technologies.

- Systems should, to the maximum extent possible, be rugged enough to withstand rural conditions typically found in developing countries, such as rough roads, a dusty environment, extreme temperatures and high humidity, while at the same time providing long equipment lifetime with minimum maintenance.

Operators who are looking for technologies to employ for WLL applications would be well-advised to weigh up the advantages of the different technologies in terms of the above-mentioned factors.

Supplier attributes

Operators are well advised to look for the following attributes and resources when considering a supplier of WLL systems:

- Project/programme support and consultancy capability.

- WLL network design and implementation expertise.

- Training, technical support and maintenance capabilities.
- Manufacturers that offer a variety of WLL solutions that employ different industry standard cellular base transceiver stations and subscriber units. (Manufacturers that can configure WLL systems using proven CDMA, NAMPS, AMPS, E-TACS, TACS or J-TACS technologies obviously offer an advantage).

5.5.3 Regulatory aspects

WLL networks based on cellular technologies use the same frequencies, channel assignments and air-interface standards as any conventional cellular system using the same technology.

5.5.3.1 Spectrum

Administrations who are considering the allocation of spectrum for WLL systems should make sure that ample spectrum to meet their country's needs is allocated. To make provision for both mobile cellular and WLL applications in the same band may require more spectrum than may be available, depending on what technology is used. It may therefore be prudent to consider different bands for the mobile cellular and WLL applications. Otherwise, if consideration is given to employing WLL and mobile cellular applications on the same network, one band may be imperative. In this case, great care should be taken to employ a technology that is so spectrum-efficient that the available spectrum will be sufficient for both applications. Administrations will be well-advised to seriously consider spectrum-efficient technologies, such as CDMA, when making RF spectrum allocations. The latter, for instance, has the ability to accommodate a large number of users, mobile and fixed, on a relatively limited amount of spectrum.

In making spectrum allocations, one may want to take note of the advantages some technologies have with respect to other technologies. However, it is not advocated that technologies be made mandatory. The final choice of technology is best left to the operator.

5.5.3.2 Other aspects

Administrations should be clear on what they consider to be priorities for their countries. It may be tempting to want to include high-speed data services, for instance, for ISDN, in their WLL applications. However, it must be realised that a high-speed data capability comes at a cost premium. Great care should be exercised in making sure that the expansion of the basic telephone is not impeded by a high-level requirement for a minimal number of applications. Basic telephony is the most important communication need, by far, for the greatest majority of people.

If ISDN services are essential for certain applications in rural areas, such as hospitals and schools, serious consideration should be given to making use of separate overlaid network for this purpose. Such a network may add a small incremental cost to that of the WLL network. Depending on what WLL technology is used, the total cost may even be less than that of some expensive system capable of both basic telephony and high data transmission rates for ISDN. The advantage of excluding those high-level requirements that have low usage is that an optimal solution may be employed for basic telephony. The roll-out for basic telephony systems can then take place in a fast and unimpeded way.

As for other issues of a regulatory nature, the reader should refer to section 5.4.5, which discusses the issues of operator licences, type approval and standard specifications. The issues are broadly the same for WLL systems.

Operators and administrations should take note of dramatic developments in encoder technology that have taken place in recent years. Some technologies will offer wireline voice quality at a data transmission rate of 8 kbit/s. The quality may be comparable to that of another technology using 32 kbit/s. In essence, should the emphasis be on basic telephony, i.e. voice communication, the data transmission rate is of only secondary importance. What is more important is the voice quality, as measured using some objective tests. Of particular note are technologies where voice quality can be traded off against parameters such as traffic capacity and geographical coverage.

5.6 Satellite Systems

Satellite networks find markets wherever wired networks and terrestrial radio networks:

- are not available;
- are not sufficiently developed;

- do not have the necessary transmission capacity; or
- cannot provide the degree of mobility required by the user (e.g. ships, travellers to all parts of the globe).

INMARSAT, the satellite system used for global mobile satellite communication, provides services to a wide range of users in business circles at sea, in the air and on land via a small suitcase-size terminal.

Various international consortiums are currently planning global satellite systems that will enable portable mobile satellite phones to be used anywhere in the world just like INMARSAT. These portable devices (handies) will not differ in construction from, say, a 200g GSM handy.

Innovative mobile satellite services require satellites to circle the earth at low orbits. Satellites circling a few hundred kilometres above the earth are known as LEOs (Low Earth Orbit). Satellites orbiting a few thousand kilometres above the earth are known as MEOs (Medium Earth Orbit).

The whole of the earth's surface can be covered by carefully positioning a number of identically-built satellites. Depending on the system chosen, between 12 and 800 satellites per network will be required.

Slim mobile devices with low transmitter power and small omnidirectional antennas can be built as a result of the "low" satellite altitudes and the use of multiple spot beams. Then it really will be possible to introduce mobile satellite services as services for the public at large.

World-wide, a large section of the population, travellers to far-flung parts of the globe, but first and foremost the population in underdeveloped regions in Africa, Asia, South America and Eastern Europe will have affordable access to a telephone service for the very first time.

For areas lacking the infrastructure, planners are considering the use of solar-operated public telephones. World-wide, market researchers anticipate high growth rates for the transmission of voice, fax and data at low bit rates. By the year 2000, there will be around 100 million customers using mobile satellite links for their telephony, market researchers predict.

A potential application of Demand Assignment Multiple Access (DAMA) involves the combination of conventional cellular systems with INTELSAT's VSAT-based DAMA product. DAMA provides on-demand mesh connectivity between multiple earth stations and is therefore a flexible and cost-effective multiple access technology. INTELSAT DAMA is a thin route-on-demand digital satellite solution service that is very advantageous for use in international and domestic rural communications networks. It provides for satellite circuit sharing and switching capabilities for greater efficiencies in the utilisation of the space segment. These efficiencies are passed on to the user who is charged on the basis of the amount of satellite capacity actually used on a per-minute basis.

Suitable for developing countries, DAMA networks are now authorised for INTELSAT operation in all three ocean regions, with initial operation in the Atlantic Ocean region. INTELSAT's initial DAMA offer includes basic telephone service for voice, fax and voiceband data applications with the future capability of providing on-demand 64 kbit/s connections, offering users higher bandwidth for multimedia (integrated voice, data and video applications).

The control and signalling in DAMA is by the Network Management and Control Centre (NMCC) in a star configuration, while the traffic between any pair of user earth stations is carried on a mesh network basis. The earth stations can be as small as 1.8 m dish. This ability to use the newly standardised (Standard H) small earth terminals further reduces the equipment costs.

The INTELSAT DAMA system is well-suited for thin route telephony applications of which VSAT/WLL services are a part. In-house demonstrations showing the technical feasibility of WLL extension to DAMA have been conducted by INTELSAT. The cellular Wireless Local Loop (WLL) base station performs local switching as well as forward signalling information into the DAMA network. The system used in the demonstration is based on the North American AMPS standard (824-849 and 869-894 MHz frequency ranges for transmit and receive, respectively). In actual use, this WLL system has a range of 30 kilometres without the use of repeaters. This, in combination with a VSAT-based DAMA terminal, is particularly well-suited to remote areas with no telecommunications infrastructure or backhaul to a regional switching centre. The WLL system shown above supports the standard AMPS mobile cellular phones, with public kiosk or telecentre installations as possible sites for a village or township community. It should be noted that other WLL standards deployed in different parts of the world are also possible for this technology. However, though technically feasible, the development of standards to interface and to integrate VSAT/WLL systems with DAMA may have long-term cost efficiencies on the price of WLL/VSAT products.

6 Factors to be considered when considering introducing and utilising new technologies and services

As already indicated in the introduction, the focus of this paper is on mobile communications. This section, which describes the important factors in the deployment and use of new technologies, confines itself entirely to mobile communications, since an account of other technologies would exceed the paper's scope.

The introduction and deployment of new technologies and systems should always be preceded by an assessment of market potential as a whole. A first estimate can be achieved with reference to upper and lower limits. Other countries' relative rates of penetration can serve as the lower limit. With personal communications as the desired aim, a possible upper limit would cover the entire population as from an age determined according to communications requirements. Defining these upper and lower limits reveals whether growth potential exists and if so, to what extent.

Required in addition to identification of the growth potential is an analysis of the market. Knowledge of the requirements of the market is essential in all further proceedings: in what segments of the market (e.g. large customers, business customers, residential customers) is there demand for what technologies and services? Is there heavy demand for existing services, or is there demand for new services?

The most important factor determining further action is the stage of network development reached.

Before any mobile communications service can be provided, mobile radio networks containing elements of other telecommunications networks must be set up. These elements are, for instance, the public telephone network, radio relay links and (following the abolition/in the absence of monopolies) network elements of other licensed carriers. Other options must be sought when the deployment of a particular technology or the introduction of a particular service is not possible on account of a lack of network infrastructure. In the mobile communications sector, paging for instance is a viable alternative to costly fixed or mobile communications networks.

Before new technologies and services are introduced, the level of investment required and the implementation and follow-up costs must of course be calculated. The question of funding is primary.

As this is such a complex and wide-ranging issue, Study Group Q4/1 has been charged with preparing a paper. Reference is made here to this paper.

Yet investments must not be confined solely to a new technology or a new service. It is also vital to invest in human capital in order to guarantee the quality of the technology or service. Against the backdrop of developing the right corporate culture, human relations are becoming ever more important. Staff must be properly informed, motivated and trained if they are to fully support corporate policy and action.

And, of course, the scarce resource of frequencies must be properly used and distributed. In a competitive environment, well-functioning regulation is necessary to provide effective frequency management.

Different measures can be taken depending on the particular customer structure. With appropriate pricing, for instance, a better balance of traffic in the network can be achieved in off-peak periods (with a large number of business customers, traffic is heavy during the day, with a large number of residential customers, traffic is heavy in the evening; careful pricing can perhaps spread this out).

Prices in mobile communications generally have four main components:

- the cost of the mobile phone;
- the one-off cost of connection;
- the basic monthly tariff (usage-dependent);
- the usage-dependent call charges.

Other components are the various forms of price differentiation available, e.g. discounts, unit intervals, content (voice, data, fax), distance, internal/external use and social components (for the disabled, for the socially underprivileged).

These components must be interwoven to produce a strategic tariff structure (problem of optimum pricing) incorporating own costs, the market/demand and the competition.

The crucial element in pricing is demand. When demand is elastic, the price will dictate whether migration to other technologies or services (e.g. letter – telephone) takes place. And again, an intimate knowledge of demand and the market is necessary for demand to be correctly assessed.

To satisfy customers' wishes and requirements, it is usually a good idea to offer tariffs that reflect customer structure, in other words, tariffs for business and residential customers, evening/weekend tariffs, business tariffs, etc.

The creation of joint ventures in connection with the introduction and deployment of new technologies and services should be viewed from several angles.

One possibility is the merger of several carriers. Then, however, the anti-trust aspects must also be considered in addition to the economic implications.

Co-operation between carriers under a roaming agreement between several countries is necessary to capitalise on the benefits of digital cellular mobile radio standards (e.g. the GSM standard).

Another possibility is the integration of service providers with a view to intensifying competition and exploiting customer potential more rapidly. A number of companies differing markedly from each other in terms of core business and financial resources seize the opportunity to make profits in hitherto unfamiliar branches.

Reference is made to Germany's June 1995 contribution to this Study Group on the matter of licensing new carriers for specific services. Basically, it must be said here that licensing, and the wider range of offer that generally accompanies it, often makes sense in segments of the market experiencing rapid development in customer requirements.

However, the frameworks must be changed to accommodate the transition from (mostly state) monopoly provision to the principle of competition.

Responsible nevertheless for guaranteeing basic supply are the politicians, that is to say, a regulatory authority which imposes conditions and stipulates requirements.

APPENDIX A

The FLEX^{TM} family of protocols for paging

1 Introduction

Paging experienced its world-wide explosive growth in the 1980s and 1990s using the POCSAG protocol at speeds of 512, 1 200 or 2 400 bit/s. With this dramatic growth in paging, especially in many Asian markets, networks were becoming more and more overcrowded. Subscriber growth and requirements for a mix of tone, numeric and alpha-numeric capabilities also began to reduce total capacity, and frequency limitations began to appear. In addition, RF spectrum was not readily available because of demands by other wireless applications. Paging operators therefore pressed for the development of higher speed protocols. In response to this problem, Motorola developed the new FLEX^{TM} high speed paging codes. These codes enhance a system's throughput and efficiency, allowing new and powerful features to be built into pagers as well as the networks. The new features benefit both system operators and pager users.

One of the design goals for FLEX^{TM} was to provide improved performance with respect to POCSAG. Relative to POCSAG 1 200, FLEX^{TM} can support more than four times the number of pagers on an RF channel while providing much higher protection against signal fades common in FM simulcast paging systems. The combination of the increased bit error correction capability of FLEX^{TM} and the superior fade protection improves the probability of receiving a message intact, especially longer alpha-numeric messages.

2 The FLEX^{TM} Standard

2.1 Short description of FLEX^{TM}

First introduced in June, 1993, FLEX^{TM} is a family of high-speed wireless transport protocols that greatly enhance the channel efficiency and cost of traditional radio paging channels while also enabling new value-added wireless services and applications. FLEX^{TM}, ReFLEX^{TM} and InFLEXion^{TM} are registered trademarks of Motorola Inc. and all belong to the FLEX^{TM} family of protocols. FLEX^{TM} is a multi-speed (1 600, 3 200 and 6 400 bit/s) coding format that greatly expands the available subscriber capacity for each RF channel assignment. The FLEX^{TM} coding format is synchronous, which allows for greatly enhanced battery life performance and robust performance under multipath fading conditions.

The FLEX^{TM} coding format is able to provide a service in a situation where numeric, alpha-numeric and information services are mixed, with minimal loss of the system's operating efficiency. Because three signalling speeds of 1 600 bit/s, 3 200 bit/s and 6 400 bit/s are available, the introduction of FLEX^{TM} in an existing low-speed operating system infrastructure can be accomplished with minimum added cost. As the service provider builds the system's subscriber base, the system can be grown gracefully and incrementally. This can be done up to the highest speed of 6 400 bit/s, with reasonable added cost. Thus, the service provider is able to maintain the lowest system cost per subscriber during system growth.

The ability to provide local, regional, nation-wide and global roaming operations is also structured within the FLEX^{TM} coding format. FLEX^{TM} is compatible with the standard VHF, UHF (400 MHz) and 900 MHz paging radio air interfaces.

2.2 Characteristics of FLEX^{TM}

Present paging systems have the receivers operating at 300/600 bits per second (Golay format) and 512/1 200 bits per second (POCSAG). Higher speeds are being targeted to improve throughputs in a system. POCSAG, at 2 400 bits per second, has been successfully implemented and the new FLEX^{TM} high speed paging code, developed by Motorola, will give much more advanced features in helping the paging industry to break through today's capacity limitations for new growth and expansion. The FLEX^{TM} paging code is a fully synchronous paging code. By keeping the receiver's electronics continuously in synchronism with paging transmission, FLEX^{TM} code opens the door to an entirely new generation of paging technology world-wide.

Some of the features and benefits of FLEX^{TM} are as follows:

- Compared to other protocols, FLEX^{TM} offers greatly increased transmission speed and capacity, flexibility, improved data integrity, significantly improved battery life and the lowest cost per user in any paging code.
- FLEX^{TM} is designed to run concurrently with existing paging systems world-wide, including POCSAG and GSC. System operators need not move to the ultimate FLEX^{TM} speed of 6 400 bit/s in one single step. They can add FLEX^{TM} 1 600 to their existing 1 200 bit/s system by upgrading existing terminals and continuing service to existing subscribers.
- FLEX^{TM} protocol will accommodate the ever-increasing sophistication of the paging marketplace, allowing growth to enhanced services, such as two-way paging and nation-wide roaming. The FLEX^{TM} protocol was designed to allow future variations to co-exist on the same system.

2.3 Key Benefits of FLEX^{TM}

2.3.1 Faster paging speed

FLEX^{TM} raises paging speeds up to 6 400 bit/s. This is achieved through multiplexing up to four data streams into one 6 400 bit/s transmission. Each data stream or phase operates independently and pagers will only decode a single phase. This helps prevent long messages from blocking or delaying other messages.

2.3.2 Higher channel capacity

FLEX^{TM} supports up to one billion individual addresses and up to 600 000 numeric pagers per channel. For 10-digit numeric pagers, FLEX^{TM} has more than four times the capacity of the most advanced POCSAG systems running at 1 200 bit/s. For 40-character alpha-numeric pagers, FLEX^{TM} has a capacity that is five times greater than POCSAG 1 200.

2.3.3 Low system cost per user

Higher capacity allows for carriers (operators) to add subscribers to existing channels resulting in the lowest cost per delivered bit and lowest cost per user of any pager.

2.3.4 Efficient mixing of services

Today's POCSAG systems quickly run out of capacity when mixing numeric, alpha-numeric and information services on the same channel. With FLEX^{TM}, all of these services can efficiently mix with no penalty to numeric users. This is accomplished by dedicating phases to a single service, since these phases operate independently of each other.

2.3.5 Compatibility with existing codes

FLEX^{TM} is effective alone or when mixed with existing codes. This means that an existing POCSAG system that is not fully loaded can migrate to FLEX^{TM} and initially use only 3.1% of the existing air time. And, in this 3.1%, FLEX^{TM} supports from 5 000 (1 600 bit/s operation) to 20 000 (6 400 bit/s operation) numeric subscribers.

2.3.6 Robust and reliable code

FLEX^{TM} gives pager users exceptional protection against signal fading, which translates to improved page reliability for all paging services, especially alpha-numeric and information services. When there is a variation in signal strength, FLEX^{TM} is able to withstand 10 ms fade at all speeds and to still correctly decode the information.

FLEX^{TM} improves reliability through: checksum validations, which is another error detection mechanism; message numbering to allow for missed message retrieval; and positive end-of-message control by specifying the length of a message. This means that fades will have to be longer in duration to corrupt a word.

2.3.7 Improved page delivery

With its greater reliability FLEX^{TM} offers improved page delivery capacity. This means that busy-hour delays are reduced and that redials into the paging terminal and subsequent over-the-air retransmissions are reduced or eliminated. Not only does this lead to increased customer satisfaction, it also makes for more efficient use of infrastructure resources, like telephone inputs and air time.

2.3.8 Graceful growth

FLEX^{TM} makes efficient use of existing infrastructure systems by building on the current POCSAG 1200 system. The FLEX^{TM} system is flexible, running at 1 600, 3 200 and 6 400 bit/s to enable service providers to match their system capacity to market requirements. FLEX^{TM} enables service providers to dynamically alter the transmission speed to match traffic patterns.

POCSAG is used widely at present and it is unlikely that operators will want to upgrade their systems in any other way than using FLEX^{TM}, because of the cost advantages.

2.3.9 Improved battery performance and smaller pagers

With FLEX^{TM}, a pager's battery can last up to 10 times as long as pagers running on POCSAG. This is because FLEX^{TM} is a synchronous code, meaning that the pager is synchronised with the transmitting station and searches for its cap code in only a fraction of the time thereby saving power. This improved battery life will allow for the use of smaller batteries and the design of smaller, uniquely shaped pagers.

2.3.10 Minimum investment in upgrading infrastructure

FLEX^{TM} can be used both on dedicated channels or mixed on an existing system with POCSAG or GSC without compromising performance. System operators need not move to the ultimate FLEX^{TM} speed of 6 400 bit/s in one single step. They can add FLEX^{TM} 1 600 to their existing 1 200 bit/s system by upgrading existing terminals, and continue servicing existing subscribers.

2.3.11 Higher integrity and user confidence

FLEX^{TM} offers maximum prudent error protection against possible multipath fading errors caused by simulcasting. It is also designed to provide positive end-of-message control and optional missed-message flag indication to prompt the user to request re-transmission. Even when the pager is out of range or turned off, FLEX^{TM} will let its user know that a message has been missed. FLEX^{TM} can handle pure tone alert. ASCII, HEX, numeric, alpha-numeric as well as unformatted binary data streams can also be handled.

2.4 Status on FLEX^{TM} adoption

The FLEX^{TM} protocol has been widely adopted and paging systems are operating in: Argentina, Brazil, Canada, Colombia, Guatemala, Mexico, Uruguay, Venezuela, the United States, China (national standard), Japan (national standard), South Korea (national standard), Russia (national standard), India (national standard), Indonesia, Malaysia, the Philippines, Lithuania, Hungary, Germany and Singapore, and this list is growing by the day. Through its widespread global use, FLEX^{TM} has become a *de facto* world-wide standard for wireless paging and messaging. The FLEX^{TM} protocol is openly licensed so as to promote the introduction of subscriber devices from multiple manufacturers. Multiple semiconductor chip manufacturers have also been licensed to provide integrated circuits, world-wide, for the decoding of the FLEX^{TM} protocol.

3 Advanced two-way messaging

3.1 Introduction

In the United States, the Federal Communications Commission (FCC) has created a new industry in wireless communications by licensing a new service known as Narrowband PCS. The FCC defines Narrowband PCS as a family of mobile services that include advanced voice paging, data messaging, and both one- and two-way messaging on a nation-wide and regional basis. The FCC has licensed Narrowband PCS in the 901-902, 930-931, and 940-941 MHz bands. Brazil, Canada and Mexico are in the process of making similar allocations.

New messaging protocols have been developed to service two-way messaging. In two-way messaging, the messaging unit responds to an incoming message. Simply, in addition to a receiver, the subscriber has, in the same unit, a transmitter that operates both automatically and by the subscriber’s actions. Two-way messaging offers four progressive levels of service:

- System acknowledgement.
- Simple personal acknowledgement.
- Multiple-choice response or pre-programmed response.
- Message origination.

Two-way protocols provide two-way communication, but not in the same sense as traditional two-way data systems. They are asymmetric, which means that the data transmitted from the messaging units back to the system is optimised to a much smaller size. This concentrates the transmitted power into a smaller bandwidth, and thus minimises the number of receiver sites required to achieve proper coverage.

One of the major applications of two-way messaging in US Narrowband PCS is voice messaging. Basically, voice messaging repeats the spoken word of the caller to the subscriber through the messaging communicator. Essentially, voice messaging functions as an answering machine on the belt. Incorporating all the features of an answering machine, such as message storage and play-back, this technology uses a compressed voice protocol, again to optimise the service provider’s valuable spectrum by increasing system capacity. Voice messaging retains most of the benefits of two-way messaging and the first of these devices is approximately the same size, shape and weight as some of today’s one-way alpha-numeric pagers.

No Narrowband PCS standard exists, although several protocols are receiving favourable attention by paging operators and others interested in entering the Narrowband PCS market around the world. In the US, the trend is towards a *de facto* standard based on the ReFLEX TM and InFLEXionTM protocols. These protocols, based on the FLEXTM protocol, are being licensed on an open basis. This allows manufacturers to design and fabricate to a common set of specifications and, therefore, provide critical-massed production and lower priced equipment.

3.2 The ReFLEXTM protocol

ReFLEXTM protocol supports two-way paging at speeds of 12 800 bit/s and interactive messaging at 25 600 bit/s. ReFLEXTM two-way paging is asymmetrical in nature with relatively large amounts of data moved from the network to the subscriber unit, but with minimal amounts of data (100 bytes initially) coming back to the network from the subscriber unit. This enables low-bit-rate signalling on the return channel, which minimises the number of fixed receivers and sites required. The resulting cost structure more closely approximates traditional paging costs rather than higher priced wireless alternatives. User features include message confirmation, message origination, error-free messages, and the ability to forward messages to a personal computer. Network features include localised transmission, frequency re-use, message truncation, registration and location, and transfers at 25 600 bit/s through the network in a subdivided 50 kHz channel.

ReFLEXTM systems are similar in nature to traditional one-way systems in that they use simulcast within zones (such as a metropolitan area). This means that multiple transmitters are activated at the same time, transmitting the same messaging traffic. Between zones, though, re-use of spectrum is possible (which increases subscriber capacity) while providing two-way messaging capabilities.

3.3 The InFLEXionTM protocol

The InFLEXionTM protocol will allow high-speed voice and data messaging. With data rates exceeding 100 kbit/s, the InFLEXionTM protocol enables the re-emergence of voice paging in the global paging market, as well as value-added data services such as wireless facsimile, imaging and multimedia applications. The InFLEXionTM system provides for frequency re-use based on up to seven subchannel frequencies within the 50 kHz channel. This creates a cellular-like system design where an individual transmitter site can be active and broadcasting on a given subchannel, while an adjacent transmitter is active and broadcasting on a different subchannel. Additionally, transmitters that are properly spaced can be operating on the same frequency, transmitting different messages at the same time.

APPENDIX B

The ERMES standard for paging

The European Telecommunications Standards Institute (ETSI) developed a new international radio messaging system named ERMES (European Radio Message System) potentially capable of offering enhanced paging services both to national subscribers and to those roaming outside their home country in Europe. Introduction of ERMES started in Europe in 1993. The technical and operational characteristics of ERMES are included in Annex 2 of Recommendation ITU-R M.539-3, entitled Technical and Operational Characteristics of International Radio-Paging Systems.

ERMES uses a synchronous protocol at a speed of 6 250 bit/s to achieve increased subscriber capacity, improved message performance under signal fading conditions and improved battery-saving operation. The system operates on sixteen contiguous 25 kHz channels in the band 169.4-169.8 MHz and is intended to provide roaming throughout Europe.

APPENDIX C

Systems aspects of paging

1 Introduction

The coverage of a paging system refers to the region within which a paging receiver can reliably receive the transmission of the paging signals. The various factors which determine the coverage of a paging system are discussed in section 2.

For on-site private systems, e.g. those used in hospitals, hotels and factories, the coverage is limited and usually a single-site system using a low-cost, low-power (up to 10W) compact transmitter will suffice.

The coverage for public paging systems can vary significantly in extent. For a small city, one paging transmitter site may be sufficient, but when the area to be covered is extensive, it may be necessary to have multiple transmitter sites. When more than one transmitter is used for the purpose of improving coverage, the techniques of simultaneous transmission (simulcasting) from all the transmitters usually needs to be employed. This is discussed in greater detail in section 3.

In addition, “network” paging is examined in section 4. This is an arrangement whereby individual systems are linked up (networked), such that a subscriber who roams out of range of his “home” system can still be paged. This is made possible by passing the original page request from his “home” paging system through the network to the paging system covering his new location. Networking enables nation-wide paging for big countries like the USA. When satellite links are employed in the network, international or global paging facilities can be realised.

2 Coverage

2.1 Factors affecting coverage

The coverage of a paging station is dependent on the following factors:

- transmitter power;
- receiver sensitivity;
- antenna gain;
- antenna height;
- frequency of transmitter;
- path losses;
- fading.

2.1.1 Transmitter power

Increasing transmitter RF power output is an obvious way to increase coverage area but very often a more effective method to improve coverage is to increase base station antenna height. In most situations, analysis shows that doubling the transmitter power results in only a 1.4 times increase in field-strength at the receiving point, while doubling antenna height nearly doubles this field-strength.

2.1.2 Receiver sensitivity

Receiver sensitivity determines the field-strength that a paging receiver needs in order to respond to a call. A pager with a high receiver sensitivity is desirable as it means that a lower-field strength is sufficient for it to respond correctly at the fringe of the coverage area. Therefore, using pagers with a higher sensitivity will result in wider coverage as compared with the case where less sensitive pagers are used. Receiver sensitivity in analogue voice applications is commonly defined in terms of the signal input level required to produce a certain audio signal-to-noise ratio (usually 20 dB) at the receiver output. Receiver sensitivity for digital systems is specified in terms of the signal level required to attain a BER (bit error rate) not exceeding 1%.

2.1.3 Antenna gain

The antenna gain is a measure of the directivity of the antenna. It is equivalent to the degree to which the antenna directs the electromagnetic energy in one direction and not equally in all directions. For example, an antenna with unity gain will have no directivity. Gain is a means by which coverage of a paging system can be improved. The design engineer has to weigh the penalty of using an antenna with gain versus using a unity gain antenna along with a transmitter of higher power. However, too much directivity in antennas may lead to the problem of the beam passing over users that are close to the transmitter.

An omnidirectional antenna radiates the electromagnetic energy equally in all directions on the horizontal plane, while a directional antenna provides relatively higher gain in a particular direction. The appropriate antenna type is chosen and aligned/(adjusted) to give a pattern consistent with the desired coverage. Sometimes the coverage pattern is also adjusted with directional antennas, to minimise interference with other communication systems using a frequency identical or close to that used by the paging system.

2.1.4 Antenna height

As was discussed earlier, increasing antenna height is an attractive alternative to increasing transmitter output power for better coverage. Increasing the height of an antenna usually means using a longer feed line with additional line losses, so a complete system trade-off is required. Typically, transmitters are located at the top of tall buildings or hills to gain additional height and therefore coverage. If no buildings are available in the desired location, a tower is sometimes constructed with a protected enclosure at the base with the antenna mounted as high as possible.

2.1.5 Frequency of transmission

Frequencies widely used for paging are the VHF low (40 MHz) and high (150 MHz) bands, UHF (450 MHz) and 900 MHz. In some regions of the world, 280 MHz is also available. Generally, penetration of the transmitted signal through buildings is better at higher frequencies. Trees and foliage tend to attenuate more at higher frequencies.

2.1.6 Path loss

We refer to the attenuation of the signal as it propagates from the transmitter antenna to the paging receiver. One component of this path loss arises from the spreading of the wave as it propagates through free space. Path loss due to spreading of the wave as it propagates through free space (or the atmosphere) is the same at all frequencies between antennas having a constant aperture with frequency. When the path is long or the antenna height is low, such that transmission is close to the ground, the presence of the ground modifies the propagation of the radio waves so that the received field-strength is normally less than what would be expected for propagation in free space.

Other contributions to path losses are from obstruction by the earth itself, known as diffraction loss, due to the signal grazing the earth’s surface, and by hills, trees and buildings.

2.1.7 Fading

Fading is a phenomenon whereby signal level varies within short distances due to multipath propagation. Additionally, as atmospheric conditions vary, the transmission path will be altered (bent up or down) and this may increase or decrease the effective path clearance.

The severity of multipath fading usually increases as the frequency increases and it can be predicted by using statistical methods. A margin for reliability is often added during coverage calculation to take care of fading.

To check if a location is within the coverage area of a paging station, the field strength at the location is calculated. This is obtained by starting with the transmitted power, adding gains and losses from the antenna and subtracting all the path losses mentioned above plus any transmission-line, connector or filter losses.

3 Simulcasting

"Simulcast" is a reliable method of achieving wide-area coverage. It involves sending the paging signal from multiple paging transmitters at precisely the same time. This technique has the obvious advantage of a larger coverage area arising from combining the individual transmitter coverage areas. There are other advantages:

3.1 Operational advantages of simulcasting

- It provides an alternative method of achieving wide area coverage, by transmitter sequencing. Transmitters are sequentially operated and keyed on multiple frequencies. Transmitter sequencing accommodates less pages per channel because of the length of time taken to communicate to a pager unit. Multiple transmitters/frequencies are spectrally inefficient, i.e. they will require the use of more of the already scarce radio bandwidth.

- A special "sector" feature which can be designed into a simulcast system allows transmitters to be programmed into sectors. Each sector can have multiple transmitters. Sector control permits addressing and keying only the required group of transmitters necessary for a particular service. This allows differential tariffs to be charged to customers.

- Obstruction losses due to hills, trees and buildings are considerably reduced by multiple transmitter configurations. For example, if a pager is shadowed by a hill with respect to one transmitter, it is highly probable that a second transmitter has a clear path.

3.2 Operational requirements

A page is initiated by the user using an encoder and/or a terminal. The controller could be integrated into a paging terminal or it could be a separate unit. Paging signals are sent to a distribution system which can either be a wireline or a radio link.

In simulcasting, the following parameters must be kept within tight tolerances:

- Relative carrier frequencies of the paging transmitters.

- Relative audio frequency phases emanating from the paging transmitters.

- Relative audio levels of the paging transmitter.

The paging transmitters incorporate ultra-stable oscillators to ensure that any difference in carrier frequency of the paging transmitters is maintained. The difference in distance from the paging terminal to the various transmitters causes audio signals to arrive at the transmitters at different times, i.e. they arrive out of phase with respect to each other. Audio equalisers, which are variable time-delay elements, are used at the base stations to take care of this undesirable phase offset.

Precise audio level adjustments are also performed at the transmitters to optimise the system for simulcasting.

4 Network paging

This is an arrangement in which paging subscribers can be alerted, even when they move from city to city, state to state or even across national borders. In this arrangement, individual paging terminals are connected to form a network of paging terminals. Each paging terminal controls its own coverage area, but when a subscriber moves beyond a coverage area, the page request is passed across the network to the paging terminal which covers the subscriber's new location. This would require the paging subscriber to keep the system updated with regard to his movements and whereabouts.

For communication between the networked paging terminals, various communications protocols have been developed. A communication protocol is defined as a set of rules designed to facilitate efficient and reliable transfer of information between two stations. For example, a protocol may specify that the information should be divided into packets of a certain size and that sending destination address information should precede data information. Furthermore, if there are errors in a received packet, the destination station will ask for a resend of that packet from the sender.

Proprietary protocols are incompatible with each other. Therefore, where proprietary protocols are used, paging networks can only be established using paging terminals from a single supplier.

To allow for interconnection of equipment from different manufacturers into paging networks, "gateways" must be used. These are essentially bridging devices which perform protocol conversion. They act like language interpreters, allowing networks of incompatible equipment to "talk" and work together. A better solution is to use an industry standard (non-proprietary) protocol, such as X.25 and the Telecator Network Paging Protocol (TNPP).

The TNPP is a widely accepted protocol and employed for creating networks of paging terminals from different manufacturers. It can also be used in the case of networks using similar paging terminals. It is a point-to-point digital communications protocol ensuring reliable delivery of information from one paging terminal to another. The routing of page requests through the network is not covered in the TNPP specifications, it being a point-to-point protocol. However, in a large network of paging terminals, network routing needs to be performed efficiently. Hence, in the majority of such networks, routing algorithms are implemented to move paging requests between one or more nodes.

The TNPP is not restricted to linking paging terminals through wireline. Page requests can even be broadcast over a satellite to paging terminals in distant locations. This can extend paging coverage across international borders. In this satellite network system, the protocol ensures reliable delivery of data by transmitting it many times from the source, at the same time ensuring that duplicate information will not be received at the destination. This multiple re-transmission technique is required because the long communication distance involved precludes the sending of signals from the destination to the source, confirming that data has been received correctly. The TNPP is also used to provide such features as electronic mail (E-mail) communications and remote status monitoring.

APPENDIX D

The Trans-European Trunked Radio (TETRA) technology

1 Introduction

The European Telecommunications Standards Institute (ETSI), a non-profit making European organisation, has been working on a new technology for Private Mobile Radio (PMR) communications called Trans-European Trunked Radio (TETRA). As members of ETSI, a number of countries have been participating along with other leading manufacturers to define the TETRA standard and develop radio systems conforming to this new standard.

It is explained below how the standard was produced, the reasons and benefits behind the new TETRA technology, how it compares with analogue trunked radio systems and when it will be available.

2 What is TETRA?

TETRA is a set of two generic standards that allows speech and data communication within a closed user group, such as a vehicle fleet or emergency service. It is more economic and has better performance rates than other similar proprietary technologies because it:

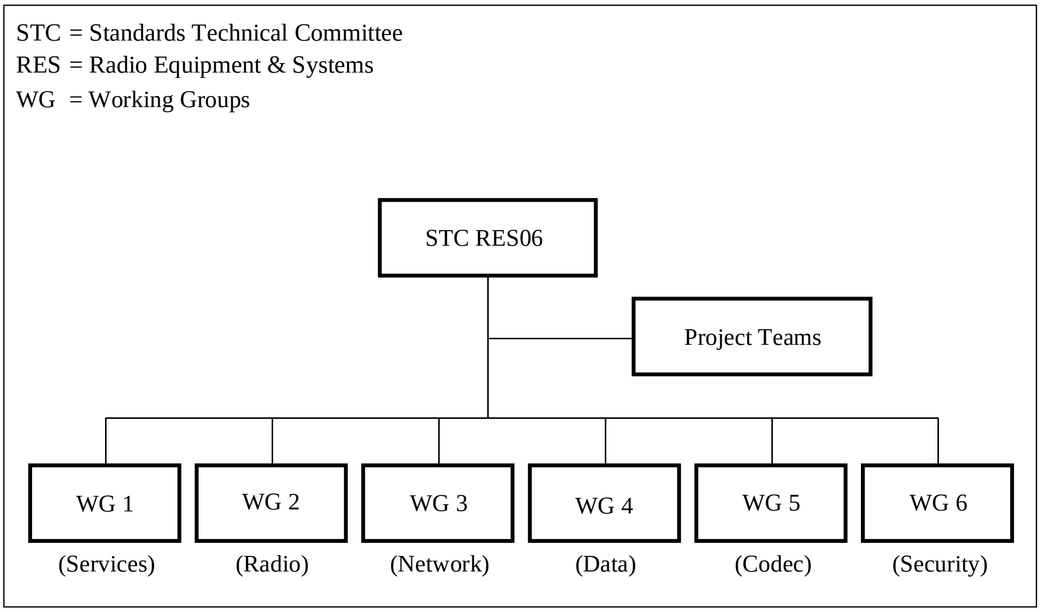
- benefits from Europe-wide frequency spectrum allocations;
- is digital, which permits high quality transmissions for both voice and data;
- provides attractive services such as encryption, fax, fixed image, data services, etc.;
- handles data in packet mode for better performance and lower costs;
- improves performance in system access and response times;
- supports direct mobile-to-mobile communication.

3 Will TETRA be suitable for professional users?

TETRA is destined to meet the requirements of private users needing to operate their own radio systems for security purposes or subscribe to an operator-provided service. Historically, Private Mobile Radio (PMR) systems first surfaced as a professional management tool for security purposes (public safety, utilities, transportation, etc.) and then progressed to other applications such as taxis, maintenance services, deliveries, etc. In the interests of efficiency and information, telecommunications technologies have evolved from fixed network to mobility of operation in the field. Today, both tend to form an integrated and modern company information technology system. TETRA will provide a cost-effective means to transmit voice and data information to remote units in the operational area of the user organisation.

4 How was the TETRA standard produced?

The European Telecommunications Standards Institute has a Standards Technical Committee, Radio Equipment and Systems Number 6 (STC RES06), which resides over a number of project teams and working groups. The organisational chart below shows how this is structured and lists the individual responsibilities for each group.



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Services (WG 1)

This working group comprised representatives from large user organisations and participating manufacturers, for example, Motorola, Ericsson, Nokia and Philips Telecom, who decided what services would be supported on TETRA.

Radio (WG 2)

This group comprised industry experts who decided on how radios would talk to each other over the air using digital radio signals and Time Division Multiple Access (TDMA) technology.

Network (WG 3)

This working group decided on how a TETRA system would interface to other TETRA systems and existing networks such as the Public Switched Telephone Network (PSTN) and the Integrated Services Digital Network (ISDN).

Data (WG 4)

The use of mobile data was seen as an important future need by many users. This working group decided how data would operate over TETRA and how it would provide industry standard interfaces to data networks and peripheral equipment such as personal computers and printers.

Codec (WG 5)

To enable voice signals to be compressed and converted into a digital signal requires a Coder and a Decoder hence the word Codec. This working group looked at several industry Codecs that were available and would meet the voice quality and frequency spectrum-efficient requirements for TETRA. An external committee chose a codec by subjectively testing each codec against several parameters such as voice quality, readability in several languages, operation in background noise, cost, memory capacity, processing speed and size.

Security (WG 6)

Because TETRA is digital, it becomes relatively easy to encrypt (code) radio signals so that they cannot be monitored and decoded by eavesdroppers. This is an important requirement for Defence, Police and other security-related organisations. This working group decided on how encryption will be incorporated in TETRA.

Project Teams

The responsibility of the project teams is to turn the various outputs from the working groups into a common technical language used by ETSI into the document that defines the standard. The project teams also have other responsibilities such as defining the conformance testing of TETRA systems so that all radios produced by different manufactures will work on each other's systems. This is important as it ensures that TETRA users will be able to source radios from several manufacturers providing them with security of supply.

STC RES 06

This committee makes decisions and recommendations regarding TETRA. For example, whether the standard is complete enough to be released for public enquiry. Decisions are made democratically through a "one vote for each member" system. Motorola, as an ETSI member, has participated in all working groups, project teams and STC RES06 since work began in 1991.

5 Why standardise mobile digital trunked radio technology?

Many reasons have contributed to the creation of the TETRA standard, such as:

- the new deregulation of European Telecommunications;
- the appearance of new Public Access Mobile Radio (PAMR) operators;
- the emergence of new digital technologies for mobile radio;
- spectrum congestion (especially on the VHF and UHF private mobile radio bands);
- the evolving needs of the users to benefit from speech and packet data services specially designed for business communications.

All these factors have contributed to the need to standardise mobile digital trunked radio technology. From a spectrum point of view, TETRA technology has the ability to:

- coexist with other private mobile radio systems;
- fit in with harmonised frequency plans at a European level.

This leads to a very attractive solution which, compared with existing analogue systems, makes it possible to:

- double capacity in terms of the number of voice channels compared with existing 12.5 kHz RF channels;
- increase the number of users on a radio system through trunking gain.

6 What are the advantages of TETRA technology?

Compared with other systems, TETRA technology means better performance and greater frequency spectrum efficiency. Moreover, it offers the same benefits found in many public cellular systems such as:

- multi-site coverage;
- cellular organisation;
- automatic location;
- control channel;
- electronic switching;
- advanced software.

This means that TETRA-based radio systems are "intelligent" digital transmissions depending on business needs and/or the operator's policy. In addition, it offers connection-oriented as well as cordless packet data services based on ISO recommendations. This enables users to easily expand their existing data networks. Expansion is an underlying concept in the TETRA technology. It provides the ability for users to easily adapt their networks to business growth in terms of traffic and coverage. TETRA's built-in flexibility can fit the operator's strategy and permits the provision of services to third parties.

7 What are the advantages of TETRA's TDMA technology?

The Time Division Multiple Access (TDMA) technology of TETRA provides four distinct advantages compared with current analogue radio systems. These are:

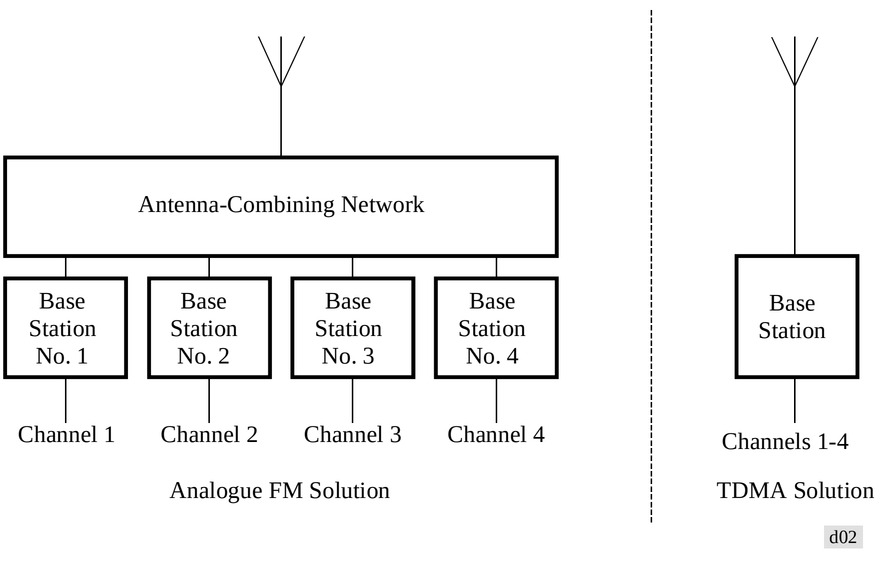
- Four channels on one RF carrier.
- Full duplex voice capability.
- Simultaneous voice and data.
- Bandwidth on demand.

Four channels on one RF carrier

Four channels on one RF carrier is an inherent feature of TDMA TETRA. Because only one carrier pair is needed to support 4 full duplex channels, only one base station is needed instead of four base stations as would be required for an equivalent analogue system. This has considerable space- and cost-saving benefits. For example, the advantages of TDMA compared to analogue FM are as follows:

- One base station instead of four.
- Less space.
- Less weight.
- Less power consumption.
- No need for antenna combining systems.

This means users benefit by significant lower capital expenditures and reductions in running costs associated with site rental and fuel bills. Even though the linear RF power amplifier requirement for TDMA requires more power than analogue FM, a four-to-one base station requirement, combined with the need for high RF power to overcome antenna combiner losses, will mean that overall TDMA will consume far less power for the same ERP.



Four-Channel Base Station Site (TDMA & Analogue FM)

In addition, as TETRA is a trunked system, there will be trunking gain provided by the four time-slot channels. This relationship between TDMA and analogue FM is shown in the base station configuration diagrams above.

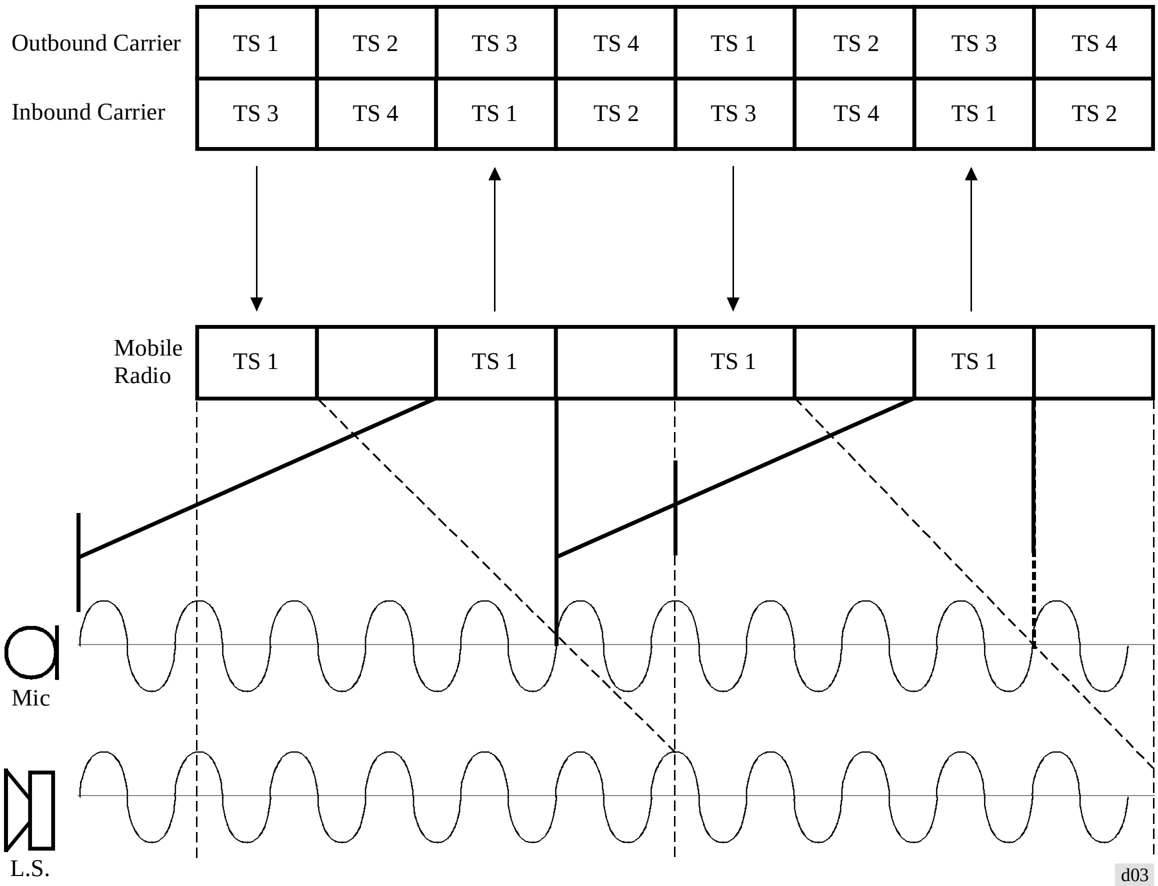
Full duplex capability

Many users now recognise the importance of conventional telephone communications being extended to the mobile radio environment. Traditional analogue PMR usually operates in two-frequency simplex mode, which means mobile radio telephone voice connections will also operate in simplex.

This is usually acceptable to the mobile radio user but totally alien to an untrained telephone user. For this reason, full access to PABX extensions on a business exchange are usually restricted to those persons familiar with mobile radio operation and voice procedures.

The TDMA access method of TETRA effectively allows a simplex radio to operate in full duplex because time-slots for uplink and downlink communications happen at different time intervals. To do this, the simplex radio rapidly switches between transmit and receive, having first compressed the voice signal for each time-slot transmission. The receiver expands the voice signal back to its original form.

This ability to talk and listen at the same time will allow both radio users and telephone subscribers to benefit from the full potential that telephone interconnect can provide.



An example of full duplex operation is shown in the above timing diagram.

Bandwidth on demand

Data throughput on a radio channel is limited by a combination of maximum permissible bit rate, channel bandwidth and error detection and correction overheads. With TETRA, a full 25 kHz of bandwidth (four time-slots) can be utilised for the transmission of data. With TETRA, one, two, three or all four time-slots can be used to transmit data, which means many choices of data throughput with different levels of protection are available, as illustrated in the table below.

Time-slots used	Unprotected	Low protection	High protection
1	7.2 kbit/s	4.8 kbit/s	2.4 kbit/s
2	14.4 kbit/s	9.6 kbit/s	4.8 kbit/s
3	21.6 kbit/s	14.4 kbit/s	7.2 kbit/s
4	28.8 kbit/s	19.2 kbit/s	9.6 kbit/s

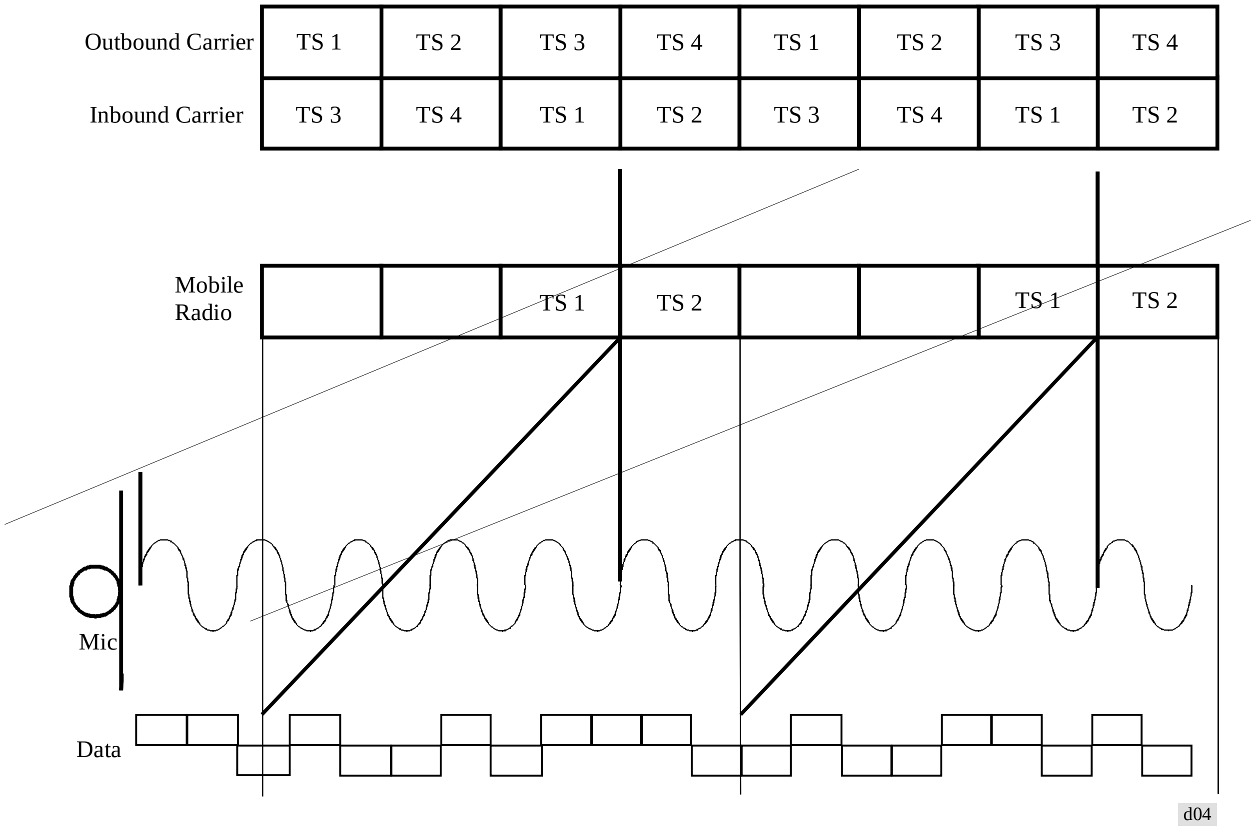
This additional bandwidth, combined with a choice of data protection, can mean unprotected data throughputs of up to 28.8 kbit/s compared with typically 1.2 kbit/s on subcarrier-modulated 12.5 kHz radio channels. Typical applications for bandwidth on demand would depend on how quickly the user needs the information and the data rate required. For example, some applications that are now possible with bandwidth-on-demand functionality are:

- Fax
- Route maps
- Slow scan video
- Digital mapping
- Fingerprints
- Data transfer
- Still images
- E-mail

Combined voice and data capability

The need to transfer and access data while on the move is a rapidly growing requirement in many organisations. Unlike analogue FM, TETRA can allow both voice and data to be transmitted at the same time. An example is shown below.

Besides an obvious improvement in channel utilisation, parallel operation of voice and data could allow mobile and fixed users to transfer files between PCs and discuss contents at the same time. This again provides greater operational efficiency as well as increasing user applications for voice and data.



8 What are the advantages of digital transmission technology?

Besides the unique TDMA features of TETRA, the use of digital radio transmission also provides additional benefits when compared with analogue radio. For example,

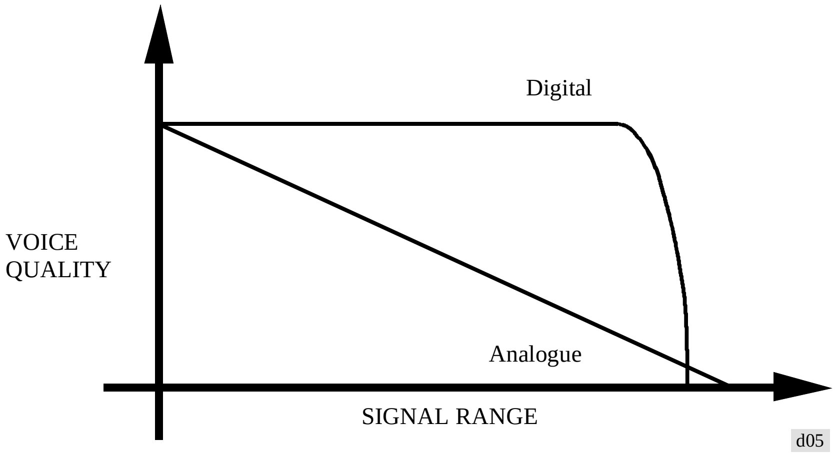
- Constant voice quality
- Encryption
- Regeneration

Constant voice quality

Analogue voice signals become noisy and difficult to understand when users are operating in weak signal strength areas. This effect can reduce operational efficiency because messages are often repeated or lost. Operating in these conditions can also cause unnecessary stress for radio users.

With digital transmission, the voice quality of received voice messages is either good or totally unreadable. In simple terms, a digitally-transmitted signal is either there or not; there is no in-between. This means that there will be no perceived difference in voice quality between messages received in strong and weak field-strength areas.

The resulting benefits for users are improved operational efficiency and reduced stress. The graph below shows the relationship between TDMA and FM voice quality.



Encryption

The need for secure voice and data communications is not only limited to military and police communication environments. Private organisations would also value the ability to prevent eavesdropping on their radiocommunications. Even though voice security methods are available on analogue systems, they usually provide a low level of protection and perform poorly in large or complex systems. Again, because TETRA is digital, the ability to incorporate digital encryption is inherent in the system. Also, it is well recognised that digital encryption generally offers a high level of security and protection against eavesdroppers. TETRA users will be able to utilise their own proprietary encryption algorithms or utilise those offered by the different TETRA system suppliers.

Regeneration

All communication elements in a TETRA system are digital except for the most important man-machine interface for voice communications, the microphone and the loudspeaker. This means that digital signal regeneration, instead of analogue signal amplification, can be used to extend radio coverage of a network, whether it be regional, national or the whole of a continent (such as Europe). Digital regeneration can, in theory, be carried out many times without introducing any signal degradation other than a small amount of transmission delay.

Analogue amplification unfortunately introduces noise, reduces frequency response and increases envelope delay distortion. Even though the adverse effects of reduced frequency response and envelope distortion can be minimised using relatively expensive compensation networks, noise cannot, which usually results in poor voice communications quality on wide-area multiple-site analogue systems.

The ability to have good quality voice communications, no matter where the radio user is located on a wide-area multiple-site system, must minimise the number of repeat or lost messages as well as reducing user stress. The resulting benefit to the user is the improved operational efficiency as well as possible reduction in running costs compared with analogue transmission (digital leased circuit costs are expected to come down in price).

9 How does TETRA compare to other mobile telecommunications technologies?

TETRA is flexible in terms of coverage, but also in terms of the services provided. Whether building a localised radio network or a full scale European network, TETRA will provide the radio coverage required. Other mobile technologies, such as cellular mobile radio telephony, make use of national or region-wide (e.g. pan-European) infrastructures based on a cellular concept which can be over-dimensioned for private mobile radio users. TETRA allows a user to set up a network which covers only the territory where the services are required. Again, services provided are tailor-made to match user needs. The table below shows how TETRA compares with existing analogue trunking systems.

TABLE 5

Comparison between TETRA and analogue trunking

Feature	Analogue	TETRA
Technology	Analogue	Digital
Access method	FDMA	TDMA
Modulation	FM	¼ DQPSK
Gross bit rate (bit/s)	1 200	36 000
Number of independent communication channels in 25 kHz of RF bandwidth	2	4
Channel spacing	12.5 kHz	25 kHz
Speech codec	n/a	ACELP
Single-site capable	Ã	Ã
Multiple-site capable (nation-wide)	Ã	Ã
Full duplex voice or data	(Note)	Ã
Simultaneous voice & cata	No	Ã
Group call	Ã	Ã
Broadcast call	Ã	Ã
Individual call (one-to-one call)	Ã	Ã
Priority call	Ã (3 levels)	Ã (8 levels)
Emergency call	Ã	Ã
Short data messaging	Ã	Ã
High speed data (28.8 kbps)	No	Ã
Digital encryption (voice security)	No	Ã
NOTE – A limited number of duplex radios are available but they are large and relatively expensive because of the need to have an antenna duplexer and RF screening between transmitters and receivers.		

Compared with other existing mobile technologies, TETRA offers a incomparable palette of services specialised for business communications from which the user can choose. Moreover, the user can exploit the capabilities of TETRA technology to create his/her own business applications. As business needs evolve, other TETRA networks can be set up to meet new requirements. TETRA networks can be interconnected using recognised standards, thus ensuring that private mobile radio services can expand in line with business needs without being tied to proprietary technologies.

10 When will TETRA systems be available?

Some manufacturers are well advanced with its TETRA research and development programme. One manufacturer already has a test and development system working in the 380-400 MHz band. This system was officially put in operation on 30 November 1994. This manufacturer's programme for product development and delivery was as follows at the time this document was compiled:

1996 Phase 1

Single-site production quality systems sold to users willing to participate in system reliability and quality trials over a period of typically 6 months.

These systems will have basic calling features but no wire-line or telephone interconnect facilities. Facilities currently planned are:

- Group call
- Broadcast call
- Emergency call
- Individual call
- Priority call

1997 Phase 2

Multiple-site system with additional features such as:

- PABX interconnect
- Talkgroup merge
- Call alert
- Dispatcher interrupt
- Short number addressing
- Radio inhibit
- Priority scan
- Status messaging
- DTMF encode

1998 Phase 3

Multiple-site wide-area system with advanced calling features, data, encryption and full PABX/PSTN telephone interconnect facilities.

It is important to note that Beta trial systems will be upgradeable, with hardware and software modules, to full-featured multiple-site wide-area systems.

Software upgrades and enhancements will continue after phase 2 at regular intervals, supporting new features and facilities as they develop.

It is believed that the manufacturers Motorola, Philips Telecom, Nokia and Ericsson have similar timescales for product delivery.

APPENDIX E

Wireless local loop

1 Introduction

There is no doubt that the advent of new digital telecommunications technologies, associated with the prodigious development of computer power, is the major lever for economic, social and cultural change as the end of the millennium approaches.

We seem to have become immune to surprise, so used are we to rapid progress. In the last dozen or so years, fax machines, PCs and cellphones have become part of daily life. Even more exciting technologies and services, such as high definition television, multimedia and other types of intelligent networks, are now on their way, and are set to radically change our working and personal lives.

Whether born of, or a midwife to such changes, world telecommunications deregulation has had a powerful effect on the way things are moving. New operators have appeared, along with new services, new service providers, a new form of competition, and better prices for end users.

However, all this is no more than the tip of the iceberg in the eyes of end users. They cannot but wonder what magical realities lurk behind the abbreviations bandied about by experts. ISDN, PCS, DCS1800, DECT, PHS, PACS, UMTS, and WLL are themselves shrouded in mystery, being, according to circumstances, a technology, a standard, a service, a product, or even no more than purely conceptual.

The acronym which is the focus of our interest today has the simplest of initials, “LL” for “Local Loop”. However, it has, like its fellows, already evolved into more complex forms, with prefixes such as “R”, or “W” for “Radio Local Loop”, or “Wireless Local Loop”.

2 What is meant by “local loop”?

The term “local loop” is generally used to mean all, or the final parts, of the public telecommunications network between local telephone exchange and subscriber premises; its definition depends on an operator’s network structure and operating vocabulary.

To remove ambiguity, this document uses the term “local loop” for the complete network distribution and access infrastructure between local exchange and subscriber premises. The “local loop” therefore includes both an “access network” and a “distribution network”.

The term “access network” is used to describe that part of the network between the subscriber premises and the first point of geographical distribution or circuit concentration.

The term “distribution network” is used to describe that part of the network between the first point of geographical distribution or circuit concentration and the local exchange.

The “distribution network” may not exist if the access network extends directly to the exchange.

The reference point between the “access network” and the “distribution network” is not fixed and varies with operator, network architecture and the local loop technology which is used.

This also means that a number of different technologies may be used for each of the two sub-networks. Hence hybrid wire/radio or radio/wire technology networks may be set up. A lot of configurations are possible. These will depend on topography, performance, services, costs, regulatory and environmental constraints, operator strategy, etc.

3 Which services?

The range of telecommunications services which can be provided for end-users is now extremely broad. At one end, we have the Plain Old Telephone Service (or POTS), at the other, interactive video, not to mention the numerous intermediate value-added services, offering features such as mobility. Of course, each of these services can be further subdivided within its own category, according to performance and quality levels offered.

Hence, on equivalent coding performance, the service quality of the voice telephone system will be the better as the transmission bit rate is higher; for example, 64 kbit/s being better than 32 kbit/s, which is itself an improvement on 16 kbit/s, etc.

Similarly, video services can range from a simple black and white image which is cyclically updated (for remote surveillance, for example) to high definition multichannel television.

Mobility itself can be of various kinds, depending on the type of geographical coverage provided or user behaviour (on foot, in car, on board train, etc.), or again, depending on the type of service required (one way or two ways, with or without “hand over”).

4 For whom?

4.1 The operators

Operator requirements are, by nature, different from and occasionally contradictory to those of the regulatory bodies or even those of the operator’s own customers (be they the service providers or the end users).

And requirements vary even more from operator to operator in the competitive environment.

The operator’s strategy will differ considerably, depending on whether it is an established operator (a former monopoly) or a new operator. The former will above all seek to hold on to a substantial market share while establishing a position in new segments (mobile for example).

The new operator may either take on an established competitor in head-on competition, or establish itself as a distinctive provider of a more attractive service (better price or higher quality), or alternatively also focus on new segments.

Similarly, a distinction must be made between developed and developing countries, in which services, access to services, economic development policies and a number of specific environmental factors must also be taken into account.

So far, potential operators of Local Loop networks may be placed in one of the two following categories :

- Established national Public Telecommunications Operators (PTOs).
- Newly-created Public Telecommunications Operators:
  - i) Specialized operators, e.g. Mercury, Mannesman, Optus, Ratelindo, Shinawatra.
  - ii) Value-Added Telecommunications Providers, e.g. Utilities (water, electricity), Transport, CATV operators, etc.

Apart from financial and regulatory differences, one key differentiating factor between these operator types is their existing telecommunications infrastructure state. Established national PTOs already have a significant quantity of infrastructure commensurate with the state of the country’s telecommunications development.

On the other hand, newly-created operators may have either no existing infrastructure at all (likely if they are to be a dedicated telecommunications provider), or significant infrastructure currently used for other services than telecommunications. Some of this infrastructure may be very effectively reused for telecommunication operations (e.g. Générale des Eaux (SFR) WLL project using a cable TV infrastructure).

The table here-after describes the services supported by the different technologies.

Local loop technologies and services
Non exhaustive list

Technologies		Services		
		Voice	**Data**	**Video**
"Wired" technology	Copper	1 conversation	up to 19.2 kbit/s	Slow
	HDSL	30 conversations	2 Mbit/s	Video conference
	ADSL	1 conversation	19.2 or 28.8 kbit/s + 6 Mbit/s	On demand
	CATV	Possible	Limited capacity	Broadcast
	Opt.fiber	Variable up to over 100 000 conversations	up to 10 Gbit/s	Multi-HDTV + interact.
"Wireless" technology	Analog cellular	1 conversation per frequency	up to 4.8 kbit/s	No
	Digital cellular	Variable	> 2.4 kbit/s	No
	Microwave	n × 30 conversations	n × 2 Mbit/s	Broadcast
	Point-to-Multipoint microwave	n × 30 conversations	16, 32, 64 kbit/s or n × 64 kbit/s	Video conference
	Cordless	12 up to 48 conversations by station	up to 4.8 kbit/s or n × 32 kbit/s	Slow
	Satellite	Depending upon type		

4.2 The subscribers

Local loop subscribers can be classified according to their activitties and potential mobility.

The subscriber types

Subscriber activity	Mobility		
	Fixed + premises covering	**Local-area mobility**	**Wide-area mobility**
"Residential"	Domestic cordless	WLL + neighbourhood + Telepoint	Cellular
"Business"	Cordless PABX WLAN	Telepoint	Cellular Trunk Mobile Data
"PCO" Public Call Office	Coin boxes Telecenters	Telepoint	N.A.

5 Which technology? At what price?

These are, of course, the questions that any operator, regulator, manufacturer or user rightly raises. The mass of contradictory or partial information on this subject is such that it only adds to the reigning confusion.

Some figures, possibly because they are easier to remember than others, are taken as a sort of gospel, without relation to any form of underlying reality. US dollar-denominated costs are estimated in units of $ 100, $ 1,000 or even $ 10,000, depending on the studies.

What do these figures apply to? What services do they relate to? And in which configuration? These are questions which in most cases remain unanswered or at least only partially tackled.

In practice, there is no such thing as an inaccurate figure, provided the figure is related to questions such as:

- **Which services?** (voice, data, images, video?)
- **For whom?** (existing or new operator, private or professional user?)
- **What performance level?** (GOS, capacity, voice quality, reliability?)
- **Which configuration?** (country, region, environment or distance?)
- **With which existing or future hardware and supply limits?:** switching?, transmission?, distribution equipment?, subscriber terminal?, power supply?, pylons?, cables?, aerials?, buildings?, integration?, installation?, commissioning?, training?, operation?, subscriber management?, billing? etc.

The parameters are many and varied, which only makes the comparison more difficult.

We lay no claim to defining a modelling technique under which it would be automatically possible to reach the best solution to so complex a problem. After all, the parameters are not only multiple but in many cases correlated. Our only aim is to provide comparative cost factors, for the various wire-based and radio technologies, for a small number of typical configurations – on the understanding that a definitive choice of the one or more appropriate technologies will depend, more than anything else, on the sort of replies given to the questions raised above.

6 The case for DECT

The DECT standard was designed to support cordless telecommunications access in a number of existing and future telecommunications applications, e.g.:

- Residential Cordless telephony.
- Business Cordless PBX.
- Public access: PCS access (enhanced telepoint) and Wireless Local Loop (WLL).

Regarding the Wireless Local Loop (WLL) application, the standard includes many features to ensure suitable performance in the WLL application, such as the provision for antenna gain on fixed subscriber terminals stations to increase radio range and a specific WLL equipment identity structure.

6.1 The DECT services

The DECT service provision is given in the ETSI Technical Report ETR043. The services and facilities can be summarized as follows:

- Voice telephony (POTS): 32 kbit/s ADPCM coding (ITU-T G.726).
- Voice band data: bit rates up to 2 400 bit/s and 4 800 bit/s.
- Digital services (ISDN): DECT/ISDN profile draft by ETSI RES03.

The DECT double-slot structure is used to provide an error-protected user information channel of 64 kbit/s, and two or more slots may be combined in a single slot to provide a 144 kbit/s liaison suitable for ISDN 2B+D basic rate access.

6.2 The DECT service attributes

- Network Access Delay: the Round Trip delay is around 24 milliseconds.
- Grade Of Service (GOS): DECT is designed for 99% GOS or better.

This is mainly due to the following DECT features:

- Multicarrier TDMA and decentralised radio resource management.
- Dynamic channel selection.
- Intercell and intracell handover.
- Antenna diversity.
- Robust and high-speed control channel.

- Service security (encryption).
- Authentification.
- Mobility.

7 Conclusion

The Wireless Local Loop will undoubtedly cover a significant part of line installation in the next few years. This will not only concern the new operators, but also existing PTOs in new urban, suburban and rural areas where flexibility and low initial investment are the key issues.

As the report for question 4/2 on communications for remote and rural areas will undoubtedly mention, it is important to remember that the Local Loop includes both distribution and access networks. According to key parameters such as the operator strategy, the services to be offered, the cost and the local constraints (the topology, the regulation and the subscriber location are the most critical), wired and/or wireless technologies can be used.

This also explains the difference in cost between urban and suburban areas where, usually, the distribution network is reduced to a minimum, with subscribers connected nearly directly to the local exchange, and rural areas, where the distribution network accounts for a large part of the total local loop cost.

The evaluation of the different models shows that the total cost of the local loop may vary very much within the ratio 1 to 5 and even more according to the case.

It also shows that none of the proposed technologies can be considered the cheapest in all models, for any number of subscribers.

This means that, to make the right choice, the operator will have to search for the lowest initial investment, to be recovered as soon as possible by catching a sufficient number of subscribers, and, at the same time, must keep the flexibility to expand both technically and commercially at the lowest final cost per subscriber.

In this respect, when comparing the costs of the different technologies in the different models, it is clear that both Cordless for the access part and Point to Multipoint for the distribution are, individually or in combination, the most appropriate solutions to cover all urban, suburban and rural areas.

Finally, it appears that the existing regulation rules will have to evoluate to take into account the new technologies which will allow several operators to offer in the same geographical area either similar or different services to share the same frequency band.

It is suggested that reference be made to the Handbook on Land Mobile (including wireless access) Volume 1, prepared by the ITU-R Study Group 8.

APPENDIX F

New technologies

ATTACHMENT 1

ITU-R Working Party 4B thanks ITU-D Study Group 1 for its inquiry on new technologies. Working Party 4B has identified the following new technologies and has attached a brief description of each technology:

- Asynchronous Transfer Mode (ATM)
- Synchronous Digital Hierarchy (SDH)
- On-Board Processing (OBP)
- New 30/20 GHz-band Satellite Systems

Working Party 4B has assumed that ITU-D Study Group 1 has availed itself of the information that is contained in the Fixed-Satellite Service Handbook and its Supplements. This book contains a great deal of valuable, basic information on satellite systems and should be of great use to ITU-D Study Group 1.

Asynchronous Transfer Mode (ATM)

General Description – Asynchronous Transfer Mode (ATM) is a data transfer mechanism which has been agreed to within the ITU-T and is the selected method for multiplexing and switching of Broadband ISDN (this does not preclude its use for other applications). It packages data into 53 byte cells (including 5 bytes of header/overhead) and allows users to inject data into a network at a wide range of information rates through the same User/Network interface on a call-by-call basis. The overhead bytes allow sophisticated traffic management to be performed within that network.

Satellite Implications – ATM signals can be transported between ATM Nodes/Switches via either PDH- or SDH-based transmission systems (including satellite links). The packet/cell-based switching functionality which ATM offers can be built into a satellite network (either within the earth stations or on board the satellites) with the possibility of exploiting the inherent capability of such networks to share satellite capacity between a number of users/nodes within a network. ATM signals have already been successfully transported via existing point-to-point satellite links. ATM switching within a satellite network is likely to be available in the next few years.

Synchronous Digital Hierarchy (SDH)

1 SDH Transport Network Description

1.1 SDH Multiplexing Techniques

1.1.1 Basic structure

The basic SDH multiplexing techniques (bit-rate, frame format and structures) are described in ITU-T Recommendations G.707, G.708 and G.709. The SDH multiplex hierarchy has a level-1 bit-rate of 155.52 Mbit/s (STM-1) as well as higher levels currently defined as STM-4 (622 080 Mbit/s) and STM-16 (2.48832 Gbit/s) formed by byte interleaving hierarchically lower synchronous multiplex signals.

Figure 1 shows the basic 125 μsec duration frame structure of the STM-1 signal. It is illustrated in a 270 × 9 bytes matrix format to simplify the identification of the control overhead from the traffic load.

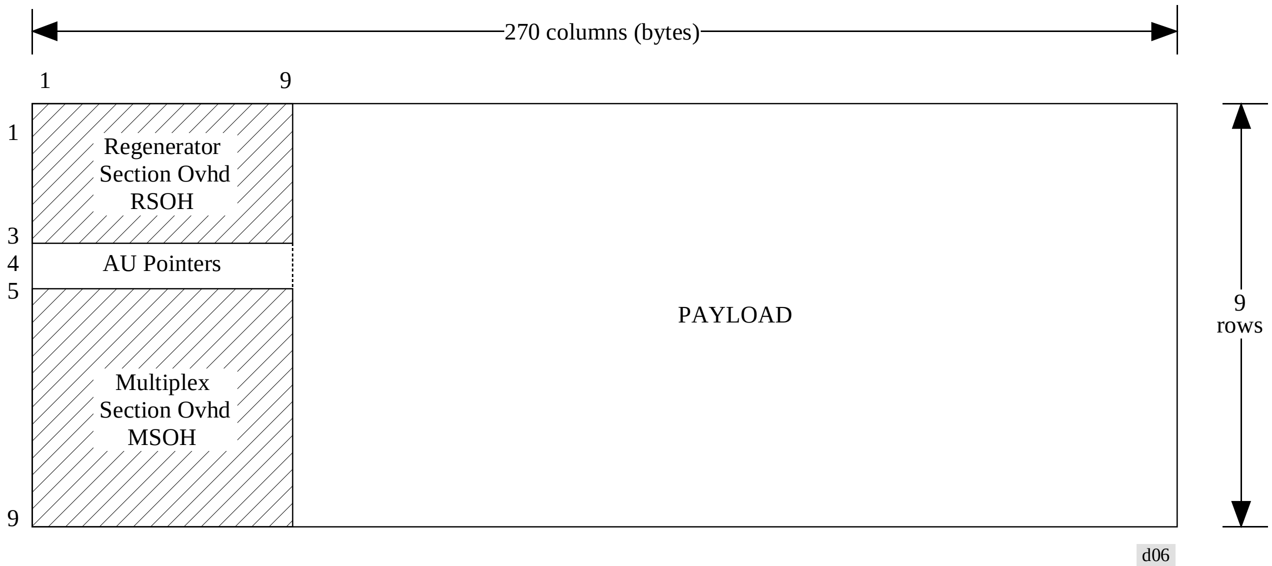
The smallest two SDH synchronous tributary signal elements defined in the STM-1 multiplex are VC-12 (Virtual Container 12) and the VC-11. The VC-12 carries a payload of 2 048 Mbit/s and a 64 kbit/s path overhead. The VC-11 carries a payload of 1.544 Mbit/s.

End-to-end transparency at the VC level is available to the SDH transport network users. Lower order paths (LOVC) and higher order path (HOVC) are defined, which can be flexibly configured on an end-to-end or node-to-node basis.

Network nodes in SDH are interconnected by Multiplex Sections, which in turn may consist of a number of Regenerator Sections. Internode remote management is facilitated by functions communicated within Multiplex Section Overhead (MSOH) and Regenerator Section Overhead (RSOH). The allocation of SOH capacity and byte allocation to various management functions and the functions and protocols are described in G.708, G.784, etc.

FIGURE 1

STM-1 Frame Structure



1.1.2 Submultiplex signals for radio systems

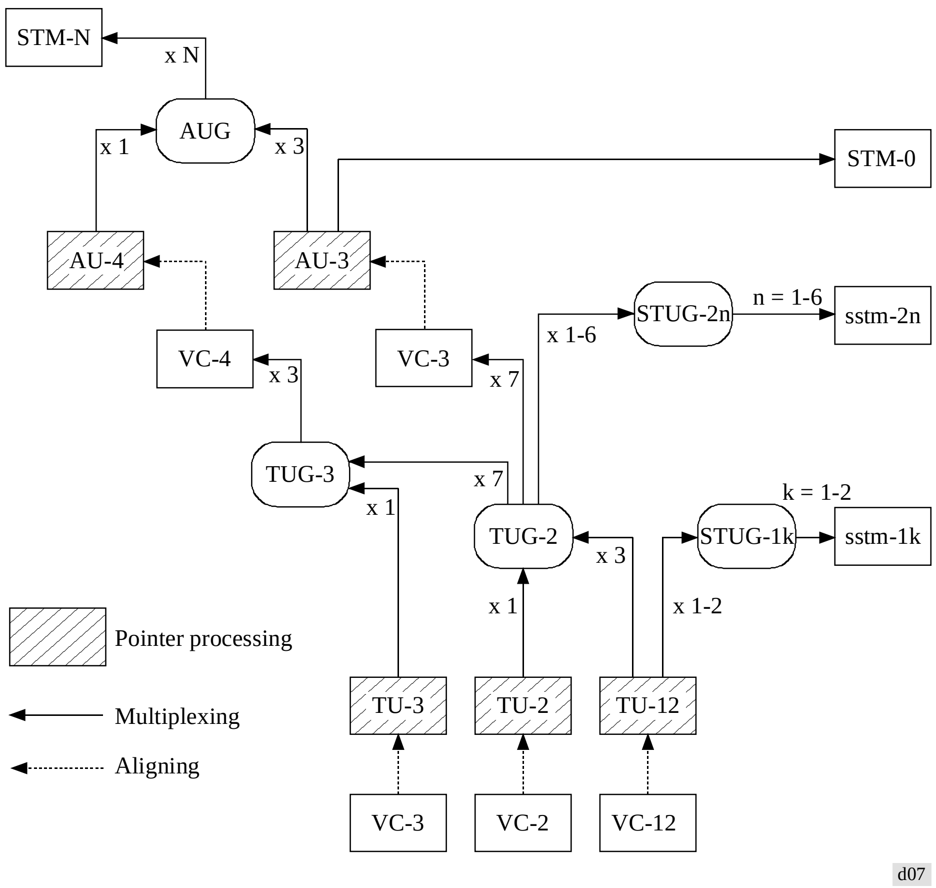
Construction of lower (than STM-1) SDH multiplex signal bit-rates for satellite system transmission follows the interworking multiplexing tree of Figure 2, reproduced from ITU-T Recommendation G.861 with the addition of Satellite Tributary Unit Groups (STUGs). STUGs SDH signal element multiplex groups with different sizes are used as baseband signals of multi-destination FDMA carriers or TDMA bursts.

In all cases, the following SDH principles shall be adhered to in constructing sub-STM-1 satellite multiplex signals:

- byte orientation of the multiplex signals,
- transparency to the lowest and possibly higher order basic SDH signal elements,
- provision of an appropriate degree of SDH based section overhead functionalities, including OAM and network management across the satellite transmission paths and between the SDH baseband units.

FIGURE 2

Demultiplexing/remultiplexing routes for constructing sub-STM-1 multiplex signals for FSS transmission



NOTE 1 – The need for a maximum value of n in STUG-2n is for further study

NOTE 2 – Possible conversion routes: STM/-N/AUG/AU-4/VC-4/TUG-3/TUG-2/TU-12/STUG-1k/sstm-1k
STM/-N/AUG/AU-4/VC-4/TUG-3/TUG-2/STUG-2n/sstm-2n
STM/-N/AUG/AU-4/VC-4/TUG-3/TUG-2/VC-3/AU-3/STM-0
STM/-N/AUG/AU-3/STM-0

1.2 SDH Layered Network Modelling

General

ITU-T Recommendation G.803 SDH network functional description includes the concept of layered model of the transport network. Its use by all SDH network participants (designers, operators, equipment vendor) is essential for compatibility in design, operation and management commonality. In G.803, two groups of network layers relevant for transport network design and network management are defined. The SDH basic frame structure in Figure 2 corresponds to the organization of the network in logical layers:

- The Path Layer, consisting of:
  - i) The lower order VC (LOVC) Layer.
  - ii) The higher order VC (HOVC) Layer.
- The Section Layer, consisting of:
  - i) The Multiplex Section (MS) Layer.
  - ii) The Regenerator Section (RS) Layer.

The Circuit Layer Network in the G.803 model represents the SDH network "client" applications (e.g. ISDN, PSTN, ATM) transported as SDH payload signals.

The RS is media dependent and the MS may be media dependent. The HOVC and LOVC are designed to be media independent and are components to construct, within their respective layers, subnetworks with a wide variety of topologies.

1.3 Expansion to satellite SDH systems

Figures 3, 4 and 5 provide G.803 type representation of a FSS-SDH system in the three different scenarios. The models are modified to reflect transparency of the system to one or more layers of the interconnected terrestrial networks. A Multi-Destination Satellite Server (MDSS) layer is introduced to aid the modelling of multi-destination connectivities in Scenarios 2 and 3.

Within the MDSS layer, flexible satellite system internal connection configurations involving STM-0 or STUG-based SDH signal multiplexes can be modelled. MD trails in the MDSS Layer provide link connections with simple point-to-point topology in the client path layer networks. MD trails also lend themselves as servers of complex point-to-multipoint topology in the client path layer networks (under study in ITU-T).

SDH signal handling within the MDSS layer is characterized by:

- SDH signal element groupings optimized to satellite traffic route sizes (STUGs, STM-0 payload);
- Asymmetries in number and sizes of directional satellite sections between communicating earth stations;
- Restricted visibility from the externally terminated SDH network server trails.

Satellite networks formed within the MDSS layer are restricted to the FSS-SDH system, whereas G.803 type subnetworks in the client path layer networks have global SDH transport network significance.

The MDSS layer extends strictly from the bottom Satellite Medium Sublayer, to the (sub)layer boundary with the client layer network. The upper boundary depends on the FSS-SDH network scenario in which the MDSS is used.

2 Applications of FSS in SDH Transport Networks

2.1 Service Aspects

Satellite systems in the FSS in any of the three scenarios described herein make up a part of the SDH transport network, thus contributing in varying degrees to the provision of efficient transmission network services to the SDH network users.

2.2 Network Management Aspects

2.2.1 General

Incorporation of SDH multiplex equipment functions as part of the system Terrestrial Baseband Equipment facilitates commonality, accessibility, uniformity and integration in the overall SDH network management, and thus of the enhanced management functionality and automation thereof.

2.2.2 SDH Equipment and Management Functional Blocks

The description methodology follows the "Functional Reference Model" approach used in ITU-T Recommendations G.782, G.783 and G.784. The SDH equipment is defined as a collection of functional blocks only, logically partitioned to facilitate the description of functions, operation and management of the whole system. It does not impose nor imply any physical partitioning along the block boundaries. A generic functional block diagram of an SDH multiplex equipment including its management and timing functional blocks is given in Figures 6A and 6B, derived from Figure 2-1/G.783 and adapted for FSS-SDH TBE purposes.

Equipment functions include all those functions required for the transport and management of user's traffic from one or more external ingress interfaces to one or more external egress interfaces.

Decomposition of FSS-SDH terrestrial baseband equipment into selected functional blocks for the three network scenarios is discussed in § 5.1, 5.2 and 5.3.

FIGURE 3

Layered model of point-to-point FSS-SDH digital section at STM-1

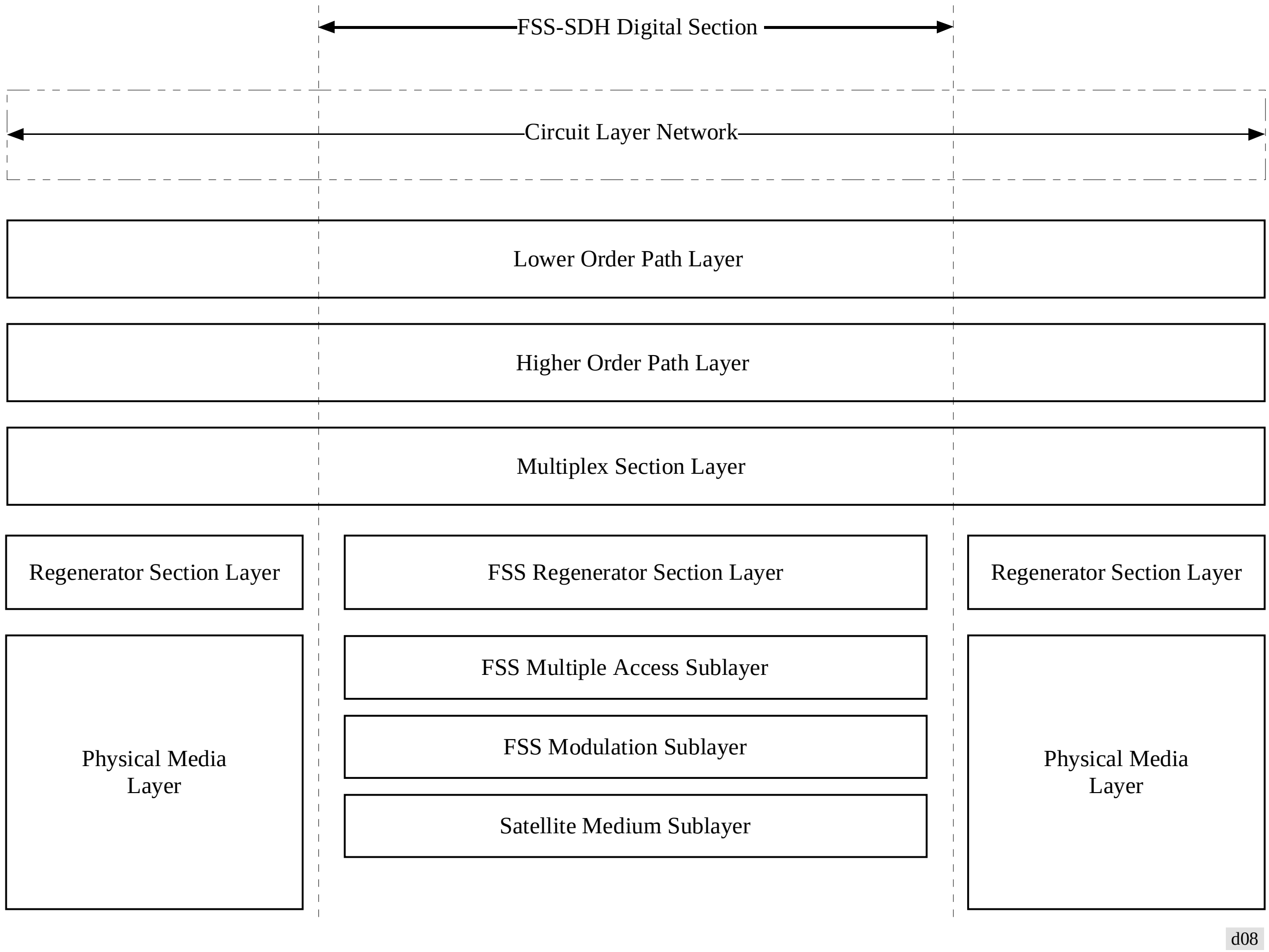


FIGURE 4

Layered model of scenario 2 with MDSS

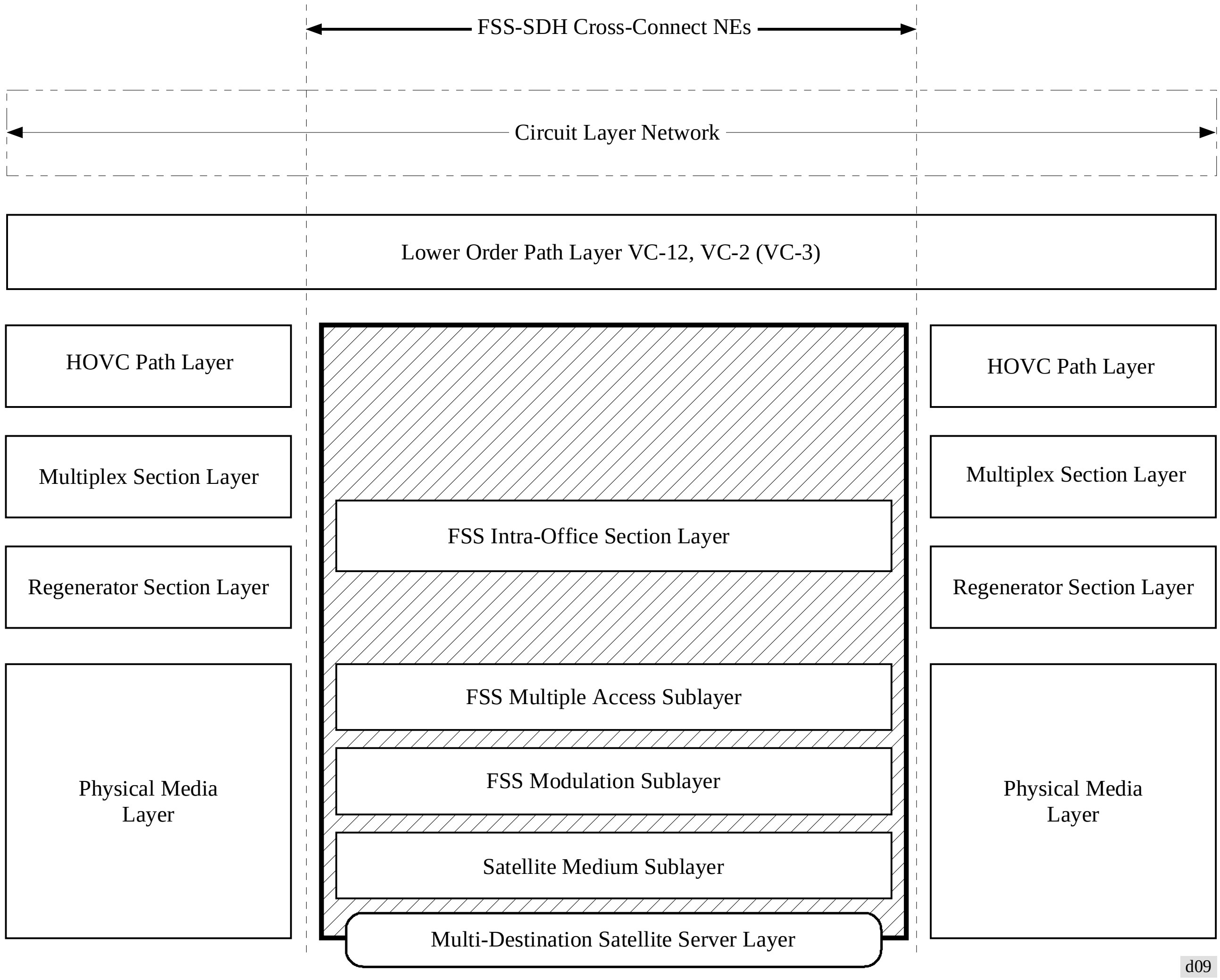


FIGURE 5

Network layered model of scenario 3 with MDSS

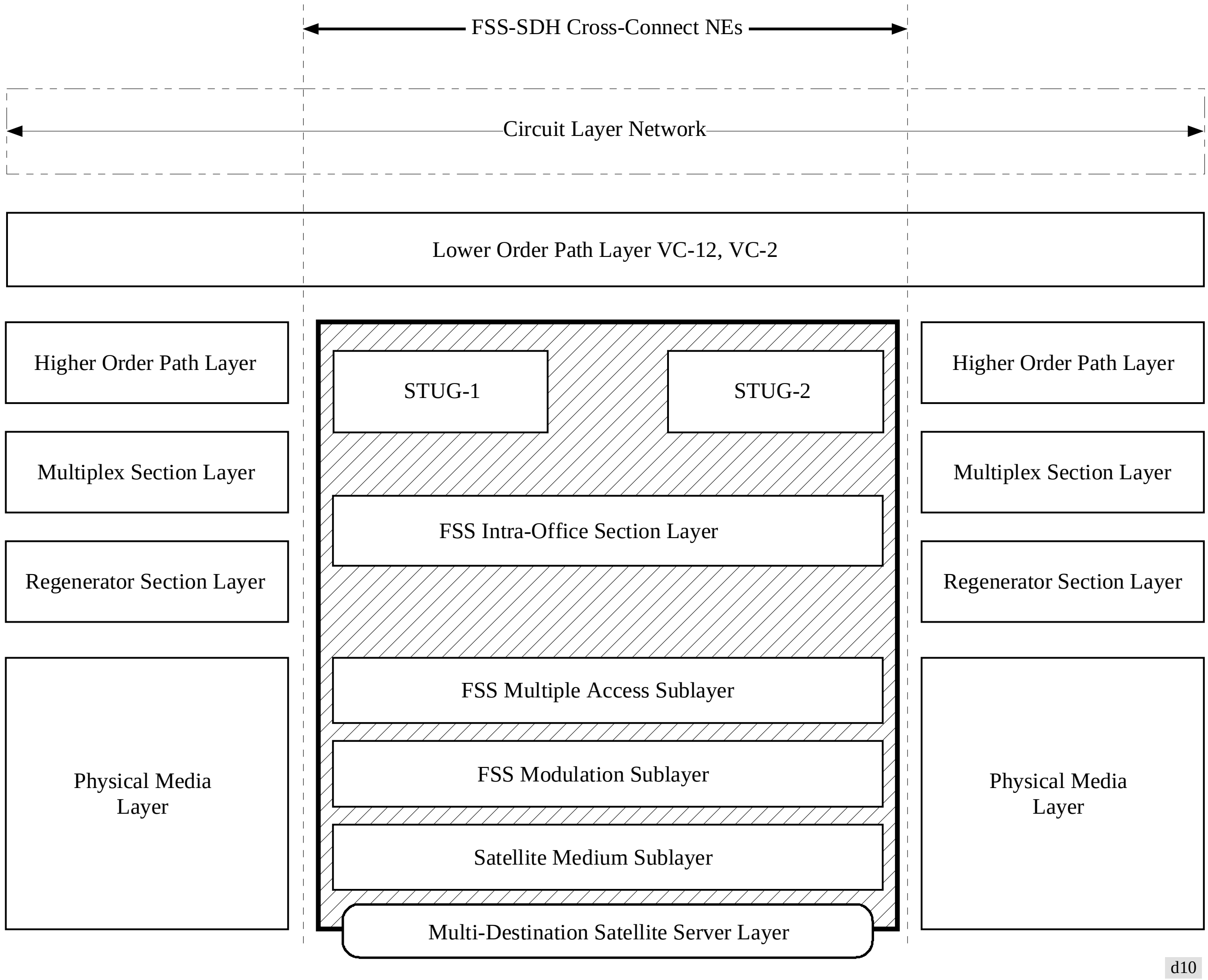


FIGURE 6A

General Functional Block Diagram of SDH-based TBE (transport functional blocks)

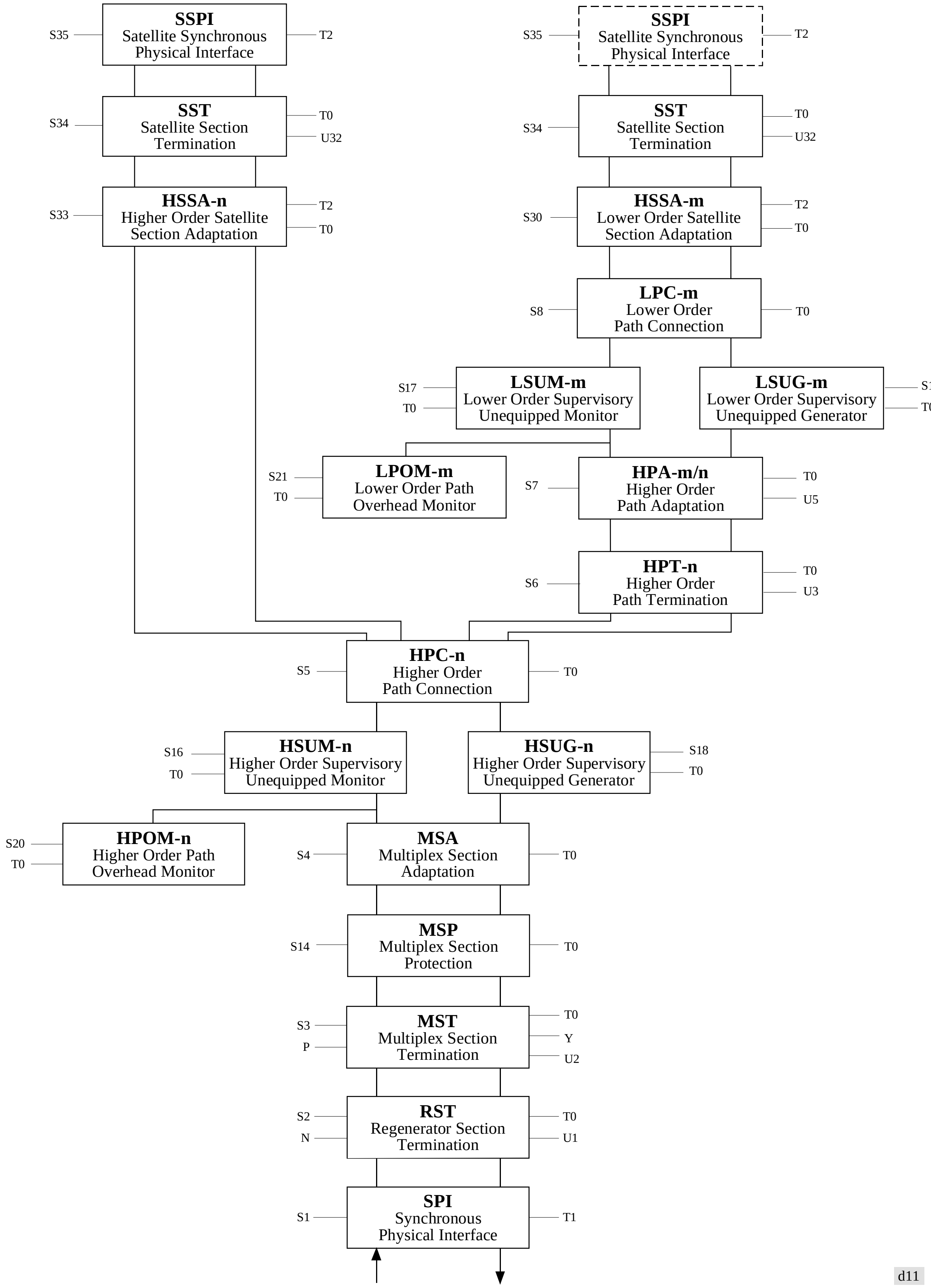
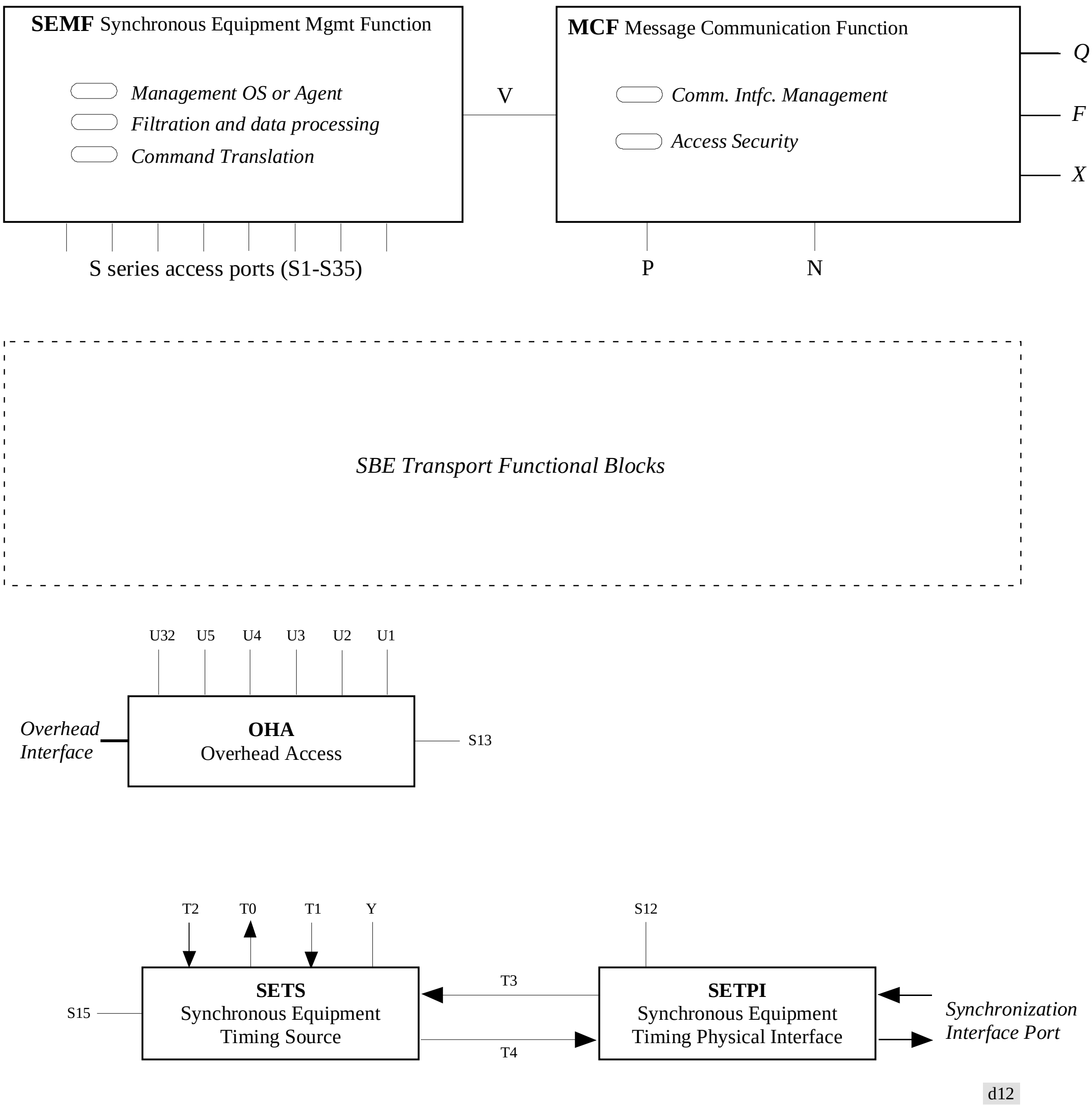


FIGURE 6B

General Functional Block Diagram of SDH-based TBE (timing and management functional blocks)



On-Board Processing (OBP)

Satellites using on-board processing (OBP) convert uplink traffic to baseband (digital form) at the spacecraft and apply digital signal processing techniques to correct, route, switch, replicate, reformat or otherwise manipulate the signals before retransmitting them (either to another ground station or to another satellite via an intersatellite link).

The use of OBP provides several distinct advantages over non-processing satellite systems, such as allowing the satellite to act as a switching node in a digital network, potentially reducing the required complexity of the ground segment, reducing required link margins due to on-board signal regeneration processing gain (theoretically 3 dB or less), and potentially allowing for a larger degree of autonomous operation of the space segment.

OBP satellites typically offer high-power spot beams which, at higher frequencies, can be rather tightly focused on well-defined coverage areas. Systems employing “hopping” spot beams with relatively small footprints in conjunction with on-board signal routing can provide very high data rates to large coverage areas. Most current and planned OBP systems operate at Ku band and higher frequencies.

New 30/20 GHz-band satellite systems

Geostationary

As a result of the proliferation of geostationary satellite communication systems in the 6/4 GHz and in the 14/12 GHz frequency bands new satellite systems have been proposed at the 30/20 GHz band. In particular, some new 30/20 GHz-band satellite communication systems are being planned for the GSO/FSS and some are expected to be operational by the year 2001.

These systems will all have the capability of providing international and domestic communications. Also, they will likely offer a wide range of public and private services ranging from traditional low-speed data, facsimile and telephony to broadband services such as video-conferencing, video broadcasting, high-speed data, etc.

Furthermore, 30/20 GHz-band satellite systems will be characterized by smaller beams with higher energy densities than those of 6/4 GHz and 13/11-12 GHz-band systems and thus may require smaller (hence less expensive) earth terminals that could be installed at customer's premises.

Some of the systems that have been proposed may include On-Board Processing (OBP) and some may be capable of carrying ATM-based services.

Non-Geostationary

The technology of low-Earth orbit Fixed-Satellite Service at 20 and 30 GHz can provide to all countries of the world affordable wireless access to advanced broadband digital communications with the characteristics of low delay, fibre-like communications. Hundreds of satellites, capable of sending and receiving digital packet communications to all parts of the world are an egalitarian use of technology that treats developing and developed countries alike, with the same communications density available to each. The short path length to the low-Earth orbit satellites allows many low power channels per satellite and contributes to the high capacity and low cost of such systems. Small area, earth-fixed cells provided by the satellite create, on many occasions, frequency re-use and resultant high communications density. Small, low-cost fixed terminals can link remote areas via voice, data and video, thereby supporting economic development, health care and government functions within any country and can provide connections to other countries as well.

ATTACHMENT 2

List of new technologies being studied by ITU-R SG 8

1 Future Public Land Mobile Telecommunication Systems (FPLMTS)

Studies in the ITU-R on FPLMTS are aimed at providing mobile telecommunications anywhere, anytime. These studies are intended to develop systems that could be used around the year 2000 and will operate in a frequency band near 2 000 MHz.

A number of different radio environments are involved covering indoor “pico” cells with very high capacity all the way through large outdoor terrestrial cells to satellite coverage. A major focus of the ITU-R standards work on FPLMTS is to maximize the commonality between the various radio interfaces involved in order to simplify the task of building multi-mode mobile terminals covering more than one radio environment.

An important part of the ITU-R studies on FPLMTS is the potential for these new mobile radio technologies to provide cost-effective and flexible access to the global telecommunications networks in developing countries and under-developed parts of developed countries.

Currently a number of digital mobile systems have been standardized in some regions and more are planned to be defined in the near future; these are often referred to as “second generation” systems. Second generation systems include various paging, cordless, cellular, mobile data and satellite systems.

FPLMTS are third generation systems which aim to unify the diverse systems we see today into a seamless radio infrastructure capable of offering a wide range of services around the year 2000 in many different radio environments.

Relevant texts: ITU-R Recommendations, 1994 M-series Volume, Part 2, and 1995 M-series Fascicle, Part 2.

2 Transport Information and Control Systems (TICS)

TICS are integrated systems utilizing the combination of computers, communications, positioning and automation technologies to improve the safety, control, management and efficiency of terrestrial transportation/road systems, and to provide for more traveller-friendly surface transportation systems worldwide.

TICS not only assist in addressing existing transportation problems, but also facilitate effective short- and long-term planning to meet future demands through an intermodal, strategic approach to surface transportation.

The objective of the work within ITU-R is to study the radiocommunication aspects of TICS including: basic characteristics and objectives, radio-based services, spectrum requirements and band suitability, interconnect require-ments with the switched telecommunication networks, technical factors affecting sharing between TICS and other users, and the ability of evolving mobile telecommunication systems to deliver TICS services.

Relevant texts: ITU-R Document 8A/1, Attachments 8 and 9 (1996).

ATTACHMENT 3

Development of new technologies studied by ITU-R Study Groups 10 and 11

1 Study Group 10 Broadcasting Service (SOUND)

1.1 Introduction of SSB emissions in the HF bands

Development of mass-production SSB receivers;

Development of SSB transmitters.

1.2 Introduction of digital audio services at LF and MF (and eventually at HF) (Question 217/10)

Development of an ITU radio system standard (possibly unique and worldwide applicable);

Single worldwide multiband digital receiver (low-cost to satisfy the needs of developing countries).

1.3 Implementation of Digital Audio Broadcasting services at VHF and UHF (terrestrial and satellite)

Efforts to implement a single worldwide applicable system (as outlined in Recommendation BS.1114 and BO.1130) allowing for:

- Single worldwide digital receiver both for terrestrial and satellite services (low cost due to scale economies to satisfy the needs of developing countries).

1.4 Introduction of high data rate data channel multiplexed with conventional FM emissions at VHF (see Recommendation BS.1194)

Development of new pay-on-demand and /or conventional data services;

Development of low-cost receivers.

2 Study Group 11 Broadcasting Service (TELEVISION)

2.1 Implementation of Enhanced Television Systems (such as Pal-plus, see Recommendations BT.796, 797, 1117, 1118 and 1119)

Development of low-cost receivers.

2.2 Introduction of digital terrestrial television broadcasting at VHF and UHF (see Question 121/11 and Recommendations BT.798-1, 1206, 1207, 1208, 1209 and 1125)

Efforts to achieve a single worldwide applicable system allowing for:

- Single low-cost worldwide TV receiver,
- Easier programme exchange.

2.3 Introduction of digital multiprogramme TV emission by satellite (see Recommendation BO.1121)

Efforts to achieve a common decoder allowing for an overall receiver economy.

2.4 Development of data service for multimedia applications associated to digital TV emissions (terrestrial and satellite)

Development of worldwide standard to allow for cheaper receivers;

Development of customer-oriented pay-services.