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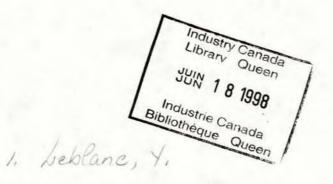
FUTURE SPECTRUM REQUIREMENTS

FOR

MOBILE RADIO COMMUNICATIONS

IN CANADA

Canadä

Government of Canada
Department of Communications

1. Leblanc, Y.

2. **A STUDY OF**

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EXECUTIVE SUMMARY

In 1989 the team of ADGA and Ernst & Young conducted a study to determine the Market and Technological Trends in Radio Communications. This study confirmed that major changes in both the technology and the size of mobile communications markets would have a profound effect upon spectrum requirements in Canada. As a consequence ADGA was awarded this contract to determine the frequency spectrum required to satisfy the expected traffic densities of various types of mobile radio services over the next ten years in metropolitan, urban and rural areas.

The study makes use of the Canadian Demographic data base to project the number of possible users in major metropolitan, suburban and rural areas. This projection subdivides the population base into industrial and domestic groupings for which reasonable market penetrations can be established. These are based on consideration of the nature of operations, number of employees requiring fixed and/or mobile communications, the nature of traffic and the relative cost factors associated with different modes of service. The total traffic due to all users was then calculated based upon the normally accepted traffic loadings of various types of subscriber.

The spectrum required to support the total traffic in each category of service was calculated using the CCIR/Canadian model used by Interim Working Group (IWG) 8/13 for estimating spectrum requirements for FPLMTS. The model was adapted as appropriate to consider i) the peak capacity in dense urban environments under busy hour conditions; ii) the frequency reuse distances applicable to non-cellular systems; and iii) the overlapping coverage of wide area systems.

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Initial calculations for the 1990 to 2000 decade, based upon the use of existing technology, clearly indicated that the required spectrum would greatly exceed that which may reasonably be allocated to mobile services. Consequently, the further calculations presented in the report assume a phasing-in of new spectrally-efficient technologies. It is shown that the rate of phase-in of new technologies will likely be fairly high. However, the timing of the introduction of the new technologies is less certain, and so calculations based upon two projections separated by five years were made. As a result, in the year 2001 total projected spectrum width requirements for a metropolitan area of 600,000, vary from 307 MHz, to approximately 408 MHz. These projections clearly show the urgent need to implement new spectrum management plans and policies which encourage the use of new technologies and the rapid phasing out of existing technologies. A notable anomaly in the demand for excessive spectrum is that of data communications. Given the use of efficient network access protocols, total spectrum requirements could be only 5.4 MHz. In most cases this spectrum is, however, additional to voice spectrum requirements rather than a substitution.

Finally the report provides a short discussion as to the frequencies which are either preferred, or necessary, to support the various categories of service. It was concluded that the existing frequency bands for mobile dispatch and cellular are well suited to these applications although some change would be possible. Aeronautical and marine applications are also well suited and, in any event, would be very difficult to change either in frequency band or technology. Proposed new services of Public Cordless, Wireless Office Products and Personal Communication should occupy higher frequency bands in the range 1 to 10 GHz although future reservation in the 60 GHz band should be made for Public Cordless and Personal Communication to permit implementation as the technology becomes available.

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The main conclusions drawn from the study are:

- Current Canadian spectrum allocations are barely able to accommodate the projected requirements in 1991. A further rapid increase in spectrum requirements is likely to occur over the subsequent five years until such time as the impact of new technologies can take effect. In the years 1996 to 2001 growth will be small and could decline if more dispatch services are forced into the use of trunking techniques.

- New services such as Public Cordless Telephony and Wireless Office Products will not be dominant factors within the next five years but will become significant over the subsequent five years unless highly efficient spectrum techniques are employed as these services are first introduced.

- Assuming adequate spectrum can be found for growth of current dispatch services over the next five years, then new services, such as Public Cordless Telephony and Wireless Office Products, could possibly be accommodated within these allocations as spectrum requirements shrink in the years after 1996.

- The spectrum requirements as summarized in Tables 5, 6 and 7 are based on the forecast growth in demand for services and the gradual phasing in of advanced spectrum efficient technologies. As a result, although the total number of subscribers increases by 13:1 over the ten year period from 1991 to 2001, the spectrum requirements grow by a more modest 2:1 in metropolitan areas and only 1.5:1 in urban areas.

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- A comparison of the spectrum requirements of the different geographic areas clearly indicates that spectrum requirements are greater in larger metropolitan areas. Extrapolation from the reference city of 600,000 to say Toronto at 2.5 million, the spectrum width requirement will increase (by the year 2001) from 307 to approximately 408 MHz.

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1.0 INTRODUCTION

The availability of mature, low cost components, such as the microprocessor and large scale integrated circuits, has had a major impact upon the cost, size and user friendliness of mobile radio communications. This has had an impact on both the radio equipments and the system infrastructures within which they operate. As a consequence, there has been a significant increase in the use of mobile radio which now encompasses many businesses and user convenience services as well as the emergency, law enforcement and essential services which have previously dominated the market. This is especially true in the case of Cellular Telephony, which has been experiencing dramatic growth since its introduction a few years ago. This growth, and that of mobile radio services in general, is expected to continue at the present rates for the foreseeable future.

The growth in the use of the different mobile radio services will continue to place increasing demands on the frequency spectrum that is allocated to these services. The planned introduction of new services, such as Public Cordless Telephony, is expected to place additional demands on this very limited resource. In order to ensure that sufficient frequency spectrum is available to satisfy present and future demands, there is a requirement to forecast the traffic densities resulting from the current and anticipated use of the various types of mobile radio services.

2.0 PURPOSE

The purpose of this study was to determine the frequency spectrum required to satisfy the expected traffic densities of various types of mobile radio services over the next ten years in metropolitan, urban and rural areas. The types of mobile radio services that were considered are:

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a) cellular telephony;

b) public cordless telephony;

c) wireless office products;

d) two-way radio dispatch;

e) aeronautical mobile;

f) maritime mobile;

g) paging; and

h) mobile data.

3.0 TERMS OF REFERENCE

This study was carried out for the Department of Communications in accordance with contract #36100-9-0428 and the methodology outlined in the ADGA letter dated January 30, 1990.

4.0 METHODOLOGY

The previous ADGA study "Market and Technology Trends in Radio Communications" showed that many of the mobile radio services specified in Section 2.0 will continue to experience rapid and sustained growth for the next 5 to 10 years. Major growth will likely derive from an increased penetration of each of the potential user groups. The continued penetration will be driven by the lower cost of operating mobile radio and the greater competitiveness attained from the more efficient operation and/or enhanced services provided by a company. Eventually each user group will saturate. This will be at a level largely determined by the total population in each group of users.

A spreadsheet was developed to assist in forecasting the growth in the number of subscribers of each type of mobile radio service over the next ten years, and to determine the spectrum bandwidth required to satisfy the traffic densities (in Erlang per square kilometre) resulting from the use of

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these services. The growth in the number of subscribers was estimated based on the growth of each mobile radio service and certain user groups, and on the estimated maximum market penetration of these services within each user group. The spectrum bandwidth requirements were determined using the formula developed by CCIR Interim Working Party (IWP) 8/13, where applicable.

Statistics Canada census data on Census Metropolitan Areas (CMAs) and Census Agglomerations (CAs) was used to develop appropriate models for typical metropolitan, urban and rural areas, and to forecast the population of each user group over the next ten years. These models and growth forecasts were used in the spreadsheet described above to determine the spectrum bandwidth required in each area and for each type of mobile radio service.

A more detailed description of the methodology outlined above can be found at Annex A.

5.0 DISCUSSION

5.1 General

The methods used in estimating the growth in the number of subscribers and in determining the spectrum bandwidth requirements relied heavily on obtaining sufficient and accurate data. During the course of the study it was found that some of the data was difficult to obtain or was not available. It was also found that vastly different results could be obtained depending on the initial conditions that were used in the various calculations. The situations where this occurred are described in more detail in the discussion which follows.

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5.2 Growth of Mobile Radio Services

Most of the information on the anticipated growth of the different mobile radio services was obtained from the previous ADGA study "Market and Technology Trends in Radio Communications". In the case of Public Cordless Telephony the growth rates for Cellular Telephony were used because of the many similarities between the two services, and the possibility that this service could experience the same type of dramatic growth as Cellular Telephony. For the Aeronautical and Maritime Mobile services conservative growth rates were used based on the continued use of these services by government, industry and certain types of consumers (ie. such as pilots and boaters). The minimum and maximum annual growth rates for each type of service are shown in Table 1.

TABLE 1
Annual Growth of Mobile Radio Services

	Minimum Growth	Maximum Growth
Cellular Telephony	20%	30%
Public Cordless Telephony	20%	30%
Wireless Office Products	20%	30%
Two-way Radio Dispatch	10%	20%
Aeronautical Mobile	5%	10%
Maritime Mobile	5%	10%
Paging	20%	25%
Mobile Data	20%	30%

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5.3 <u>Identification and Growth of User Groups</u>

The industry groups as defined by Statistics Canada's Standard Industrial Classification (SIC) Codes for 1970 were used to identify and categorize all possible users of the different mobile radio services. The various categories were combined into major user groups similar to those that are used by equipment and service suppliers. These user groups are listed in Table 2.

The DOC license data for Hamilton was used in the models for metropolitan and rural areas since the population of this city closely correlated with the average populations that were calculated for these areas. Similarly, the license data for Orillia, Ontario was used, where possible, in the urban area model because of the comparable population sizes of these two areas. This data was used to determine the present usage (ie. number of subscribers) of the Two-way Radio Dispatch, Aeronautical Mobile, Maritime Mobile and Mobile Data services. The license data for Hamilton and Orillia is shown in Table 3.

For the remaining services approximate figures were used to determine future spectrum requirements. These figures were based on an estimate of the number of subscribers that will be present in each user group in 1991 and that will result in the saturation of each group by the year 2001.

The growth in the number of subscribers/users of each type of mobile radio service over the next ten years was estimated by using information obtained on the anticipated growth of these services. The forecast in the number of subscribers/users was used to determine the traffic densities resulting from the use of the various mobile radio services by these users.

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TABLE 2
Major User Groups

SIC Codes	Major User Groups	Types of Users
N/A	Consumers	Adults(15 yrs & over)
001-099	Primary Industries	
001-021		Agriculture
041-047		Fishing and Trapping
031-039		Logging and Forestry
051-099		Mining and Oil
101-399	Manufacturing	
404-421	Construction	
501-519	Transportation	
543-579	Communication/Utilities	
602-886	Service Industries	
602-629		Wholesale Trade
701-721		Finance & Insurance
735-737		Real Estate/Ins Agent
851-869		Business Services
801-809		Education
821-828		Health & Social Svcs
881-886		Accommodation & Food
902-951	Government Services	

Note: <u>1970</u> Standard Industrial Classification (SIC) Codes

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TABLE 3
Mobile Radio Licenses

Major User Groups	Land Mobile		Aeronautic	Maritime
	Hamilton	Orillia	Hamilton	Hamilton
Consumers (Adults)	0	0	5	2503
Primary Industries	162	40	7	0
Manufacturing	3245	151	11	0
Construction	1642	65	20	0
Transportation	2035	228	354	196
Communications & Utilities	765	134	1	0
Service Industries	1610	286	55	0
Government Services	8431	490	9	42

(Data as of February 1990)

Notes

1) # Channels - Each license is equivalent to one simplex channel that has been authorized for use.

2) Land Mobile - The license information was used for the Two-way Radio Dispatch service, and at 10% for the Mobile Data service. In both cases the figures for Hamilton were used for metropolitan and rural areas. The figures for Orillia were used for urban areas.

3) Aeronautical - The license information was used for the Aeronautical Mobile service. The figures for Hamilton were used for metropolitan and rural areas, and at 6% for urban areas (based on the population ratio between urban and metropolitan areas).

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4) <u>Maritime</u> - The license information was used for the Maritime Mobile service. The figures for Hamilton were used for metropolitan and rural areas, and at 6% for urban areas (based on the population ratio between urban and metropolitan areas).

5.4 <u>Cross Impact of Different Services</u>

In order to examine the cross impact between services, it is necessary to define the basic nature of the mobile communications services. These are:

a) Two-way Radio Dispatch, usually typified by a highly centralized communication service within a localized area in which the predominant traffic is between one or more dispatchers and a large group of users. Calls are frequently 20 seconds or less;

b) Mobile Telephony, an extension of the public switched network in which the traffic is highly distributed. Calling times are generally in excess of 1 minute;

c) Mobile Data, usually overlaid onto mobile dispatch systems; and

d) Paging, a one way calling system either from a predesignated telephone location or, with added messaging capability, from any location.

5.4.1 <u>Two-way Radio Dispatch - Mobile Telephony</u>

Historically, dispatch radio equipments have always been cheaper than the equivalent radio telephone. Hence as the service quality, coverage and cost of radio telephone services improve, migration to dispatch from radio telephony is considered to be highly unlikely.

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Conversely, many people have postulated that there will be a migration from dispatch to radio telephony. The degree of migration will, however, be influenced by factors such as:

a)   amortized cost of fixed equipment and maintenance versus service charges for cellular radio;

b)   call set-up time versus message length and traffic loading;

c)   spectrum availability; and

d)   traffic routing.

Based upon the typical traffic loading of .005 Erlangs per mobile and cellular service charges of $ 0.50 /minute (local calls), the service charge for cellular telephone is $360.00 per subscriber per year. Assuming $5,000.00 for base station, antenna and a small tower with a 10 year life the amortized cost, including interest charges, is of the order of $1,200.00 per year. Therefore, any dispatch radio system with more than four subscribers or higher traffic loadings than .005 Erlangs per subscriber is potentially more economical than cellular telephone. It is therefore unlikely that many dispatch radio users will migrate for reasons of cost.

Call set-up times for radio telephony involve a number of sequential activities. Neglecting the delay time due to called party response, delays are typically of the order of five seconds. In many dispatch systems, (eg, taxis) the average message length is between 12 and 20 seconds. Thus the effective capacity of a radio dispatcher is reduced by 25 to nearly 50% when compared with the voice calling or selective calling used in dispatch systems. This would mitigate against migration

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on large systems but would not be a significant factor for small systems.

The availability of spectrum, approximately 4560 x 25KHz channels, is a serious limitation to potential users of radio systems within a metropolitan area in which frequency reuse is impractical. Except for cellular type systems, the total number of allocated channel slots is greatly reduced. Assuming 50% of channels are assigned in adjacent suburban and rural areas and a mix of simplex and duplex systems, then a total of only 1000 channels may be available within a metropolitan area. With fully loaded, (50 subscribers per channel) or trunked channels (150 subscribers per channel) the 1000 channels could support the expected demand through to the year 1996. In reality many channels will be more lightly loaded at no more than 10 to 20 mobiles per channel in which case the existing subscriber base, approximately 18000 in the average metropolitan area, will effectively consume all channels. New users of radio communications will therefore tend to be forced towards the use of radio telephone type systems based upon cellular frequency reuse.

Radio users requiring a single point of contact can satisfy their communication requirements through the use of dispatch radio. Many small companies, however, operate with only part time office personnel. The sales and operational functions are combined in a few staff who are generally out of the office. These companies can benefit greatly through the use of radio telephony to provide instant contact with potential customers. Those companies in this category currently using dispatch radio could be expected to migrate to radio telephony.

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5.4.2 <u>Paging - Mobile Telephony</u>

Paging currently offers the lowest cost and physically smallest, (a wrist watch pager has just been announced) means of contacting personnel away from the office. To be effective, however, the called party must be able to respond through physically reporting or through access to a telephone.

As radio telephone units become smaller and more economical, the convenience of instant two way communication to the called party is expected to be sufficiently attractive that some users of paging will migrate to public cordless and personal communication forms of radio telephone. Such migration is unlikely to occur until a wide-spread infrastructure is in place. Therefore, the effects of migration are unlikely to be seen much before the year 2001.

5.4.3 <u>Voice - Data</u>

Many advocates of mobile data services have emphasized the reduced air time required and the potential spectrum savings. These concerns are seldom of interest to the user unless it results in a reduction in cost. Given the increased cost of the mobile equipment, any savings are generally derived through improved efficiency in the use of dispatch personnel. This is most evident in systems with a large number of mobile subscribers and a high volume of routine or preformatted type messages. The most notable examples are taxi and police operations. More generally it has been found that mobile data is complementary to, rather than a replacement for, voice communication. In many cases this occurs since mixed voice and data over single multiple subscriber radio channels creates access control difficulties which are frequently resolved by providing separate channels for

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voice and data. Therefore, if only one channel was previously required for a group of mobile subscribers, then the addition of data may in fact increase the total channel requirements, and savings in channels may only occur for systems previously requiring 3 or more voice channels.

5.5 Market Penetration of Mobile Radio Services

In order to ensure that the number of subscribers/users of a particular mobile radio service did not exceed the saturation level for each user group, it was necessary to estimate the maximum market penetration of that service within each group. The market penetration of each type of service was estimated based on information obtained from equipment and service suppliers, and from the results of a survey conducted with 9 different industry associations. These figures are listed in Table 4 and are explained in the following paragraphs.

5.5.1 Market Penetration of Radio Telephony

The market penetrations of Cellular Telephony, Public Cordless Telephony and ultimately Personal Communications are highly interrelated since they all are variants of the same basic service.

The predominant variant today is cellular telephony, a service currently available in both mobile and portable versions. The low cost of equipment and the dramatic service improvements provided by today's cellular telephone have created a very high growth rate of 30% in a previously virtually non-existent service. This growth has primarily occurred in business applications involving either sales and services, and operations too small to justify the cost of dedicated systems.

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At first sight the rapid reduction in price of mobile and portable cellular radios could be expected to result in a continued rapid penetration of potential market. High service charges are, however, expected by both CANTELL and BELL CELLULAR to remain in effect for the foreseeable future. It is claimed that this is necessary to finance continued expansion of the network infrastructure in both coverage and capacity. These high service charges will tend to mitigate against the use of cellular radio by many potential users. The nature of operations of some businesses will also mitigate against the use of radio telephony versus dispatch and/or paging categories of mobile service. These include those operations requiring a high volume of communications between users in a well defined geographic area, as well as those users requiring multiple short communication transactions, eg, Taxis.

The above factors, together with estimates of the number of employees within a business group for whom mobile communication would be necessary, were used to estimate the ultimate penetration of cellular telephony into business operations. These ultimate penetrations are assumed to occur by the year 2001. This is consistent with a maximum penetration of 20% due to an expansion of 30% annually from the current penetration levels of around 1.5%.

Since cellular systems involving mobile equipments tend to use higher powers and larger cells than public cordless telephone systems, they are less spectrally efficient. The study has therefore assumed the current growth rate of 30% annually would not be exceeded for the much larger consumer group class of users. The total market penetration by the year 2001 would therefore also be 20%.

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Public cordless telephones are forecast to cost less than 25% of the cost of cellular radios. Recent filings by the MILCOM Group in USA suggest a price of $70.00 US. At this price cost-of-ownership is insignificant to most of the Canadian population. We have therefore assumed a total penetration of 50%.

The service cost pricing structure is, however, likely to have a large impact upon the utilization of public cordless telephones. If the pricing structure mirrors existing telephone services then a high utilization can be expected. If, however, a service charge is made for each local call then the existing wireline telephone will continue to be utilized even where a subscriber has access to a public cordless radio. This will significantly affect the spectrum requirements and so must be considered in future pricing policies.

5.5.2   Market Penetration of Wireless Office Products

It was difficult to estimate the maximum market penetration of Wireless Office Products since these types of products are not yet commercially and widely available. In many applications wired office products provide the required services in a highly cost effective manner. Only where construction and frequent recabling costs are high are Wireless Office Products likely to replace wired products. Once suitable products are available it is believed that the major users of this technology will be the Service Industries and the Government. One survey respondent felt that the use of these types of products in a competitive business environment would depend on the degree of reliability and communications security that these products could provide.

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5.5.3   <u>Market Penetration of Two-way Radio Dispatch</u>

Two-way radio dispatch will continue to remain attractive primarily with the Transportation and Utility Industries, and the Government. This type of service is expected to reach a maximum market penetration of 100% in those user groups that rely on this service to remain competitive, such as the Trucking, Courier and Taxi Industries.

5.5.4   <u>Market Penetration of Aeronautical and Maritime</u>

The total market of Aeronautical and Maritime Mobile services is expected to be relatively small due to the specialized applications of these services and the limited number of potential users within most groups. It is believed that the only major users of these two services will continue to be the Transportation Industry, and to some extent certain types of Consumers.

5.5.5   <u>Market Penetration of Paging</u>

The continued growth of Paging services is expected to lead to a market penetration of between 5% and 10% for this type of service within certain user groups, such as the Construction and Service Industries. In spite of the relatively low prices for paging devices, it is believed that this type of service will remain a business tool since one-way communications do not satisfy the consumers' requirement for basic communications.

5.5.6   <u>Market Penetration of Mobile Data</u>

It is believed that the use of Mobile Data will continue to be limited to the Transportation Industry, which includes the Taxi and Urban Transit Industries, and the larger Police forces. There is a possibility that some businesses, such as Computer Service and Repair Companies, will make use of this technology to provide

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their field technical support representatives with the capability of performing on-site maintenance of faulty equipment. To most users this service offers few advantages over voice communications and is expensive as compared to other types of mobile radio services. Except for the rare circumstance when spectrum is unavailable, users do not appear prepared to pay a premium for the spectrum efficiency but only for the operational efficiency of data services.

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TABLE 4
Maximum Market Penetration of Mobile Radio Services

Major User Groups	Mobile Radio Services							
	Cell	Pub	Wire	Disp	Aero	Mari	Page	Data
Consumers (Adults)	20%	50%	X	X	1%	5%	5%	X
Primary Industries	5%	5%	X	10%	1%	1%	X	X
Manufacturing	5%	5%	5%	25%	1%	X	5%	X
Construction	5%	20%	X	25%	1%	X	10%	X
Transportation	20%	X	X	50%	10%	5%	X	25%
Communications & Utilities	5%	X	5%	50%	1%	X	5%	X
Service Industries	20%	5%	10%	10%	1%	X	10%	5%
Government Services	5%	5%	10%	50%	1%	1%	5%	5%

Legend

Cell - Cellular Telephony

Pub - Public Cordless Telephony

Wire - Wireless Office Products

Disp - Two-way Radio Dispatch

Aero - Aeronautical Mobile

Mari - Maritime Mobile

Page - Paging

Data - Mobile Data

X - Indicates negligible market penetration

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5.6 Technology Transition

Until the introduction of cellular telephony most changes in mobile radio equipments and services have been of a evolutionary nature. They have had modest cost impact and for the most part have been backward interoperable with existing systems. In addition, radio spectrum availability has been sufficient that new services and systems could be introduced in parallel with existing services. As a result, the transition from one technology to another was very gradual and typically exceeded the economic life of equipment.

Note: For mobile systems the economic life is normally considered to be 7 to 10 years, whereas for fixed equipment up to 15 years can be anticipated.

The changes identified in ADGA's study "Market and Technology Trends in Radio Communications" are of a more revolutionary nature. The systems are highly, if not completely digital, they compete for spectrum with existing assignments, they are not backward interoperable and furthermore they are forecast to be much more economical. ADGA believes that the combination of factors will lead to a much more rapid phasing in of the new technologies than hitherto has been experienced. In practice the duration of the transition period is more likely to be controlled by the production capability rather than by any other factors. Even in the existing cellular infrastructures the transition from today's analogue to tomorrow's digital can be accomplished rapidly and economically through the exchange of only the base station transmitter and receiver. The antenna system including towers and multicouplers, the baseband equipment, switching system and the intersite communications links would not require to be changed by the technology transition in the cellular radio.

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Therefore, we assume that service providers will rapidly attach a digital service channel or channels within the existing analogue system infrastructure.

For these reasons we have considered that once one of the major new technologies is introduced then the majority of new sales will be of the new technology. There will be stock of existing equipments which will be unloaded at bargain prices and some owners of large private systems will continue to purchase existing technology for purposes of growth or replacement of damaged units. However, within the economic life of mobile equipment (typically seven years), we anticipate that virtually all of the existing technology will be phased out.

The biggest uncertainty is likely to be the introductory date. This must take account of technical factors, including an adequate period for proving of the technology at the system level, regulatory factors, which in the case of the first generation cellular took over ten years to resolve, and economic factors.

The most optimistic dates for introduction of services are derived from promoters of the various systems. These dates have been used to calculate the spectrum requirements as shown in Tables 5.10.1-1 and 5.10.4-1. A more conservative introduction date is based upon a five year slippage. The calculated spectrum requirements based upon the five year slippage are shown in Tables 5.10.1-2 and 5.10.4-2.

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5.7   Frequency Reuse Criteria

5.7.1   Dispatch Systems

Dispatch-orientated mobile radio systems are predominant in the VHF and low UHF frequency bands. Cost considerations generally require maximum coverage attainable from a few desirable base station sites located at high points within the terrain prevailing in the required coverage area. Terrain variations and the consequential uncertainty due to path losses requires a system margin to be included in the radiated power of transmitters. This margin ranges from, typically 10 dB for 90% coverage probability, to 30 dB for 99.9% coverage probability. The excess power results in extended coverage outside of the desired coverage area and creates interference to co-channel users in adjacent areas.

Within dispatch systems the currently available modulation techniques provide little protection to co-channel interference and therefore the co-channel reuse area must be defined based upon an interference probability. This is usually taken as 10% but in high priority safety-related operations the interference probability can be as low as 1%.

For the general case of 90% coverage probability and 10% interference probability the effective path loss difference is 20 dB. Hence over a "plane earth", Egli's formula can be used to show a ratio of 1:3 in coverage versus interference range. For dispatch systems operating at up to 40 kilometres the frequency reuse distance is therefore 120 kilometres. Although the ranges indicate a 1:9 ratio of coverage areas, this can be translated into a frequency reuse factor, or cell cluster size, of 7 by considering a cellular type

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arrangement. The coverage range of the centre cell is 40 kilometres. The first ring of cells provides an 80 kilometre boundary and the next ring allows frequency reuse.

5.7.2   <u>Trunked Systems</u>

Trunked systems provide service to many more users per channel and can in many cases be operated from multiple sites to provide extensive coverage while requiring smaller path loss margins. Ranges therefore tend to be more typical of "line-of-sight" rather than "plane earth" path loss conditions. Under line-of-sight conditions a 20 dB power difference translates into a 1:10 range difference. Real conditions more generally result in a coverage versus interference range difference of 1:5 which would normally require a frequency reuse factor of 21. To reduce the frequency reuse factor to 7 or less a more rigorous modulation mode is employed which requires a smaller co-channel protection margin. Analogue cellular systems typically use 10 kHz deviation compared to 5 kHz for dispatch systems and future digital cellular may employ coding techniques to increase the protection margin.

5.7.3   <u>Aeronautical Systems</u>

Aircraft operations from near ground level to many thousands of feet present considerable difficulties to efficient frequency management if reliable interference-free communications are to be provided. To simplify the frequency management problem it is generally considered appropriate to subdivide the traffic into three groupings with typical ranges of 25, 60 and 150 miles. Each range uses different frequencies.

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At the lower altitudes safety requires a 99% to 1% or better signal to interference probability. This requires a 40 dB signal margin which over "plane earth" signal paths requires a 10 to 1 range difference for frequency reuse. This implies a cell cluster size of 100.

At higher altitudes a higher interference level could be tolerated and the predominantly line-of-sight propagation paths allow smaller signal margins. Hence, for the 60 and 150 mile ranges cell cluster sizes of 25 and 7 respectively are probably adequate.

Assuming an equal division of traffic between the different service altitudes, and as a result of service ranges, the average cell cluster size is 44.

5.7.4   <u>Maritime Systems</u>

The operation of Maritime Mobile is generally performed through a manned coastal station using a scheme of "calling" and "traffic" channels. There are normally five traffic channels for every one calling channel. This system provides a form, albeit inefficient, of trunking. It is therefore considered appropriate to use a weighted Erlang formula for calculating the number of channels required to service a given volume of traffic at a predefined blocking rate.

This type of service typically is only 50% efficient and requires a minimum of one extra channel for calling purposes. A Blocking Probability of 10% is higher than desirable, but is probably more realistic than 2%.

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Although the Maritime Mobile service offers a form of trunking, it is more appropriate to use the frequency reuse criteria for Dispatch Systems due to the relatively low efficiency of this service. In this case a cell cluster size of 4 is used rather than 7 due to the semi-circular coverage area provided by the coastal stations.

5.8   Subscriber Density Factor

5.8.1   Cellular Systems

Peak requirements tend to be generated in the city core under peak traffic (vehicular) conditions. At these times, city streets are effectively saturated with cars moving at 20 km/hour or less. The average vehicle spacing is around 15 metres and assuming four-lane highways in a grid pattern and roads spaced 200 metres apart, there would be 2666 vehicles/square kilometre.

These vehicles would be populated with cellular phones and dispatch radios in roughly the same proportion as predicted for an average population density of 217 people/square kilometre for metropolitan areas. The peak factor, or subscriber density factor, is therefore 12.3:1.

Note that in urban areas the peak traffic will exist over a much smaller area than the average cell size. This corresponds to a vehicle spacing of about 30 metres and two-lane highways for a total of 666 vehicles/square kilometre. In this case a subscriber density factor of between 3 and 5 is appropriate. For rural areas where the subscriber population is spread out over a very large area a density factor of one is more suitable.

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5.8.2   Wireless Office Products

Wireless Office Products are likely to be implemented
within individual buildings. It is therefore appropriate
to examine the possible population within a typical large
downtown office block.

Office accommodation is normally recommended at between
10 and 12 square metres per person. Thus for a 50 storey
building at 50% occupancy with a 50 metre square base the
total population is 12,500. This is equivalent to
approximately 2 million people/square kilometre. Based
on a population density of 217 people/square kilometre
in a metropolitan area this relates to a subscriber
density factor of about 10,000.

For an urban area it is appropriate to use the same
figures but for a 5 storey building at 25% occupancy.
In this case the subscriber density factor is
approximately 500. For rural areas where the subscriber
population is spread out over a very large area a density
factor of one is sufficient.

5.8.3   Dispatch Systems

In respect to metropolitan areas the coverage area of a
single station is smaller than that of the subscriber
base. It is therefore appropriate to consider the
subscriber density within the coverage area of a single
station.

In general the dispatch type service, which includes the
Mobile Data service, is well distributed within a
metropolitan area. This also applies to the Paging
service which enjoys a very large subscriber base.
However, some allowance must be made for peak densities

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which may apply to certain services, for example taxis which tend to concentrate in the core area.

It has not been possible to quantify the peak loading with any great certainty, however, it is suggested that a subscriber density factor of between 2 and 5 be considered as the likely extremes. The higher figure is appropriate for metropolitan areas where a greater concentration of subscribers could be expected in the core area as compared to urban areas. The figure of 2 is therefore more suitable for urban areas. In the case of rural areas where the subscriber population is spread out over a very large area a density factor of one is sufficient.

5.8.4   <u>Aeronautical Systems</u>

For Aeronautical Mobile the average subscriber density does not apply over the full service area due to the different altitudes at which aircraft operate and the various communication distances involved. However, because of the very large service area it is probably appropriate to take into account the total number of subscribers due to two or more metropolitan areas plus ten or more urban areas.

For metropolitan areas this corresponds to a subscriber density factor of .4 based on the ratio of the total metropolitan area to the cell size. A factor of .02 is obtained for an urban area using the same method. For rural areas where the subscriber population is spread out over a very large area a density factor of one is considered to be more appropriate.

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5.8.5   Maritime Systems

As described in Section 5.7.4, Maritime Mobile operators make use of coastal stations to establish communications between ships. The traffic presented to the coastal stations is dependent upon the total number of subscribers in the coverage area. Since the coverage area is greater than the collective area of subscribers, the peak traffic should not be based upon an extrapolation of the subscriber density over the service area. Rather, it should be based on the same method as that used for the Aeronautical Mobile service.

For metropolitan and urban areas the subscriber density factors are .5 and .05 respectively. In the case of rural areas where the subscriber population is spread out over a very large area a density factor of one is considered to be more appropriate.

5.9   Summary of Assumptions

The following general assumptions were made in estimating the growth in the number of subscribers and in determining the spectrum bandwidth requirements:

a)   The anticipated growth of a particular mobile radio service is the same for all user groups.

b)   The anticipated growth of a particular mobile radio service is the same in each type of area (metropolitan, urban and rural) where this service is available. Realistically, the anticipated growth is not likely to be the same for all user groups and in each type of area, however, since this type of detailed information was not readily available from the previous ADGA study or from discussions with equipment and service suppliers, it was

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necessary to use general growth figures in determining the spectrum bandwidth requirements.

c)   The forecast growth of a particular user group is the same in metropolitan, urban and rural areas.

d)   The estimated maximum market penetration of a particular mobile radio service within a user group is the same for that group in metropolitan, urban and rural areas where this service is available.

e)   The transition period from one technology to another for equipment that is used in a particular mobile radio service is approximately 10 years. A particular characteristic of communication systems is the need to simultaneously provide services based upon old and new standards as systems transition from spectrally inefficient to spectrally efficient technologies. The transition period should be based upon the economic life of the large inventory of equipment in service, typically 7 to 10 years.

During this time total spectrum requirements must be based upon a mix of various technologies. The services expected to undergo the most radical change over the next ten years are the Cellular and Two-way Radio Dispatch communication systems. Distributions between technologies for these services are shown in Sections 5.10.1 and 5.10.4.

Additional assumptions were made, where required, for each type of mobile radio service. These assumptions are stated in the relevant parts of Section 5.10.

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5.10 Calculation of Spectrum Bandwidth Requirements

The spectrum bandwidth requirements for each type of mobile radio service were calculated using the CCIR formula described in Annex A. The values that were assigned to each variable in this formula are specified in the following sections, along with an explanation of why these values were used. Printouts of the spreadsheets that were used to calculate the spectrum requirements are attached as Annex B.

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5.10.1 Cellular Telephony

The values that were assigned to each variable in the CCIR formula are based on those specified by IWP 8/13 and are as follows:

5.10.1-1 Cellular Telephony – Early Technology Transition

Generation:	1st	2nd	3rd -->	
Variables	1986	1991	1996	2001

1.Cell Diameter- M
  (metres)   - U
            - R
	5,000
	5,000
	8,000
		3,000
		3,000
		8,000
			850
			850
			8,000
				850
				850
				8,000

2.Cell Type	Hexagonal	Hexagonal	Hexagonal	Hexagonal
3.Traffic load/ user (Erlang)	.02	.02	.02	.02

4.Subscriber - M
  Density   - U
  Factor   - R
	12.3
	3
	1
		12.3
		3
		1
			12.3
			3
			1
				12.3
				3
				1

5.Blocking Probability	2%	2%	2%	2%

6.Effective Single
  Channel Band-
  width (kHz)
	30	15	5	5

7.Effective Cell Cluster Size	21	9	24	24
8.#Frequencies/ Channel	2	2	2	2
Spectrum - M Bandwidth - U (MHz) - R	12.6 6.3 1.3	25.6 9.6 2.8	28.5 11.2 3.5	7.5 3.1 1.3

M - Metropolitan
U - Urban
R - Rural

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Generation: 1st   2nd   3rd -->

Variables	1986	1991	1996	2001
1. Cell Diameter- M (metres) - U - R	5,000 5,000 8,000	3,000 3,000 8,000	850 850 8,000	850 850 8,000
2. Cell Type	Hexagonal	Hexagonal	Hexagonal	Hexagonal
3. Traffic load/ user (Erlang)	.02	.02	.02	.02
4. Subscriber - M Density - U Factor - R	12.3 3 1	12.3 3 1	12.3 3 1	12.3 3 1
5. Blocking Probability	2%	2%	2%	2%
6. Effective Single Channel Band- width (kHz)	30	15	5	5
7. Effective Cell Cluster Size	21	9	24	24
8. #Frequencies/ Channel	2	2	2	2
Spectrum - M Bandwidth - U (MHz) - R	12.6 6.3 1.3	30.2 11.3 2.5	71.6 22.8 3.1	8.0 25.5 3.8

M – Metropolitan
U – Urban
R – Rural

Notes

1) <u>Cell Diameter</u> – The cell diameters used for 1986 and for rural areas are based on typical values. The anticipated reduction in cell size to 1.5 km radius was used as the basis for the cell diameter for 1991 in metropolitan and urban areas. The values for 1996 and 2001 are the same as those specified by the CCIR.

2) <u>Subscriber Density Factor</u> - The Subscriber Density Factors are based on the criteria outlined in Section 5.8.

3) <u>Channel Bandwidth</u> - Effective single channel bandwidth is based on an optimistic projection of future technology.

4) <u>#Frequencies/Channel</u> - Value of two used to represent duplex voice channel.

5) <u>Technology Transition</u> - The distribution of subscribers between the three technology generations is based upon 1991 as the first fielding of second generation and 1996 as the first fielding of third generation systems. Using the 30% growth rate the resultant distribution is:

	1986	1991	1996	2001
1st Generation	1	0.7	0.18	0
2nd Generation	0	0.3	0.52	0.14
3rd Generation	0	0	0.30	0.86

6) <u>Delayed Technology Transition</u> - Based upon a five year delay in the initial technology transition the resultant distributions is:

	1986	1991	1996	2001
1st Generation	1	1	0.7	0.18
2nd Generation	0	0	0.3	0.52
3rd Generation	0	0	0	0.30

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5.10.2   <u>Public Cordless Telephony</u>

The values that were assigned to each variable in the CCIR formula for both Personal Outdoor and Personal Indoor communications are the same as those specified by IWP 8/13 and are as follows:

Personal Outdoor

Generation: 1st -->

Variables	1986	1991	1996	2001
1. Cell Diameter- M (metres) - U - R	↑	↑	200 200 N/A	200 200 N/A
2. Cell Type			Square	Square
3. Traffic load/ user (Erlang)			.02	.02
4. Subscriber - M Density - U Factor - R			100 50 N/A	100 50 N/A
5. Blocking Probability	── N/A ──	── N/A ──	1%	1%
6. Effective Single Channel Band- width (kHz)			25	25
7. Effective Cell Cluster Size			16	16
8. #Frequencies/ Channel			2	2
Spectrum - M Bandwidth - U (MHz) - R	↓	↓	4 3 N/A	8 6 N/A

M - Metropolitan
U - Urban
R - Rural

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Notes

1) Cell Diameter - Values for metropolitan and urban areas the same as those specified by the CCIR. It is believed that Personal Outdoor communications will not be economically suitable for use in rural areas due to the extremely low population densities in these areas.

2) Subscriber Density Factor - The subscriber density factors are based on the criteria outlined in Section 5.8.

3) #Frequencies/Channel - Value of two used to represent duplex voice channel.

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Personal Indoor

Generation: 1st -->

Variables	1986	1991	1996	2001
1. Cell Diameter - M (metres) - U - R	↑	↑	30 30 30	30 30 30
2. Cell Type			Square	Square
3. Traffic load/ user (Erlang)			.05	.05
4. Subscriber - M Density - U Factor - R	N/A	N/A	10,000 500 1	10,000 500 1
5. Blocking Probability			.5%	.5%
6. Effective Single Channel Band- width (kHz)			25	25
7. Effective Cell Cluster Size			21	21
8. #Frequencies/ Channel			2	2
Spectrum - M Bandwidth - U (MHz) - R	↓	↓	14.7 3.2 <1	36.8 5.3 <1

M - Metropolitan
U - Urban
R - Rural

Notes

1) <u>Cell Diameter</u> - Cell diameter for the UK "Telepoint" System used for metropolitan, urban and rural areas.

2) <u>Subscriber Density Factor</u> - The subscriber density factors are based on the criteria outlined in Section 5.8.

3) <u>#Frequencies/Channel</u> - Value of two used to represent duplex voice channel.

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5.10.3 · <u>Wireless Office Products</u>

The values that were assigned to each variable in the CCIR formula are based on those specified by IWP 8/13 for Personal Indoor communications and are as follows:

Wireless Office Products

Generation: 1st -->

Variables	1986	1991	1996	2001

1.Cell Diameter- M
  (metres)   - U
           - R
	↑	↑	30
			30
			30
				30
				30
				30

2.Cell Type			Square	Square
3.Traffic load/ user (Erlang)			.05	.05

4.Subscriber - M
  Density   - U
  Factor   - R
			10,000
			500
			1
				10,000
				500
				1

5.Blocking Probability	N/A	N/A	.5%	.5%

6.Effective Single
  Channel Band-
  width (kHz)
			25	25

7.Effective Cell Cluster Size			21	21
8.#Frequencies/ Channel			2	2
Spectrum - M Bandwidth - U (MHz) - R	↓	↓	4 2 1	8 3 1

M - Metropolitan
U - Urban
R - Rural

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1) <u>Traffic Load/User</u> - The traffic was assumed to be the same as that for voice traffic for Personal Indoor communications.

2) <u>Subscriber Density Factor</u> - The subscriber density factors are based on the criteria outlined in Section 5.8.

3) <u>Blocking Probability</u> - The blocking probability was assumed to be the same as that for Personal Indoor voice communications.

4) <u>#Frequencies/Channel</u> - Value of two used to represent duplex voice channel.

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5.10.4   Two-way Radio Dispatch

The values that were assigned to each variable in the modified CCIR formula are based on typical values for this type of service (as described below) and are as follows:

5.10.4-1 Two-way Radio Dispatch - Early Technology Transition

Variables	1986	1991	1996	2001

1.Cell Diameter- M
  (metres)   - U
            - R
	25,000
	25,000
	40,000
		25,000
		25,000
		40,000
			25,000
			25,000
			40,000
				25,000
				25,000
				40,000

2.Cell Type	Circular	Circular	Circular	Circular
3.Traffic load/ user (Erlang)	.005	.005	.005	.005

4.Subscriber - M
  Density   - U
  Factor   - R
	5
	2
	1
		5
		2
		1
			5
			2
			1
				5
				2
				1

5.Max Traffic - N Capacity/cell - T	.25 .75	.25 .75	.25 .75	.25 .75

6.Effective Single
  Channel Band-
  width (kHz)
	25	25	25
			12.5
				25
				12.5

7.Effective Cell Cluster Size	7	7	7	7
8.#Frequencies/ Channel	2	2	2	2
Spectrum - M Bandwidth(MHz) - U Non-trunked - R	Not Calculated	104.9 56.0 0.8	121.9 60.0 0.9	123.7 55.1 0.9
Spectrum - M Bandwidth(MHz) - U Trunked - R	Not Calculated	1.8 1.0 0	25.4 12.5 0.2	55.0 24.5 0.4

M - Metropolitan   N - Non-trunked Systems
U - Urban   T - Trunked Systems
R - Rural

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5.10.4-2 Two-way Radio Dispatch –
5 Year Delayed Technology Transition

Variables	1986	1991	1996	2001

1.Cell Diameter- M
  (metres)   - U
          - R
	25,000
	25,000
	40,000
		25,000
		25,000
		40,000
			25,000
			25,000
			40,000
				25,000
				25,000
				40,000

2.Cell Type	Circular	Circular	Circular	Circular
3.Traffic load/ user (Erlang)	.005	.005	.005	.005

4.Subscriber   - M
  Density   - U
  Factor   - R
	5
	2
	1
		5
		2
		1
			5
			2
			1
				5
				2
				1

5.Max Traffic - N Capacity/cell - T	.25 .75	.25 .75	.25 .75	.25 .75

6.Effective Single
  Channel Band-
  width (kHz)
	25	25	25
			12.5
				25
				12.5

7.Effective Cell Cluster Size	7	7	7	7
8.#Frequencies/ Channel	2	2	2	2
Spectrum - M Bandwidth(MHz) - U Non-trunked - R	Not Calculated	110.4 59.0 0.9	241.3 118.6 1.7	197.9 81.2 1.3
Spectrum - M Bandwidth(MHz) - U Trunked - R	Not Calculated	0 0 0	4.2 2.1 0	41.2 18.4 0.3

M – Metropolitan   N – Non-trunked Systems
U – Urban   T – Trunked Systems
R – Rural

1) <u>Cell Diameter</u> - Cell diameter of 25 km is based on radio coverage provided by a central repeater/base station in a typical metropolitan or urban area. Diameter of 40 km is based on the increased range that can be expected for communications in a rural area.

2) <u>Traffic Load/User</u> - Traffic is based on an average message length of 16 seconds and an average message frequency of 1 message/busy hour.

3) <u>Subscriber Density Factor</u> - The subscriber density factors are based on the criteria outlined in Section 5.8.

4) <u>Maximum Traffic Capacity/Cell</u> - The maximum traffic handling capacity per cell (in Erlang) is based upon the FCC recommended loading of 50 mobile subscribers per single channel for non-trunked systems and 150 subscribers for trunked systems. The maximum capacities are therefore 0.25 and 0.75 Erlangs respectively.

5) <u>Channel Bandwidth</u> - The effective single channel bandwidth of two-way radio equipment could be reduced in the foreseeable future by channel splitting.

6) <u>Effective Cell Cluster Size</u> - Cell cluster size of 7 is based on the frequency reuse criteria outlined in Section 5.7.

7) <u>#Frequencies/Channel</u> - Value of two used to represent two frequency simplex channels used via repeaters.

8) <u>Technology Transition</u> - The distribution of subscribers between trunked and non-trunked systems is based upon a current distribution of 5% and 95% respectively with future subscribers being equally divided between the two systems. The effective distributions for the two systems are shown below:

	1991	1996	2001
Non-trunked (25 kHz spacing)	0.95	0.26	0
Non-trunked (12.5 kHz space)	0	0.44	0.6
Trunked (25 kHz spacing)	0.05	0.30	0.4

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5.10.5 Aeronautical Mobile

The values that were assigned to each variable in the modified CCIR formula are based on typical values for this type of service (as described below) and are as follows:

Aeronautical Mobile

Variables	1986	1991	1996	2001
1.Cell Diameter- M (metres) - U - R	100,000 100,000 240,000	100,000 100,000 240,000	100,000 100,000 240,000	100,000 100,000 240,000
2.Cell Type	Circular	Circular	Circular	Circular
3.Traffic load/ user (Erlang)	.0025	.0025	.0025	.0025
4.Subscriber - M Density - U Factor - R	.4 .02 1	.4 .02 1	.4 .02 1	.4 .02 1
5.Maximum Traffic Capacity/cell	.1	.1	.1	.1
6.Effective Single Channel Band- width (kHz)	25	25	25	25
7.Effective Cell Cluster Size	44	44	44	44
8.#Frequencies/ Channel	1	1	1	1
Spectrum - M Bandwidth - U (MHz) - R	Not Calculated	14 1 3	23 1 5	37 2 8

M - Metropolitan
U - Urban
R - Rural

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Notes

1) <u>Cell Diameter</u> - Cell diameter of 100 km for metropolitan and urban areas is based on the maximum range at which communications take place between a control tower and an aircraft that is preparing to land. Diameter of 240 km is based on the maximum range at which communications take place between a control tower and an aircraft that is on- route.

2) <u>Traffic Load/User</u> - Traffic is assumed to be half of that for two-way radio dispatch. This corresponds to an average message length of 16 seconds and an average message frequency of 0.5 messages/busy hour.

3) <u>Subscriber Density Factor</u> - The subscriber density factors are based on the criteria outlined in Section 5.8.

4) <u>Maximum Traffic Capacity/Cell</u> - The maximum traffic handling capacity per cell (in Erlang) is based on a Blocking Probability of 10%.

5) <u>Channel Bandwidth</u> - The effective single channel bandwidth of aeronautical radio equipment is not expected to be reduced in the foreseeable future due to international interoperability requirements.

6) <u>Effective Cell Cluster Size</u> - Cell cluster size of 44 is based on the frequency reuse criteria outlined in Section 5.7.

7) <u>#Frequencies/Channel</u> - Value of one used to represent simplex voice channel.

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5.10.6 Maritime Mobile

The values that were assigned to each variable in the modified CCIR formula are based on typical values for this type of service (as described below) and are as follows:

Maritime Mobile

Variables	1986	1991	1996	2001

1.Cell Diameter- M
  (metres)   - U
            - R
	75,000
	75,000
	75,000
		75,000
		75,000
		75,000
			75,000
			75,000
			75,000
				75,000
				75,000
				75,000

2.Cell Type	Circular	Circular	Circular	Circular
3.Traffic load/ user (Erlang)	.0025	.0025	.0025	.0025

4.Subscriber   - M
  Density   - U
  Factor   - R
	.5
	.05
	1
		.5
		.05
		1
			.5
			.05
			1
				.5
				.05
				1

5.Maximum Traffic Capacity/cell	.1	.1	.1	.1

6.Effective Single
  Channel Band-
  width (kHz)
	25	25	25	25

7.Effective Cell Cluster Size	4	4	4	4
8.#Frequencies/ Channel	1.2	1.2	1.2	1.2
Spectrum - M Bandwidth - U (MHz) - R	Not Calculated	6.5 0.7 0.2	10.5 1.1 0.3	16.9 1.8 0.5

M - Metropolitan
U - Urban
R - Rural

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Notes

1) <u>Cell Diameter</u> - Cell diameter of 75 km is based on the maximum range at which voice communications take place between a coast station and a ship using the VHF frequency band.

2) <u>Traffic Load/User</u> - Traffic is assumed to be half of that for two-way radio dispatch. This corresponds to an average message length of 16 seconds and an average message frequency of 0.5 messages/busy hour.

3) <u>Subscriber Density Factor</u> - The subscriber density factors are based on the criteria outlined in Section 5.8.

4) <u>Maximum Traffic Capacity/Cell</u> - The maximum traffic handling capacity per cell (in Erlang) is based on a Blocking Probability of 10%.

5) <u>Channel Bandwidth</u> - The effective single channel bandwidth of maritime radio equipment is not expected to be reduced in the foreseeable future due to international interoperability requirements.

6) <u>Effective Cell Cluster Size</u> - Cell cluster size of 4 is based on the frequency reuse criteria outlined in Section 5.7 for a cell that provides semi-circular coverage.

7) <u>#Frequencies/Channel</u> - Value of 1.2 used to represent one calling channel for each five traffic channels.

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5.10.7   <u>Paging</u>

The values that were assigned to each variable in the modified CCIR formula are based on typical values for this type of service (as described below) and are as follows:

Paging

Variables	1986	1991	1996	2001
1. Cell Diameter- M (metres) - U - R	25,000 25,000 40,000	25,000 25,000 40,000	25,000 25,000 40,000	25,000 25,000 40,000
2. Cell Type	Circular	Circular	Circular	Circular
3. Traffic load/ user (Erlang)	.00002	.00002	.00002	.00002
4. Subscriber - M Density - U Factor - R	5 2 1	5 2 1	5 2 1	5 2 1
5. Maximum Traffic Capacity/cell	.02	.02	.02	.02
6. Effective Single Channel Band- width (kHz)	25	25	25	25
7. Effective Cell Cluster Size	7	7	7	7
8. #Frequencies/ Channel	1	1	1	1
Spectrum - M Bandwidth - U (MHz) - R	Not Calculated	1 <1 <1	3 1 <1	9 3 <1

M - Metropolitan
U - Urban
R - Rural

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Notes

1) <u>Cell Diameter</u> - Cell diameter of 25 km is based on radio coverage provided by a wide-area paging system in a typical metropolitan or urban area. Diameter of 40 km is based on the increased range that can be expected for communications in a rural area. For the purposes of this study in-house paging systems were not considered separately since wide-area paging systems are thought to be the "worse case" scenario in terms of spectrum usage.

2) <u>Traffic Load/User</u> - Traffic is based on an average alphanumeric message length of 320 bits and an average message frequency of 0.1 messages/busy hour for a system operating at 512 bps.

3) <u>Subscriber Density Factor</u> - The subscriber density factors are based on the criteria outlined in Section 5.8.

4) <u>Maximum Traffic Capacity/Cell</u> - The maximum traffic handling capacity per cell (in Erlang) is based on a Blocking Probability of 2%.

5) <u>Channel Bandwidth</u> - The effective single channel bandwidth of paging equipment is not expected to be reduced in the foreseeable future, although there is a possibility that the bandwidth may eventually be reduced as a result of advances being made in data modulation techniques.

6) <u>Effective Cell Cluster Size</u> - Cell cluster size of 7 is based on the frequency reuse criteria outlined in Section 5.7.

7) <u>#Frequencies/Channel</u> - Value of one used to represent simplex data channel.

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5.10.8   Mobile Data

The values that were assigned to each variable in the modified CCIR formula are based on typical values for this type of service (as described below) and are as follows:

Mobile Data

Variables	1986	1991	1996	2001

1. Cell Diameter- M
   (metres)   - U
             - R
	25,000
	25,000
	40,000
		25,000
		25,000
		40,000
			25,000
			25,000
			40,000
				25,000
				25,000
				40,000

2. Cell Type	Circular	Circular	Circular	Circular
3. Traffic load/ user (Erlang)	.005	.005	.005	.005

4. Subscriber   - M
   Density   - U
   Factor   - R
	5
	2
	1
		5
		2
		1
			5
			2
			1
				5
				2
				1

5. Maximum Traffic Capacity/cell	1.0	1.0	1.0	1.0

6. Effective Single
   Channel Band-
   width (kHz)
	25	25	12.5	12.5

7. Effective Cell Cluster Size	7	7	7	7
8. #Frequencies/ Channel	2	2	2	2
Spectrum - M Bandwidth - U (MHz) - R	Not Calculated	1.9 1.1 <1	2.4 1.5 <1	5.4 3.9 <1

M - Metropolitan
U - Urban
R - Rural

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Notes

1) <u>Cell Diameter</u> - Cell diameter of 25 km is based on radio coverage provided by a central repeater/base station in a typical metropolitan or urban area. Diameter of 40 km is based on the increased range that can be expected for communications in a rural area.

2) <u>Traffic Load/User</u> - Traffic is assumed to be similar to that for two-way radio dispatch since for most applications mobile data provides the sole means of communications. This corresponds to an average message length of 360 bits and an average message frequency of 60 messages/busy hour for a system operating at 1200 bps.

3) <u>Subscriber Density Factor</u> - The subscriber density factors are based on the criteria outlined in Section 5.8.

4) <u>Maximum Traffic Capacity/Cell</u> - The maximum traffic handling capacity per cell (in Erlang) is based on a loading of 200 mobile subscribers per single channel.

5) <u>Channel Bandwidth</u> - The effective single channel bandwidth of mobile data radio equipment is likely to be reduced in the foreseeable future as a result of advances being made in Cellular Telephony technology.

6) <u>Effective Cell Cluster Size</u> - Cell cluster size of 7 is based on the frequency reuse criteria outlined in Section 5.7.

7) <u>#Frequencies/Channel</u> - Value of two used to represent duplex data channel.

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6.0 DESIRABLE SPECTRUM CHARACTERISTICS

From the perspective of the mobile and personal communications systems considered by this study, the characteristics and suitability of the various parts of the electromagnetic spectrum vary a great deal. The variances occur not so much as a result of the basic communication requirement, which is for a 3 KHz speech or equivalent data channel, but from the mode of operation and infrastructure requirements. These requirements are briefly summarized for each of the communication categories identified in the study in the following paragraphs.

6.1 Cellular Telephony

Cellular telephony is, in Canada, primarily a mobile mode of communication within cities and within the connecting corridors between cities. The potential high volume requires an efficient infrastructure in which control and traffic channels separated by tens of megahertz, provide essentially identical propagation characteristics. Within city cores achieving 100% coverage is usually dependent upon multipath reflections from buildings. However, efficient coverage in rural areas necessitates the use of frequencies in which propagation losses through vegetation and over rolling terrain are minimal.

For purely mobile modes of communication the 400 MHz band probably provides a good compromise between the somewhat conflicting requirements described above. However, the high congestion of this band for use by non-cellular services have resulted in cellular services being implemented in the 800 to 900 MHz band. Although initially selected due to the low congestion, this band has the advantage of a smaller antenna, smaller fading interval and very low probability of anomalous propagation. It therefore permits the use of small handheld

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units (due to antenna lengths of only a few centimetres), the use of space diversity to minimize multipath fading and efficient frequency reuse on a non-interfering basis.

The 800 to 900 MHz band typically allows a coherent bandwidth in excess of 100 KHz since multipath spreads seldom exceed 10 microseconds. This readily permits high quality analogue FM channels or digitalized speech channels; it suggests the use of time division duplex operation to ensure a high correlation between the fading on forward and reverse traffic channels. However, the frequency division duplex mode currently implemented would likely experience poor correlation between forward and reverse channels.

6.2 Public Cordless Telephony

Personal communications are largely considered to be the functional equivalent of cellular communications, however, they will differ as a result of small cell sizes. The small cell sizes are necessary to permit the use of handheld units, in which low transmit powers are used to minimize battery requirements, and to allow frequent geographic reuse of frequencies.

Neglecting the cost or availability of the enabling technologies the 60 GHz band could be considered ideal since it provides a huge unoccupied bandwidth, propagation losses which are high and independent of weather conditions, and high reflectivity from small structures. It therefore allows good coverage within buildings and very small fading intervals, thereby permitting antenna diversity to be used to counter multipath fading.

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In practice technological and cost constraints probably preclude the use of the 60 GHz band in the immediate future so that a frequency between about 1 GHz and 10 GHz is necessary. The lower end is dictated by the need for small antennas and small fading intervals, whilst the upper end is decided by the need for propagation losses independent of weather conditions. The 10 GHz limit is generally considered the lowest frequency at which absorption losses in rain or fog become excessive.

6.3 Wireless Office Products

The characteristics required of wireless office products are for the most part the same as personal communications. The exception occurs in the event that high speed data communications are required to be superimposed upon the voice communications. In this case the very low error rates of 1 in 10^6 required for data will necessitate the use of powerful error correction coding. As a result, the transmission bandwidth is likely to exceed the data bandwidth by a factor of 2:1 or greater. To counter fading frequency diversity, as well as or in place of antenna diversity, may well be necessary. The use of low transmitter powers and frequencies exhibiting higher losses will likely preclude multipath spreads in excess of about 1 microsecond (equivalent to 300 metres). The minimum coherent bandwidth of 1 MHz should support most data communication requirements.

6.4 Two-way Radio Dispatch

The two forms of two-way dispatch, non-trunked and trunked, are both operated on a centralized basis in which a small number of base station sites provides extensive coverage to the mobile users.

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The extended coverage, particularly over rolling terrain is best achieved through the use of lower frequencies, nominally 30 to 150 MHz. At the lower end, 30 to 50 MHz, anomalous propagation (E layer refraction) quite frequently causes unacceptable interference from distant stations. It has therefore fallen into disfavour with many users. In addition, the long antennas required for efficient transmission make the lower part of the band impractical for use in systems involving portable subscribers.

With the advent of modern signal processing it is likely that many of the interference problems associated with the 30 to 54 MHz band could be overcome. For purely mobile applications, particularly in rural areas, the future use of the 30 to 54 MHz band could be encouraged. Elsewhere the existing 136 to 174 MHz band is the technically most suitable.

6.5 Aeronautical Mobile

The 118 to 136 MHz band allocated to this service is allocated on a world wide basis. The primary use for air traffic control requires that all aircraft are fitted with radios in this band. A change in either frequency band or modulation format would be extremely difficult to implement.

For the emerging aeronautic public telephone services two modes of operation are likely to be required. Satellite based services will be necessary over oceans and sparsely populated areas but terrestrial based services may prove more economical in much of North America and Europe.

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To ensure efficient use of the satellite orbit, directional antennas will be required on the aircraft. This suggests the use of frequencies above about 1 GHz if antenna size is to be suitable for use on small as well as large aircraft. For terrestrial based services, (which are more likely to be used in small aircraft) directional antennas will reduce the requirements for spectrum. However, cost considerations may require the use of omnidirectional antennas. In this case, size is not a major concern and almost any available frequency band could be allocated.

6.6 Maritime Mobile

Marine services to commercial vessels are in many ways similar to aeronautical services since they are required to be internationally co-ordinated. The existing VHF bands supplemented by the use of the "L" band (INMARSAT) services are likely to predominate for these applications.

For inland waterways many recreational boaters have adopted the cellular radio for public correspondence. This has the advantage of low blocking probability and direct dial features. It also avoids the licensing requirements associated with the VHF marine service.

6.7 Paging

Paging systems are required to provide wide coverage and good penetration of buildings. Fortunately the one-way service allows this to be achieved through the use of a high power, centrally located transmitter. The receive-only paging device allows the use of electrically short antennas so that operation in almost any segment of the frequency band is practical. Even if low VHF frequencies are used the unique coding of each transmission effectively overcomes co-channel interference during anomalous propagation conditions.

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7.0 REVIEW OF SPECTRUM BANDWIDTH REQUIREMENTS

The spectrum requirements as summarized in Tables 5, 6 and 7 are based on the forecast growth in demand for services and the gradual phasing in of advanced spectrum efficient technologies. As a result, although the total number of subscribers increases by 13:1 over the ten year period from 1991 to 2001, the spectrum requirements grow by a more modest 2:1 in metropolitan areas and only 1.5:1 in urban areas.

Currently Canadian frequency allocations to the Land, Mobile and Maritime Mobile services amount to 176 MHz, only 13% more than the total spectrum required in metropolitan areas in 1991. Since annual growth is close to 30%, it is no surprise to find industry and service providers clamouring for additional spectrum. This demand for additional spectrum can be expected to increase over the next five years at which time the impact of new technologies and the beginning of the phase-out of older technologies should stabilize spectrum requirements.

As an interim step during the analysis, the requirements for Cellular spectrum based entirely upon more advanced technologies were calculated. Although impractical to implement, the ultimate bandwidth requirement for metropolitan areas of 3.6 MHz, compared with 7.5 MHz due to a mix of technologies, clearly demonstrated the advantage of introducing spectrum efficient technologies. Similarly, a calculation of the spectrum requirements of Dispatch radio based only on single channel, rather than a mix of trunked and non-trunked systems, gave a spectrum requirement of 206 versus 178.7 MHz. This clearly indicated the essential need to enforce the use of spectrally efficient technologies.

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A comparison of the spectrum requirements of the different geographic areas clearly indicates that spectrum requirements are greater in larger metropolitan areas than either rural or high density, but smaller, urban centres. Insufficient data exist to provide a strict mathematical relationship between either city size or population density. However, as a first approximation the required spectrum appears to vary with the log of the population size. Hence, extrapolation from the reference city of 600,000 to, say Toronto at 2.5 million, the overall spectrum width requirement will increase (by the year 2001) from 307 to approximately 408 MHz.

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TABLE 5

Metropolitan Spectrum Requirements (MHz)

	1991	1996	2001
Cellular Telephony (Delayed Technology Transition)	25.6 (30.2)	28.5 (71.6)	7.5 (80.0)
Public Cordless - Outdoor	-	4	8
Public Cordless - Indoor	-	14.7	36.8
Wireless Office Products	-	4	8
Dispatch - Single Channel (Delayed Technology Transition)	104.9 (110.4)	121.9 (241.3)	123.7 (197.9)
Dispatch - Trunked (Delayed Technology Transition)	1.8 (0)	25.4 (4.2)	55.0 (41.2)
Aeronautical Mobile	14	23	37
Maritime Mobile	6.5	10.5	16.9
Paging	1	3	9
Mobile Data	1.9	2.4	5.4
Total (in MHz) (Delayed Technology Transition)	155.7 (164.0)	237.4 (378.7)	307.3 (440.2)

(Based on a Metropolitan Population of 600,000)

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TABLE 6
Urban Spectrum Requirements (MHz)

	1991	1996	2001
Cellular Telephony (Delayed Technology Transition)	9.6 (11.5)	11.2 (22.8)	3.1 (25.5)
Public Cordless - Outdoor	-	3	6
Public Cordless - Indoor	-	3.2	5.3
Wireless Office Products	-	2	3
Dispatch - Single Channel (Delayed Technology Transition)	56.0 (59.0)	60.0 (118.6)	55.1 (81.2)
Dispatch - Trunked (Delayed Technology Transition)	1.0 (0)	12.5 (2.1)	24.5 (18.4)
Aeronautical Mobile	1	1	2
Maritime Mobile	0.7	1.1	1.8
Paging	0.5	1	3
Mobile Data	1.1	1.5	3.9
Total (in MHz) (Delayed Technology Transition)	69.9 (73.8)	96.5 (156.3)	107.7 (150.1)

(Based on an Urban population of 36,000)

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TABLE 7
Rural Spectrum Requirements (MHz)

	1991	1996	2001
Cellular Telephony (Delayed Technology Transition)	2.8 (2.5)	3.5 (3.1)	1.3 (3.8)
Public Cordless - Outdoor	-	-	-
Public Cordless - Indoor	-	0.3	0.3
Wireless Office Products	-	1	1
Dispatch - Single Channel (Delayed Technology Transition)	0.8 (0.9)	0.9 (1.7)	0.9 (1.3)
Dispatch - Trunked (Delayed Technology Transition)	0 (0)	0.2 (0)	0.4 (0.3)
Aeronautical Mobile	3	5	8
Maritime Mobile	0.2	0.3	0.5
Paging	0.5	0.5	0.5
Mobile Data	0.3	0.3	0.5
Total (in MHz) (Delayed Technology Transition)	7.6 (7.4)	12.0 (12.2)	13.4 (16.2)

(Based on a Rural Population of 600,000)

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8.0 CONCLUSIONS

Current Canadian spectrum allocations are barely able to accomodate the projected requirements in 1991. A further rapid increase in spectrum requirements is likely to occur over the subsequent five years until such time as the impact of new technologies can take effect. In the years 1996 to 2001 growth will be small and could decline if more dispatch services are forced into the use of trunking techniques.

New services such as Public Cordless Telephony and Wireless Office Products will not be dominant factors within the next five years but will become significant over the subsequent five years unless highly efficient spectrum techniques are employed as these services are first introduced.

Assuming adequate spectrum can be found for growth of current dispatch services over the next five years, then new services, such as Public Cordless Telephony and Wireless Office Products, could possibly be accommodated within these allocations as spectrum requirements shrink in the years after 1996.

Although Aeronautical and Maritime Mobile requirements are presently not excessive, they could become significant by the year 2001. Since large coverage areas from single base stations are inherent to these services, spectrum efficient techniques will likely be required to be based upon the reduction of modulation bandwidth. This will cause interoperability problems which should be addressed as soon as possible before the user base becomes too large.

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ANNEX A
Details of Methodology

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DETAILS OF METHODOLOGY

1.0 GENERAL

The frequency spectrum requirements for each type of mobile radio service in metropolitan, urban and rural areas were determined by:

a) identifying present and potential users;

b) estimating the growth of the subscribers/users;

c) calculating the expected traffic densities of the subscribers/users; and

d) calculating the spectrum bandwidth required to satisfy the expected traffic densities.

The steps outlined above are described in detail in the following sections.

2.0 IDENTIFICATION OF PRESENT AND POTENTIAL USERS

In order to determine the frequency spectrum requirements, it was first necessary to:

a) identify the present and potential users of each type of mobile radio service;

b) estimate the maximum market penetration of these services within each group of users; and

c) determine the degree of use of these services within each group of users.

The industry groups as defined by Statistics Canada's Standard Industrial Classification (SIC) Codes for 1970 were used to identify and categorize all possible users of the different mobile radio services. The maximum market penetration of each type of service was estimated based on information obtained from equipment and service suppliers, and from the results of a survey conducted with 9 different industry associations. The degree of use (ie. number of subscribers) of the different

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mobile radio services in certain regions of the country was determined by analyzing the DOC license data and service supplier data that was obtained for this purpose.

3.0 GROWTH OF SUBSCRIBERS/USERS

The next step was to estimate the growth in the number of subscribers/users of each type of mobile radio service over the next ten years by using information obtained on the anticipated growth of these services. In order to ensure that the estimated number of subscribers/users of each type of service did not exceed the number of employees in each user group (based on the maximum market penetration of the different services within each group), it was also necessary to:

a)   forecast the growth of the different industry groups representing the present and potential users of each type of mobile radio service; and

b)   determine the average number of employees (as a percentage of population) per industry group in metropolitan, urban and rural areas.

Information on the anticipated growth of the different mobile radio services was obtained from the previous ADGA study "Market and Technology Trends in Radio Communications". The growth of each industry group was forecast based on an analysis of Statistics Canada data on the past growth of the number of employees in each group for each province and for Canada as a whole. The average number of employees (as a percentage of population) per industry group for major urban centres and smaller cities was determined based on an analysis of Statistics Canada census and industry data.

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The growth figures for each industry group were applied to the average number of employees per industry group to estimate the anticipated number of employees per industry group over the next ten years. These figures were compared to the estimated number of subscribers/users per industry group to ensure that the market penetration of a particular service did not exceed the estimated maximum penetration rate for that service.

4.0 TRAFFIC DENSITY

The expected traffic density for each type of mobile radio service was calculated by multiplying the number of subscribers in a given area (in square kilometre) by the estimated traffic load per subscriber. This was done for each type of service in metropolitan, urban and rural areas. The traffic density was multiplied by a Subscriber Density Factor to obtain the peak traffic resulting from the possible concentration of subscribers in a given area. The figures for peak traffic density were then used in the formula developed by CCIR Interim Working Party (IWP) 8/13, where applicable, to determine the spectrum bandwidth requirements.

5.0 SPECTRUM BANDWIDTH FORMULA

The following formula was used to determine the minimum frequency spectrum bandwidth required to satisfy the estimated traffic densities for each type of mobile radio service:

$$B = (0.001) * m * b * n * c$$

where B = spectrum bandwidth in MHz

m = number of channels per cell

b = effective bandwidth in kHz per simplex channel

n = effective cell cluster size

c = number of frequencies per channel (simplex = 1, duplex = 2)

The number of channels per cell "m" was obtained from the expression below (based on the assumption that channels are preassigned to the cell):

m = f (Ec, Pb)

where Ec= traffic load per cell in Erlang

Pb= blocking probability

f = Erlang B formula

The traffic load per cell "Ec" was obtained from the following expression:

Ec = Ep * a

where Ep= peak traffic load per square kilometre in Erlang

a = cell area in square kilometres

a = 0.5 * (d * d)/1,000,000   for equal-size square cells

= 0.65 * (d * d)/1,000,000   for equal-size hexagonal cells

= 0.78 * (d * d)/1,000,000   for circular cells

where d = cell diameter in metres

The peak traffic load per square kilometre "Ep" was obtained from the following expression:

Ep = E * Ds

where E = uniformly distributed average traffic load per square kilometre in Erlang

Ds= Subscriber Density Factor

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The traffic load per square kilometre "E" was obtained by determining the number of subscribers in a given geographical area, and multiplying this number by the estimated traffic load per subscriber/user. The Subscriber Density Factor was a ratio based on the estimated peak number of subscribers in a given area versus the total population of subscribers in a metropolitan, urban or rural area.

Different values were used for the variables in the formula for "B" to take into account the differences between each type of mobile radio service and any changes resulting from the planned use of new and/or improved technologies. For the Two-way Radio Dispatch, Aeronautical Mobile, Maritime Mobile, Paging and Mobile Data services the variable "m" (for number of channels per cell) was modified as follows:

$$m = Ec/Tc$$

where Ec= traffic load per cell in Erlang

Tc= maximum traffic capacity per cell in Erlang (per simplex channel)

The maximum traffic capacity per cell "Tc" was based on the Blocking Probability of the cell. The traffic load per cell "Ec", and the remaining variables, were obtained in the same manner as shown previously for the original formula.

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ANNEX B
Spreadsheet Printouts

#EMPLOYEES - CENSUS METROPOLITAN AREAS (CMAs)

SIC CODES	POTENTIAL USER GROUPS	ST.JOHN'S		HALIFAX		ST. JOHN	
		#EMPLOYEES	#EMPLOYEES AS %POPULATION	#EMPLOYEES	#EMPLOYEES AS %POPULATION	#EMPLOYEES	#EMPLOYEES AS %POPULATION
	CONSUMERS						
N/A	Adults (15 years & over)	121,455	75.02	232,925	78.69	92,470	76.25
	INDUSTRIES						
001-021	Agriculture	450	0.28	505	0.17	380	0.31
041-047	Fishing & Trapping	425	0.26	445	0.15	145	0.12
031-039	Logging & Forestry	110	0.07	230	0.08	310	0.26
051-099	Mining & Oil	815	0.50	1,045	0.35	235	0.19
001-099	Primary Industries	1,800	1.11	2,225	0.75	1,070	0.88
101-399	Manufacturing	5,385	3.33	10,920	3.69	7,895	6.51
404-421	Construction	4,290	2.65	10,210	3.45	3,840	3.17
501-519	Transportation	3,460	2.14	7,510	2.54	3,060	2.52
543-579	Communications & Utilities	3,135	1.94	6,690	2.26	3,375	2.78
602-629	Wholesale Trade	4,200	2.59	7,365	2.49	2,945	2.43
701-721	Finance & Insurance	2,345	1.45	6,950	2.35	1,785	1.47
735-737	Real Estate/Insure Agents	1,570	0.97	3,590	1.21	1,085	0.89
851-869	Business Services	3,595	2.22	7,465	2.52	2,060	1.70
801-809	Education	7,225	4.46	12,395	4.19	3,380	2.79
821-828	Health & Social Services	8,805	5.44	15,585	5.27	6,060	5.00
881-886	Accommodation & Food Svcs	4,155	2.57	9,995	3.38	3,650	3.01
602-886	Service Industries	31,895	19.70	63,345	21.40	20,965	17.29
	GOVERNMENT						
902-951	Government Services	11,090	6.85	27,620	9.33	3,720	3.07
	POPULATION	161,901		295,990		121,265	
	AREA (SQUARE KILOMETRES)	1130.0		2508.1		2904.8	
	POPULATION DENSITY	143.3		118.0		41.7	

Source: StatsCan - 1986 Census

#EMPLOYEES - CENSUS METROPOLITAN AREAS (CMAs)

SIC CODES	POTENTIAL USER GROUPS	JONQUIERE		MONTREAL		QUEBEC	
		#EMPLOYEES	#EMPLOYEES AS %POPULATION	#EMPLOYEES	#EMPLOYEES AS %POPULATION	#EMPLOYEES	#EMPLOYEES AS %POPULATION
	CONSUMERS						
N/A	Adults (15 years & over)	119,605	75.48	2,344,765	80.26	476,170	78.93
	INDUSTRIES						
001-021	Agriculture	795	0.50	7,425	0.25	2,300	0.38
041-047	Fishing & Trapping	25	0.02	95	0.00	45	0.01
031-039	Logging & Forestry	695	0.44	980	0.03	765	0.13
051-099	Mining & Oil	260	0.16	2,180	0.07	480	0.08
001-099	Primary Industries	1,775	1.12	10,680	0.37	3,590	0.60
101-399	Manufacturing	12,975	8.19	310,705	10.64	27,200	4.51
404-421	Construction	3,700	2.33	70,675	2.42	14,080	2.33
501-519	Transportation	1,980	1.25	77,240	2.64	9,510	1.58
543-579	Communications & Utilities	2,050	1.29	55,020	1.88	7,995	1.33
602-629	Wholesale Trade	2,270	1.43	82,230	2.81	11,730	1.94
701-721	Finance & Insurance	1,970	1.24	65,960	2.26	16,810	2.79
735-737	Real Estate/Insure Agents	795	0.50	28,635	0.98	5,160	0.86
851-869	Business Services	2,240	1.41	88,195	3.02	13,745	2.28
801-809	Education	6,505	4.10	96,605	3.31	24,780	4.11
821-828	Health & Social Services	5,995	3.78	131,005	4.48	31,675	5.25
881-886	Accommodation & Food Svcs	3,915	2.47	80,110	2.74	20,590	3.41
602-886	Service Industries	23,690	14.95	572,740	19.61	124,490	20.64
	GOVERNMENT						
902-951	Government Services	5,970	3.77	82,220	2.81	48,795	8.09
	POPULATION	158,468		2,921,357		603,267	
	AREA (SQUARE KILOMETRES)	1723.3		3508.9		3150.3	
	POPULATION DENSITY	92.0		832.6		191.5	

Source: StatsCan - 1986 Census

#EMPLOYEES - CENSUS METROPOLITAN AREAS (CMAs)

SIC CODES	POTENTIAL USER GROUPS	SHERBROOKE #EMPLOYEES	SHERBROOKE #EMPLOYEES AS %POPULATION	TROIS RIVIERES #EMPLOYEES	TROIS RIVIERES #EMPLOYEES AS %POPULATION	HAMILTON #EMPLOYEES	HAMILTON #EMPLOYEES AS %POPULATION
	CONSUMERS						
N/A	Adults (15 years & over)	100,530	77.35	101,890	79.05	441,310	79.23
	INDUSTRIES						
001-021	Agriculture	805	0.62	890	0.69	5,200	0.93
041-047	Fishing & Trapping	40	0.03	25	0.02	90	0.02
031-039	Logging & Forestry	200	0.15	135	0.10	125	0.02
051-099	Mining & Oil	70	0.05	70	0.05	655	0.12
001-099	Primary Industries	1,115	0.86	1,120	0.87	6,070	1.09
101-399	Manufacturing	11,930	9.18	11,850	9.19	80,970	14.54
404-421	Construction	3,445	2.65	3,920	3.04	16,875	3.03
501-519	Transportation	1,510	1.16	1,735	1.35	8,820	1.58
543-579	Communications & Utilities	1,760	1.35	2,480	1.92	6,265	1.12
602-629	Wholesale Trade	2,095	1.61	1,965	1.52	14,540	2.61
701-721	Finance & Insurance	1,810	1.39	1,930	1.50	10,105	1.81
735-737	Real Estate/Insure Agents	755	0.58	675	0.52	5,875	1.05
851-869	Business Services	2,395	1.84	2,025	1.57	11,610	2.08
801-809	Education	7,000	5.39	5,020	3.89	20,220	3.63
821-828	Health & Social Services	8,190	6.30	5,910	4.59	23,990	4.31
881-886	Accommodation & Food Svcs	4,050	3.12	3,845	2.98	16,250	2.92
602-886	Service Industries	26,295	20.23	21,370	16.58	102,590	18.42
	GOVERNMENT						
902-951	Government Services	3,745	2.88	3,435	2.67	12,195	2.19
	POPULATION	129,960		128,888		557,029	
	AREA (SQUARE KILOMETRES)	915.8		871.9		1358.5	
	POPULATION DENSITY	141.9		147.8		410.0	

Source: StatsCan - 1986 Census

#EMPLOYEES - CENSUS METROPOLITAN AREAS (CMAs)

SIC CODES	POTENTIAL USER GROUPS	KITCHENER #EMPLOYEES	KITCHENER #EMPLOYEES AS %POPULATION	LONDON #EMPLOYEES	LONDON #EMPLOYEES AS %POPULATION	OSHAWA #EMPLOYEES	OSHAWA #EMPLOYEES AS %POPULATION
	CONSUMERS						
N/A	Adults (15 years & over)	240,140	77.17	269,000	78.59	155,030	76.16
	INDUSTRIES						
001-021	Agriculture	2,510	0.81	4,485	1.31	1,860	0.91
041-047	Fishing & Trapping	10	0.00	75	0.02	5	0.00
031-039	Logging & Forestry	55	0.02	95	0.03	25	0.01
051-099	Mining & Oil	225	0.07	235	0.07	135	0.07
001-099	Primary Industries	2,800	0.90	4,890	1.43	2,025	0.99
101-399	Manufacturing	57,525	18.49	36,345	10.62	34,145	16.78
404-421	Construction	9,970	3.20	10,385	3.03	5,290	2.60
501-519	Transportation	3,730	1.20	5,500	1.61	3,580	1.76
543-579	Communications & Utilities	3,275	1.05	5,795	1.69	5,615	2.76
602-629	Wholesale Trade	7,695	2.47	8,990	2.63	4,160	2.04
701-721	Finance & Insurance	7,225	2.32	8,625	2.52	3,530	1.73
735-737	Real Estate/Insure Agents	3,230	1.04	3,375	0.99	1,630	0.80
851-869	Business Services	6,255	2.01	8,180	2.39	4,345	2.13
801-809	Education	13,480	4.33	14,740	4.31	5,575	2.74
821-828	Health & Social Services	10,480	3.37	21,590	6.31	7,775	3.82
881-886	Accommodation & Food Svcs	9,055	2.91	11,880	3.47	5,670	2.79
602-886	Service Industries	57,420	18.45	77,380	22.61	32,685	16.06
	GOVERNMENT						
902-951	Government Services	5,525	1.78	8,600	2.51	5,640	2.77
	POPULATION	311,195		342,302		203,545	
	AREA (SQUARE KILOMETRES)	823.6		2105.1		894.2	
	POPULATION DENSITY	377.8		162.6		227.6	

Source: StatsCan - 1986 Census

#EMPLOYEES - CENSUS METROPOLITAN AREAS (CMAs)

SIC CODES	POTENTIAL USER GROUPS	OTTAWA-HULL #EMPLOYEES	OTTAWA-HULL #EMPLOYEES AS %POPULATION	ST CATHARINES-NIAGARA #EMPLOYEES	ST CATHARINES-NIAGARA #EMPLOYEES AS %POPULATION	SUDBURY #EMPLOYEES	SUDBURY #EMPLOYEES AS %POPULATION
	CONSUMERS						
N/A	Adults (15 years & over)	649,035	79.22	272,710	79.45	114,420	76.86
	INDUSTRIES						
001-021	Agriculture	4,490	0.55	6,285	1.83	370	0.25
041-047	Fishing & Trapping	95	0.01	45	0.01	40	0.03
031-039	Logging & Forestry	735	0.09	115	0.03	485	0.33
051-099	Mining & Oil	480	0.06	390	0.11	7,885	5.30
001-099	Primary Industries	5,800	0.71	6,835	1.99	8,780	5.90
101-399	Manufacturing	31,735	3.87	44,500	12.96	6,665	4.48
404-421	Construction	27,360	3.34	9,925	2.89	3,780	2.54
501-519	Transportation	12,230	1.49	6,530	1.90	2,595	1.74
543-579	Communications & Utilities	18,150	2.22	3,875	1.13	2,315	1.55
602-629	Wholesale Trade	12,775	1.56	6,005	1.75	2,900	1.95
701-721	Finance & Insurance	14,270	1.74	4,035	1.18	1,890	1.27
735-737	Real Estate/Insure Agents	8,555	1.04	2,420	0.71	1,000	0.67
851-869	Business Services	32,980	4.03	5,985	1.74	1,805	1.21
801-809	Education	32,380	3.95	9,750	2.84	6,310	4.24
821-828	Health & Social Services	35,815	4.37	13,025	3.79	5,810	3.90
881-886	Accommodation & Food Svcs	25,955	3.17	15,105	4.40	4,750	3.19
602-886	Service Industries	162,730	19.86	56,325	16.41	24,465	16.43
	GOVERNMENT						
902-951	Government Services	115,590	14.11	7,795	2.27	6,875	4.62

	OTTAWA-HULL	ST CATHARINES-NIAGARA	SUDBURY
POPULATION	819,263	343,258	148,877
AREA (SQUARE KILOMETRES)	5138.3	1399.8	2612.1
POPULATION DENSITY	159.4	245.2	57.0

Source: StatsCan - 1986 Census

#EMPLOYEES - CENSUS METROPOLITAN AREAS (CMAs)

SIC CODES	POTENTIAL USER GROUPS	THUNDER BAY #EMPLOYEES	THUNDER BAY #EMPLOYEES AS %POPULATION	TORONTO #EMPLOYEES	TORONTO #EMPLOYEES AS %POPULATION	WINDSOR #EMPLOYEES	WINDSOR #EMPLOYEES AS %POPULATION
	CONSUMERS						
N/A	Adults (15 years & over)	95,610	78.23	2,732,350	79.73	198,470	78.14
	INDUSTRIES						
001-021	Agriculture	670	0.55	13,320	0.39	1,655	0.65
041-047	Fishing & Trapping	30	0.02	345	0.01	10	0.00
031-039	Logging & Forestry	1,910	1.56	710	0.02	35	0.01
051-099	Mining & Oil	300	0.25	4,375	0.13	435	0.17
001-099	Primary Industries	2,910	2.38	18,750	0.55	2,135	0.84
101-399	Manufacturing	9,075	7.43	445,450	13.00	41,650	16.40
404-421	Construction	3,840	3.14	107,780	3.14	5,340	2.10
501-519	Transportation	5,355	4.38	73,755	2.15	4,205	1.66
543-579	Communications & Utilities	2,010	1.64	72,075	2.10	2,700	1.06
602-629	Wholesale Trade	2,760	2.26	122,050	3.56	3,650	1.44
701-721	Finance & Insurance	1,360	1.11	118,635	3.46	3,480	1.37
735-737	Real Estate/Insure Agents	880	0.72	48,240	1.41	1,810	0.71
851-869	Business Services	2,000	1.64	150,455	4.39	4,815	1.90
801-809	Education	4,775	3.91	108,920	3.18	8,040	3.17
821-828	Health & Social Services	5,435	4.45	128,630	3.75	10,300	4.06
881-886	Accommodation & Food Svcs	4,650	3.80	107,675	3.14	9,210	3.63
602-886	Service Industries	21,860	17.89	784,605	22.89	41,305	16.26
	GOVERNMENT						
902-951	Government Services	4,885	4.00	94,705	2.76	4,715	1.86

	THUNDER BAY	TORONTO	WINDSOR
POPULATION	122,217	3,427,168	253,988
AREA (SQUARE KILOMETRES)	2202.6	5613.7	861.7
POPULATION DENSITY	55.5	610.5	294.8

Source: StatsCan - 1986 Census

#EMPLOYEES - CENSUS METROPOLITAN AREAS (CMAs)

SIC CODES	POTENTIAL USER GROUPS	WINNIPEG #EMPLOYEES	#EMPLOYEES AS %POPULATION	REGINA #EMPLOYEES	#EMPLOYEES AS %POPULATION	SASKATOON #EMPLOYEES	#EMPLOYEES AS %POPULATION
	CONSUMERS						
N/A	Adults (15 years & over)	492,165	78.71	140,995	75.59	151,765	75.63
	INDUSTRIES						
001-021	Agriculture	3,435	0.55	2,575	1.38	3,710	1.85
041-047	Fishing & Trapping	135	0.02	5	0.00	30	0.01
031-039	Logging & Forestry	245	0.04	35	0.02	70	0.03
051-099	Mining & Oil	565	0.09	530	0.28	2,715	1.35
001-099	Primary Industries	4,380	0.70	3,145	1.69	6,525	3.25
101-399	Manufacturing	48,735	7.79	6,890	3.69	9,785	4.88
404-421	Construction	18,845	3.01	6,545	3.51	7,585	3.78
501-519	Transportation	23,250	3.72	3,755	2.01	4,900	2.44
543-579	Communications & Utilities	12,590	2.01	6,335	3.40	3,030	1.51
602-629	Wholesale Trade	18,580	2.97	5,220	2.80	6,340	3.16
701-721	Finance & Insurance	14,475	2.31	5,370	2.88	3,290	1.64
735-737	Real Estate/Insure Agents	6,415	1.03	1,990	1.07	2,070	1.03
851-869	Business Services	14,245	2.28	4,520	2.42	4,820	2.40
801-809	Education	23,040	3.68	6,245	3.35	9,765	4.87
821-828	Health & Social Services	31,765	5.08	9,325	5.00	10,140	5.05
881-886	Accommodation & Food Svcs	21,690	3.47	6,480	3.47	8,370	4.17
602-886	Service Industries	130,210	20.82	39,150	20.99	44,795	22.32
	GOVERNMENT						
902-951	Government Services	29,245	4.68	11,630	6.24	7,190	3.58

	WINNIPEG	REGINA	SASKATOON
POPULATION	625,304	186,521	200,665
AREA (SQUARE KILOMETRES)	3294.8	3421.6	4749.4
POPULATION DENSITY	189.8	54.5	42.3

Source: StatsCan - 1986 Census

#EMPLOYEES - CENSUS METROPOLITAN AREAS (CMAs)

SIC CODES	POTENTIAL USER GROUPS	CALGARY #EMPLOYEES	CALGARY #EMPLOYEES AS %POPULATION	EDMONTON #EMPLOYEES	EDMONTON #EMPLOYEES AS %POPULATION	VANCOUVER #EMPLOYEES	VANCOUVER #EMPLOYEES AS %POPULATION
	CONSUMERS						
N/A	Adults (15 years & over)	520,075	77.47	598,355	76.18	1,108,600	80.29
	INDUSTRIES						
001-021	Agriculture	4,730	0.70	9,300	1.18	9,555	0.69
041-047	Fishing & Trapping	90	0.01	35	0.00	2,615	0.19
031-039	Logging & Forestry	170	0.03	745	0.09	3,605	0.26
051-099	Mining & Oil	33,855	5.04	12,855	1.64	2,830	0.20
001-099	Primary Industries	38,845	5.79	22,935	2.92	18,605	1.35
101-399	Manufacturing	34,085	5.08	39,285	5.00	87,880	6.36
404-421	Construction	25,690	3.83	33,270	4.24	44,355	3.21
501-519	Transportation	19,175	2.86	22,435	2.86	44,675	3.24
543-579	Communications & Utilities	13,525	2.01	17,360	2.21	26,350	1.91
602-629	Wholesale Trade	19,845	2.96	22,635	2.88	40,345	2.92
701-721	Finance & Insurance	15,560	2.32	14,990	1.91	33,125	2.40
735-737	Real Estate/Insure Agents	9,820	1.46	9,565	1.22	19,410	1.41
851-869	Business Services	32,990	4.91	22,195	2.83	49,150	3.56
801-809	Education	24,770	3.69	31,935	4.07	40,710	2.95
821-828	Health & Social Services	30,020	4.47	38,380	4.89	58,860	4.26
881-886	Accommodation & Food Svcs	24,710	3.68	29,425	3.75	57,670	4.18
602-886	Service Industries	157,715	23.49	169,125	21.53	299,270	21.67
	GOVERNMENT						
902-951	Government Services	22,475	3.35	41,680	5.31	37,895	2.74

	CALGARY	EDMONTON	VANCOUVER
POPULATION	671,326	785,465	1,380,729
AREA (SQUARE KILOMETRES)	5056.0	11396.7	2786.3
POPULATION DENSITY	132.8	68.9	495.5

Source: StatsCan - 1986 Census

#EMPLOYEES - CENSUS METROPOLITAN AREAS (CMAs)

SIC CODES	POTENTIAL USER GROUPS	VICTORIA #EMPLOYEES	#EMPLOYEES AS %POPULATION	TOTAL # EMPLOYEES IN EACH INDUSTRY	AVG #EMPLOYEES AS %POPULATION IN EACH INDUSTRY	STANDARD DEVIATION (%POPULATION)
	CONSUMERS					
N/A	Adults (15 years & over)	207,495	81.20	11,977,335	78.0	1.7
	INDUSTRIES					
001-021	Agriculture	1,580	0.62	89,280	0.7	0.5
041-047	Fishing & Trapping	845	0.33	5,745	0.1	0.1
031-039	Logging & Forestry	1,670	0.65	14,255	0.2	0.3
051-099	Mining & Oil	295	0.12	73,915	0.7	1.4
001-099	Primary Industries	4,390	1.72	183,195	1.6	1.4
101-399	Manufacturing	7,075	2.77	1,420,655	8.4	4.6
404-421	Construction	7,560	2.96	458,555	3.0	0.5
501-519	Transportation	4,355	1.70	354,850	2.1	0.8
543-579	Communications & Utilities	3,235	1.27	287,005	1.8	0.6
602-629	Wholesale Trade	3,365	1.32	416,655	2.3	0.6
701-721	Finance & Insurance	3,370	1.32	362,895	1.9	0.6
735-737	Real Estate/Insure Agents	2,930	1.15	171,480	1.0	0.3
851-869	Business Services	6,875	2.69	484,945	2.4	0.9
801-809	Education	8,530	3.34	532,095	3.8	0.7
821-828	Health & Social Services	13,515	5.29	668,080	4.7	0.7
881-886	Accommodation & Food Svcs	10,810	4.23	499,665	3.4	0.5
602-886	Service Industries	49,395	19.33	3,135,815	19.4	2.4
	GOVERNMENT					
902-951	Government Services	22,310	8.73	625,545	4.5	2.9

			TOTAL	AVERAGE	STANDARD DEVIATION
	POPULATION	255,547	15,155,495	606,220	814,987
	AREA (SQUARE KILOMETRES)	1951.1	72,378	2,895	2,240
	POPULATION DENSITY	131.0		217.0	190.4

Source: StatsCan - 1986 Census

#EMPLOYEES - CENSUS AGGLOMERATIONS (CAs)

SIC CODES	POTENTIAL USER GROUPS	TOTAL # EMPLOYEES IN EACH INDUSTRY	AVG #EMPLOYEES AS %POPULATION IN EACH INDUSTRY	STANDARD DEVIATION (%POPULATION)
	CONSUMERS			
N/A	Adults (15 years & over)	3,085,310	75.8	2.4
	INDUSTRIES			
001-021	Agriculture	47,555	1.2	0.9
041-047	Fishing & Trapping	5,420	0.2	0.4
031-039	Logging & Forestry	27,900	0.8	1.0
051-099	Mining & Oil	47,060	1.6	3.3
001-099	Primary Industries	127,935	3.7	3.2
101-399	Manufacturing	337,505	8.5	4.8
404-421	Construction	114,330	2.7	0.7
501-519	Transportation	79,895	2.0	1.0
543-579	Communications & Utilities	58,540	1.4	0.6
602-629	Wholesale Trade	76,020	1.8	0.6
701-721	Finance & Insurance	48,505	1.2	0.4
735-737	Real Estate/Insure Agents	28,205	0.7	0.2
851-869	Business Services	53,955	1.3	0.5
801-809	Education	134,690	3.2	0.8
821-828	Health & Social Services	178,505	4.5	1.2
881-886	Accommodation & Food Svcs	139,225	3.5	0.7
602-886	Service Industries	659,105	16.0	2.8
	GOVERNMENT			
902-951	Government Services	148,345	3.5	2.0

	TOTAL	AVERAGE	STANDARD DEVIATION
POPULATION	4,066,027	35,667	25,287
AREA (SQUARE KILOMETRES)	255,578	2,242	8,875
POPULATION DENSITY		223.1	321.4

Source: StatsCan - 1986 Census

#EMPLOYEES - RURAL AREAS

SIC CODES	POTENTIAL USER GROUPS	TOTAL # EMPLOYEES IN EACH INDUSTRY	AVG #EMPLOYEES AS %POPULATION IN EACH INDUSTRY	STANDARD DEVIATION (%POPULATION)
	CONSUMERS			
N/A	Adults (15 years & over)	4,511,660	74.6	1.6
	INDUSTRIES			
001-021	Agriculture	372,425	6.5	5.1
041-047	Fishing & Trapping	35,070	1.4	1.8
031-039	Logging & Forestry	70,465	1.2	1.1
051-099	Mining & Oil	69,480	1.1	1.0
001-099	Primary Industries	547,440	10.2	9.1
101-399	Manufacturing	436,690	6.4	2.8
404-421	Construction	183,730	3.0	0.3
501-519	Transportation	128,395	2.2	0.4
543-579	Communications & Utilities	65,030	1.0	0.2
602-629	Wholesale Trade	91,305	1.5	0.3
701-721	Finance & Insurance	52,790	0.8	0.2
735-737	Real Estate/Insure Agents	25,775	0.4	0.1
851-869	Business Services	48,325	0.7	0.2
801-809	Education	168,390	2.9	0.3
821-828	Health & Social Services	192,135	3.0	0.5
881-886	Accommodation & Food Svcs	164,520	2.7	0.7
602-886	Service Industries	743,240	12.0	2.3
	GOVERNMENT			
902-951	Government Services	187,670	3.4	0.8

	TOTAL	AVERAGE	STANDARD DEVIATION
POPULATION	6,027,266	602,727	481,480
AREA (SQUARE KILOMETRES)	5,097,424.3	509,742	400,045
POPULATION DENSITY		3.4	4.0

Source: StatsCan - 1986 Census

PROJECTED % ANNUAL GROWTH OF POPULATION

PROVINCE	1986	1991	1996	2001	% ANNUAL GROWTH 1986-1991	% ANNUAL GROWTH 1986-1996	% ANNUAL GROWTH 1986-2001
Newfoundland	568,300	638,900	671,800	698,000	2.4%	1.7%	1.4%
Prince Edward Island	126,600	132,900	138,700	143,500	1.0%	0.9%	0.8%
Nova Scotia	873,200	911,100	930,700	943,000	0.9%	0.6%	0.5%
New Brunswick	709,400	757,900	783,200	801,700	1.3%	1.0%	0.8%
Quebec	6,532,461	6,786,100	6,878,700	6,903,600	0.8%	0.5%	0.4%
Ontario	9,101,700	9,627,400	9,948,700	10,160,800	1.1%	0.9%	0.7%
Manitoba	1,063,000	1,122,900	1,137,500	1,135,100	1.1%	0.7%	0.4%
Saskatchewan	1,009,600	1,095,300	1,143,700	1,182,200	1.6%	1.3%	1.1%
Alberta	2,365,800	2,373,800	2,446,800	2,514,400	0.1%	0.3%	0.4%
British Columbia	2,883,400	3,091,200	3,191,200	3,253,800	1.4%	1.0%	0.8%
Yukon	20,600	22,000	24,400	26,500	1.3%	1.7%	1.7%
Northwest Territories	51,700	53,400	53,700	53,800	0.6%	0.4%	0.3%
Canada	25,305,761	26,612,900	27,349,100	27,816,400	1.0%	0.8%	0.6%

Source: Statscan
Notes - Projections based largely on continuation of existing trends -
- (Fertility of 1.4 children per woman)
- (International migration of 50,000/year net gain)
- (Internal migration pattern - continuation of current trends)
- Annual growth for 1986-2001 (Canada) used in all spectrum requirement spreadsheets.

% ANNUAL GROWTH OF USER GROUPS

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES 1971	CANADA #EMPLOYEES 1981	#EMPLOYEES 1986	% ANNUAL GROWTH 1971-1981	% ANNUAL GROWTH 1981-1986	% ANNUAL GROWTH 1971-1986
	INDUSTRIES						
001-099	Primary Industries	720,145	839,935	845,950	1.6%	0.1%	1.1%
101-399	Manufacturing Industry	1,707,330	2,219,380	2,153,965	2.7%	-0.6%	1.6%
404-421	Construction Industry	538,220	752,370	731,940	3.4%	-0.5%	2.1%
501-519	Transportation Industry	403,735	534,835	569,045	2.9%	1.2%	2.3%
506-507 512	Trucking & Taxi Industries	135,730	185,910	199,070	3.2%	1.4%	2.6%
543-579	Communications & Utilities	251,035	378,490	373,280	4.2%	-0.3%	2.7%
602-886	Service Industries	2,329,715	3,946,720	4,432,990	5.4%	2.4%	4.4%
	GOVERNMENT						
902-951	Government Services	637,275	884,880	948,570	3.3%	1.4%	2.7%

Source: StatsCan - 1971/81/86 Census
Notes - Annual growth for 1971-1986 used for projected growth for 1986-2001
- Annual growth for Trucking and Taxi Industries not used since these groups were not identified separately in the spectrum requirement spreadsheet. In this case the annual growth for Transportation Industries was used to include these industries.

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Cellular Telephony
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

TOTAL POPULATION =   600,000
POPULATION DENSITY =   217.0
TOTAL AREA (SQUARE KM) =   2,765.0
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	78.0	0.6	20.0	# Adults	468,000	482,209	496,850	511,936
					# Subscribers	2,000	7,426	27,572	102,372
					Market Penetration	0.4%	1.5%	5.5%	20.0%
	INDUSTRIES								
001-099	Primary Industries	1.6	1.1	5.0	# Employees	9,600	10,140	10,710	11,312
					# Subscribers	11	41	152	563
					Market Penetration	0.1%	0.4%	1.4%	5.0%
101-399	Manufacturing Industry	8.4	1.6	5.0	# Employees	50,400	54,563	59,070	63,949
					# Subscribers	62	230	855	3,174
					Market Penetration	0.1%	0.4%	1.4%	5.0%
404-421	Construction Industry	3.0	2.1	5.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers	24	89	331	1,228
					Market Penetration	0.1%	0.4%	1.5%	5.0%
501-519	Transportation Industry	2.1	2.3	20.0	# Employees	12,600	14,117	15,817	17,722
					# Subscribers	70	260	965	3,544
					Market Penetration	0.6%	1.8%	6.1%	20.0%
543-579	Communications & Utilities	1.8	2.7	5.0	# Employees	10,800	12,339	14,097	16,106
					# Subscribers	16	59	221	805
					Market Penetration	0.1%	0.5%	1.6%	5.0%
602-886	Service Industries	19.4	4.4	20.0	# Employees	116,400	144,363	179,043	222,055
					# Subscribers	876	3,253	12,076	44,411
					Market Penetration	0.8%	2.3%	6.7%	20.0%
	GOVERNMENT								
902-951	Government Services	4.5	2.7	5.0	# Employees	27,000	30,847	35,243	40,264
					# Subscribers	39	145	538	1,996
					Market Penetration	0.1%	0.5%	1.5%	5.0%
TOTALS					# Adults & Employees	712,800	768,550	832,988	907,928
					# Subscribers/Users	3,098	11,503	42,709	158,094
Subscriber Distribution	- 1st Generation					100.0	70.0	18.0	0.0
	- 2nd Generation					0.0	30.0	52.0	14.0
	- 3rd Generation					0.0	0.0	30.0	86.0

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Cellular Telephony
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

SPECTRUM REQUIREMENT FORECASTS - 1st Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"		5,000	5,000	5,000	5,000
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)	16.25	16.25	16.25	16.25
Traffic Load/user (Erlang)		0.02	0.02	0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"		0.02	0.06	0.06	0.00
Subscriber Density Factor - "Ds"		12.3	12.3	12.3	12.3
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)	0.3	0.7	0.7	0.0
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)	4.5	11.6	11.1	0.0
Blocking Probability (%) - "Pb"		2.0	2.0	2.0	2.0
# Channels/cell (using Erlang B Formula) - "a"		10	19	18	0
Effective Single Channel Bandwidth (kHz) - "b"		30.0	30.0	30.0	30.0
Effective Cell Cluster Size - "n"		21	21	21	21
# Frequencies/channel - "c"		2	2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*a*b*n*c)	12.6	23.9	22.7	0.0

SPECTRUM REQUIREMENT FORECASTS - 2nd Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"			3,000	3,000	3,000
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)		5.85	5.85	5.85
Traffic Load/user (Erlang)			0.02	0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"			0.02	0.16	0.16
Subscriber Density Factor - "Ds"			12.3	12.3	12.3
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.3	2.0	2.0
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		1.8	11.6	11.5
Blocking Probability (%) - "Pb"			2.0	2.0	2.0
# Channels/cell (using Erlang B Formula) - "a"			6	19	18
Effective Single Channel Bandwidth (kHz) - "b"			15.0	15.0	15.0
Effective Cell Cluster Size - "n"			9	9	9
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*a*b*n*c)		1.6	5.1	4.9

SPECTRUM REQUIREMENT FORECASTS - 3rd Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"				850	850
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)			0.47	0.47
Traffic Load/user (Erlang)				0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"				0.09	0.98
Subscriber Density Factor - "Ds"				12.3	12.3
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)			1.1	12.1
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)			0.5	5.7
Blocking Probability (%) - "Pb"				2.0	2.0
# Channels/cell (using Erlang B Formula) - "a"				3	11
Effective Single Channel Bandwidth (kHz) - "b"				5.0	5.0
Effective Cell Cluster Size - "n"				24	24
# Frequencies/channel - "c"				2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*a*b*n*c)			0.7	2.6
Total Spectrum Bandwidth (MHz)		12.6	25.6	28.5	7.5

TYPE OF MOBILE SERVICE: Cellular Telephony
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

TOTAL POPULATION =   36,000
POPULATION DENSITY =   223.1
TOTAL AREA (SQUARE KM) =   161.4
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	75.8	0.6	20.0	# Adults	27,288	28,117	28,970	29,850
					# Subscribers	117	434	1,613	5,970
					Market Penetration	0.4%	1.5%	5.6%	20.0%
	INDUSTRIES								
001-099	Primary Industries	3.7	1.1	5.0	# Employees	1,332	1,407	1,486	1,570
					# Subscribers	2	7	28	78
					Market Penetration	0.2%	0.5%	1.9%	5.0%
101-399	Manufacturing Industry	8.5	1.6	5.0	# Employees	3,060	3,313	3,586	3,883
					# Subscribers	4	15	55	194
					Market Penetration	0.1%	0.4%	1.5%	5.0%
404-421	Construction Industry	2.7	2.1	5.0	# Employees	972	1,078	1,197	1,328
					# Subscribers	2	7	28	66
					Market Penetration	0.2%	0.7%	2.3%	5.0%
501-519	Transportation Industry	2.0	2.3	20.0	# Employees	720	807	904	1,013
					# Subscribers	4	15	55	203
					Market Penetration	0.6%	1.8%	6.1%	20.0%
543-579	Communications & Utilities	1.4	2.7	5.0	# Employees	504	576	658	752
					# Subscribers	1	4	14	38
					Market Penetration	0.2%	0.6%	2.1%	5.0%
602-886	Service Industries	16.0	4.4	20.0	# Employees	5,760	7,144	8,860	10,988
					# Subscribers	43	160	593	2,198
					Market Penetration	0.7%	2.2%	6.7%	20.0%
	GOVERNMENT								
902-951	Government Services	3.5	2.7	5.0	# Employees	1,260	1,440	1,645	1,879
					# Subscribers	2	7	28	94
					Market Penetration	0.2%	0.5%	1.7%	5.0%
TOTALS	# Adults & Employees					40,896	43,880	47,305	51,261
	# Subscribers/Users					175	650	2,413	8,841
Subscriber Distribution	- 1st Generation					100.0	70.0	18.0	0.0
	- 2nd Generation					0.0	30.0	52.0	14.0
	- 3rd Generation					0.0	0.0	30.0	86.0

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Cellular Telephony
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

SPECTRUM REQUIREMENT FORECASTS - 1st Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"		5,000	5,000	5,000	5,000
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)	16.25	16.25	16.25	16.25
Traffic Load/user. (Erlang)		0.02	0.02	0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"		0.02	0.06	0.05	0.00
Subscriber Density Factor - "Ds"		3.0	3.0	3.0	3.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)	0.1	0.2	0.2	0.0
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)	1.1	2.7	2.6	0.0
Blocking Probability (%) - "Pb"		2.0	2.0	2.0	2.0
# Channels/cell (using Erlang B Formula) - "m"		5	7	7	0
Effective Single Channel Bandwidth (kHz) - "b"		30.0	30.0	30.0	30.0
Effective Cell Cluster Size - "n"		21	21	21	21
# Frequencies/channel - "c"		2	2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)	6.3	8.8	8.8	0.0

SPECTRUM REQUIREMENT FORECASTS - 2nd Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"			3,000	3,000	3,000
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)		5.85	5.85	5.85
Traffic Load/user (Erlang)			0.02	0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"			0.02	0.16	0.15
Subscriber Density Factor - "Ds"			3.0	3.0	3.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.1	0.5	0.5
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.4	2.7	2.7
Blocking Probability (%) - "Pb"			2.0	2.0	2.0
# Channels/cell (using Erlang B Formula) - "m"			3	7	7
Effective Single Channel Bandwidth (kHz) - "b"			15.0	15.0	15.0
Effective Cell Cluster Size - "n"			9	9	9
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.8	1.9	1.9

SPECTRUM REQUIREMENT FORECASTS - 3rd Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"				850	850
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)			0.47	0.47
Traffic Load/user (Erlang)				0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"				0.09	0.94
Subscriber Density Factor - "Ds"				3.0	3.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)			0.3	2.8
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)			0.1	1.3
Blocking Probability (%) - "Pb"				2.0	2.0
# Channels/cell (using Erlang B Formula) - "m"				2	5
Effective Single Channel Bandwidth (kHz) - "b"				5.0	5.0
Effective Cell Cluster Size - "n"				24	24
# Frequencies/channel - "c"				2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)			0.5	1.2

Total Spectrum Bandwidth (MHz)		6.3	9.6	11.2	3.1

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Cellular Telephony
CITY/CENSUS AREA: Rural Area

TOTAL POPULATION = 600,000
POPULATION DENSITY = 3.4
TOTAL AREA (SQUARE KM) = 176,470.6
GROWTH OF MOBILE SERVICE = 30 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	74.6	0.6	20.0	# Adults	447,600	461,190	475,193	489,621
					# Subscribers	1,913	7,103	26,372	97,919
					Market Penetration	0.4%	1.5%	5.5%	20.0%
	INDUSTRIES								
001-099	Primary Industries	10.2	1.1	5.0	# Employees	61,200	64,641	68,275	72,114
					# Subscribers	70	260	965	3,583
					Market Penetration	0.1%	0.4%	1.4%	5.0%
101-399	Manufacturing Industry	6.4	1.6	5.0	# Employees	38,400	41,572	45,006	48,723
					# Subscribers	48	178	662	2,436
					Market Penetration	0.1%	0.4%	1.5%	5.0%
404-421	Construction Industry	3.0	2.1	5.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers	24	89	331	1,228
					Market Penetration	0.1%	0.4%	1.5%	5.0%
501-519	Transportation Industry	2.2	2.3	20.0	# Employees	13,200	14,789	16,570	18,566
					# Subscribers	73	271	1,006	3,713
					Market Penetration	0.6%	1.8%	6.1%	20.0%
543-579	Communications & Utilities	1.0	2.7	5.0	# Employees	6,000	6,855	7,832	8,948
					# Subscribers	9	33	124	447
					Market Penetration	0.2%	0.5%	1.6%	5.0%
602-886	Service Industries	12.0	4.4	20.0	# Employees	72,000	89,297	110,748	137,354
					# Subscribers	537	1,994	7,403	27,471
					Market Penetration	0.7%	2.2%	6.7%	20.0%
	GOVERNMENT								
902-951	Government Services	3.4	2.7	5.0	# Employees	20,400	23,307	26,628	30,422
					# Subscribers	30	111	414	1,521
					Market Penetration	0.1%	0.5%	1.6%	5.0%
TOTALS	# Adults & Employees					676,800	721,622	772,410	830,331
	# Subscribers/Users					2,704	10,040	37,277	138,319
Subscriber Distribution	- 1st Generation					100.0	70.0	18.0	0.0
	- 2nd Generation					0.0	30.0	52.0	14.0
	- 3rd Generation					0.0	0.0	30.0	86.0

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Cellular Telephony
CITY/CENSUS AREA: Rural Area

SPECTRUM REQUIREMENT FORECASTS - 1st Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"		8,000	8,000	8,000	8,000
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)	41.60	41.60	41.60	41.60
Traffic Load/user (Erlang)		0.02	0.02	0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"		0.0003	0.0008	0.0008	0.0000
Subscriber Density Factor - "Ds"		1.0	1.0	1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)	0.0003	0.0008	0.0008	0.0000
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)	0.01	0.03	0.03	0.00
Blocking Probability (%) - "Pb"		2.0	2.0	2.0	2.0
# Channels/cell (using Erlang B Formula) - "m"		1	2	2	0
Effective Single Channel Bandwidth (kHz) - "b"		30.0	30.0	30.0	30.0
Effective Cell Cluster Size - "n"		21	21	21	21
# Frequencies/channel - "c"		2	2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)	1.3	2.5	2.5	0.0

SPECTRUM REQUIREMENT FORECASTS - 2nd Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"			8,000	8,000	8,000
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)		41.60	41.60	41.60
Traffic Load/user (Erlang)			0.02	0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"			0.0003	0.0022	0.0022
Subscriber Density Factor - "Ds"			1.0	1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.0003	0.0022	0.0022
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.01	0.09	0.09
Blocking Probability (%) - "Pb"			2.0	2.0	2.0
# Channels/cell (using Erlang B Formula) - "m"			1	2	2
Effective Single Channel Bandwidth (kHz) - "b"			15.0	15.0	15.0
Effective Cell Cluster Size - "n"			9	9	9
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.3	0.5	0.5

SPECTRUM REQUIREMENT FORECASTS - 3rd Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"				8,000	8,000
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)			41.60	41.60
Traffic Load/user (Erlang)				0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"				0.0013	0.0135
Subscriber Density Factor - "Ds"				1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)			0.0013	0.0135
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)			0.05	0.56
Blocking Probability (%) - "Pb"				2.0	2.0
# Channels/cell (using Erlang B Formula) - "m"				2	3
Effective Single Channel Bandwidth (kHz) - "b"				5.0	5.0
Effective Cell Cluster Size - "n"				24	24
# Frequencies/channel - "c"				2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)			0.5	0.7

| Total Spectrum Bandwidth (MHz) | | 1.3 | 2.8 | 3.5 | 1.3 |

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Cellular Telephony (Delayed Technology Transition)
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area – CMA)

TOTAL POPULATION =   600,000
POPULATION DENSITY =   217.0
TOTAL AREA (SQUARE KM) =   2,765.0
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	78.0	0.6	20.0	# Adults	468,000	482,209	496,850	511,936
					# Subscribers	2,000	7,426	27,572	102,372
					Market Penetration	0.4%	1.5%	5.5%	20.0%
	INDUSTRIES								
001-099	Primary Industries	1.6	1.1	5.0	# Employees	9,600	10,140	10,710	11,312
					# Subscribers	11	41	152	563
					Market Penetration	0.1%	0.4%	1.4%	5.0%
101-399	Manufacturing Industry	8.4	1.6	5.0	# Employees	50,400	54,563	59,070	63,949
					# Subscribers	62	230	855	3,174
					Market Penetration	0.1%	0.4%	1.4%	5.0%
404-421	Construction Industry	3.0	2.1	5.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers	24	89	331	1,228
					Market Penetration	0.1%	0.4%	1.5%	5.0%
501-519	Transportation Industry	2.1	2.3	20.0	# Employees	12,600	14,117	15,817	17,722
					# Subscribers	70	260	965	3,544
					Market Penetration	0.6%	1.8%	6.1%	20.0%
543-579	Communications & Utilities	1.8	2.7	5.0	# Employees	10,800	12,339	14,097	16,106
					# Subscribers	16	59	221	805
					Market Penetration	0.1%	0.5%	1.6%	5.0%
602-886	Service Industries	19.4	4.4	20.0	# Employees	116,400	144,363	179,043	222,055
					# Subscribers	876	3,253	12,076	44,411
					Market Penetration	0.8%	2.3%	6.7%	20.0%
	GOVERNMENT								
902-951	Government Services	4.5	2.7	5.0	# Employees	27,000	30,847	35,243	40,264
					# Subscribers	39	145	538	1,996
					Market Penetration	0.1%	0.5%	1.5%	5.0%
TOTALS	# Adults & Employees					712,800	768,550	832,988	907,928
	# Subscribers/Users					3,098	11,503	42,709	158,094
Subscriber Distribution	– 1st Generation					100.0	100.0	70.0	18.0
	– 2nd Generation					0.0	0.0	30.0	52.0
	– 3rd Generation					0.0	0.0	0.0	30.0

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Cellular Telephony (Delayed Technology Transition)
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

SPECTRUM REQUIREMENT FORECASTS - 1st Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"		5,000	5,000	5,000	5,000
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)	16.25	16.25	16.25	16.25
Traffic Load/user (Erlang)		0.02	0.02	0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"		0.02	0.08	0.22	0.21
Subscriber Density Factor - "Ds"		12.3	12.3	12.3	12.3
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)	0.3	1.0	2.7	2.5
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)	4.5	16.6	43.2	41.1
Blocking Probability (%) - "Pb"		2.0	2.0	2.0	2.0
# Channels/cell (using Erlang B Formula) - "m"		10	24	54	51
Effective Single Channel Bandwidth (kHz) - "b"		30.0	30.0	30.0	30.0
Effective Cell Cluster Size - "n"		21	21	21	21
# Frequencies/channel - "c"		2	2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)	12.6	30.2	68.0	64.3

SPECTRUM REQUIREMENT FORECASTS - 2nd Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"			3,000	3,000	3,000
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)		5.85	5.85	5.85
Traffic Load/user (Erlang)			0.02	0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"			0.00	0.09	0.59
Subscriber Density Factor - "Ds"			12.3	12.3	12.3
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.0	1.1	7.3
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.0	6.7	42.8
Blocking Probability (%) - "Pb"			2.0	2.0	2.0
# Channels/cell (using Erlang B Formula) - "m"			0	13	53
Effective Single Channel Bandwidth (kHz) - "b"			15.0	15.0	15.0
Effective Cell Cluster Size - "n"			9	9	9
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.0	3.5	14.3

SPECTRUM REQUIREMENT FORECASTS - 3rd Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"				850	850
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)			0.47	0.47
Traffic Load/user (Erlang)				0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"				0.00	0.34
Subscriber Density Factor - "Ds"				12.3	12.3
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)			0.0	4.2
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)			0.0	2.0
Blocking Probability (%) - "Pb"				2.0	2.0
# Channels/cell (using Erlang B Formula) - "m"				0	6
Effective Single Channel Bandwidth (kHz) - "b"				5.0	5.0
Effective Cell Cluster Size - "n"				24	24
# Frequencies/channel - "c"				2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)			0.0	1.4

Total Spectrum Bandwidth (MHz)	12.6	30.2	71.6	80.0

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Cellular Telephony (Delayed Technology Transition)
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

TOTAL POPULATION =   36,000
POPULATION DENSITY =   223.1
TOTAL AREA (SQUARE KM) =   161.4
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	75.8	0.6	20.0	# Adults	27,288	28,117	28,970	29,850
					# Subscribers	117	434	1,613	5,970
					Market Penetration	0.4%	1.5%	5.6%	20.0%
	INDUSTRIES								
001-099	Primary Industries	3.7	1.1	5.0	# Employees	1,332	1,407	1,486	1,570
					# Subscribers	2	7	28	78
					Market Penetration	0.2%	0.5%	1.9%	5.0%
101-399	Manufacturing Industry	8.5	1.6	5.0	# Employees	3,060	3,313	3,586	3,883
					# Subscribers	4	15	55	194
					Market Penetration	0.1%	0.4%	1.5%	5.0%
404-421	Construction Industry	2.7	2.1	5.0	# Employees	972	1,078	1,197	1,328
					# Subscribers	2	7	28	66
					Market Penetration	0.2%	0.7%	2.3%	5.0%
501-519	Transportation Industry	2.0	2.3	20.0	# Employees	720	807	904	1,013
					# Subscribers	4	15	55	203
					Market Penetration	0.6%	1.8%	6.1%	20.0%
543-579	Communications & Utilities	1.4	2.7	5.0	# Employees	504	576	658	752
					# Subscribers	1	4	14	38
					Market Penetration	0.2%	0.6%	2.1%	5.0%
602-886	Service Industries	16.0	4.4	20.0	# Employees	5,760	7,144	8,860	10,988
					# Subscribers	43	160	593	2,198
					Market Penetration	0.7%	2.2%	6.7%	20.0%
	GOVERNMENT								
902-951	Government Services	3.5	2.7	5.0	# Employees	1,260	1,440	1,645	1,879
					# Subscribers	2	7	28	94
					Market Penetration	0.2%	0.5%	1.7%	5.0%
TOTALS	# Adults & Employees					40,896	43,880	47,305	51,261
	# Subscribers/Users					175	650	2,413	8,841
Subscriber Distribution	- 1st Generation					100.0	100.0	70.0	18.0
	- 2nd Generation					0.0	0.0	30.0	52.0
	- 3rd Generation					0.0	0.0	0.0	30.0

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Cellular Telephony (Delayed Technology Transition)
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

SPECTRUM REQUIREMENT FORECASTS - 1st Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"		5,000	5,000	5,000	5,000
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)	16.25	16.25	16.25	16.25
Traffic Load/user (Erlang)		0.02	0.02	0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"		0.02	0.08	0.21	0.20
Subscriber Density Factor - "Ds"		3.0	3.0	3.0	3.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)	0.1	0.2	0.6	0.6
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)	1.1	3.9	10.2	9.6
Blocking Probability (%) - "Pb"		2.0	2.0	2.0	2.0
# Channels/cell (using Erlang B Formula) - "m"		5	9	17	16
Effective Single Channel Bandwidth (kHz) - "b"		30.0	30.0	30.0	30.0
Effective Cell Cluster Size - "n"		21	21	21	21
# Frequencies/channel - "c"		2	2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)	6.3	11.3	21.4	20.2

SPECTRUM REQUIREMENT FORECASTS - 2nd Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"			3,000	3,000	3,000
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)		5.85	5.85	5.85
Traffic Load/user (Erlang)			0.02	0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"			0.00	0.09	0.57
Subscriber Density Factor - "Ds"			3.0	3.0	3.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.0	0.3	1.7
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.0	1.6	10.0
Blocking Probability (%) - "Pb"			2.0	2.0	2.0
# Channels/cell (using Erlang B Formula) - "m"			0	5	17
Effective Single Channel Bandwidth (kHz) - "b"			15.0	15.0	15.0
Effective Cell Cluster Size - "n"			9	9	9
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.0	1.4	4.6

SPECTRUM REQUIREMENT FORECASTS - 3rd Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"				850	850
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)			0.47	0.47
Traffic Load/user (Erlang)				0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"				0.00	0.33
Subscriber Density Factor - "Ds"				3.0	3.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)			0.0	1.0
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)			0.0	0.5
Blocking Probability (%) - "Pb"				2.0	2.0
# Channels/cell (using Erlang B Formula) - "m"				0	3
Effective Single Channel Bandwidth (kHz) - "b"				5.0	5.0
Effective Cell Cluster Size - "n"				24	24
# Frequencies/channel - "c"				2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)			0.0	0.7

		1986	1991	1996	2001
Total Spectrum Bandwidth (MHz)		6.3	11.3	22.8	25.5

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Cellular Telephony (Delayed Technology Transition)
CITY/CENSUS AREA: Rural Area

TOTAL POPULATION = 600,000
POPULATION DENSITY = 3.4
TOTAL AREA (SQUARE KM) = 176,470.6
GROWTH OF MOBILE SERVICE = 30 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	74.6	0.6	20.0	# Adults	447,600	461,190	475,193	489,621
					# Subscribers	1,913	7,103	26,372	97,919
					Market Penetration	0.4%	1.5%	5.5%	20.0%
	INDUSTRIES								
001-099	Primary Industries	10.2	1.1	5.0	# Employees	61,200	64,641	68,275	72,114
					# Subscribers	70	260	965	3,583
					Market Penetration	0.1%	0.4%	1.4%	5.0%
101-399	Manufacturing Industry	6.4	1.6	5.0	# Employees	38,400	41,572	45,006	48,723
					# Subscribers	48	178	662	2,436
					Market Penetration	0.1%	0.4%	1.5%	5.0%
404-421	Construction Industry	3.0	2.1	5.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers	24	89	331	1,228
					Market Penetration	0.1%	0.4%	1.5%	5.0%
501-519	Transportation Industry	2.2	2.3	20.0	# Employees	13,200	14,789	16,570	18,566
					# Subscribers	73	271	1,006	3,713
					Market Penetration	0.6%	1.8%	6.1%	20.0%
543-579	Communications & Utilities	1.0	2.7	5.0	# Employees	6,000	6,855	7,832	8,948
					# Subscribers	9	33	124	447
					Market Penetration	0.2%	0.5%	1.6%	5.0%
602-886	Service Industries	12.0	4.4	20.0	# Employees	72,000	89,297	110,748	137,354
					# Subscribers	537	1,994	7,403	27,471
					Market Penetration	0.7%	2.2%	6.7%	20.0%
	GOVERNMENT								
902-951	Government Services	3.4	2.7	5.0	# Employees	20,400	23,307	26,628	30,422
					# Subscribers	30	111	414	1,521
					Market Penetration	0.1%	0.5%	1.6%	5.0%
TOTALS	# Adults & Employees					676,800	721,622	772,410	830,331
	# Subscribers/Users					2,704	10,040	37,277	138,319
Subscriber Distribution	- 1st Generation					100.0	100.0	70.0	18.0
	- 2nd Generation					0.0	0.0	30.0	52.0
	- 3rd Generation					0.0	0.0	0.0	30.0

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Cellular Telephony (Delayed Technology Transition)
CITY/CENSUS AREA: Rural Area

SPECTRUM REQUIREMENT FORECASTS - 1st Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"		8,000	8,000	8,000	8,000
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)	41.60	41.60	41.60	41.60
Traffic Load/user (Erlang)		0.02	0.02	0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"		0.0003	0.0011	0.0030	0.0028
Subscriber Density Factor - "Ds"		1.0	1.0	1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)	0.0003	0.0011	0.0030	0.0028
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)	0.01	0.05	0.12	0.12
Blocking Probability (%) - "Pb"		2.0	2.0	2.0	2.0
# Channels/cell (using Erlang B Formula) - "m"		1	2	2	2
Effective Single Channel Bandwidth (kHz) - "b"		30.0	30.0	30.0	30.0
Effective Cell Cluster Size - "n"		21	21	21	21
# Frequencies/channel - "c"		2	2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)	1.3	2.5	2.5	2.5

SPECTRUM REQUIREMENT FORECASTS - 2nd Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"			8,000	8,000	8,000
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)		41.60	41.60	41.60
Traffic Load/user (Erlang)			0.02	0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"			0.0000	0.0013	0.0082
Subscriber Density Factor - "Ds"			1.0	1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.0000	0.0013	0.0082
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.00	0.05	0.34
Blocking Probability (%) - "Pb"			2.0	2.0	2.0
# Channels/cell (using Erlang B Formula) - "m"			0	2	3
Effective Single Channel Bandwidth (kHz) - "b"			15.0	15.0	15.0
Effective Cell Cluster Size - "n"			9	9	9
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.0	0.5	0.8

SPECTRUM REQUIREMENT FORECASTS - 3rd Generation		1986	1991	1996	2001
Cell Diameter (metres) - "d"				8,000	8,000
Hexagonal Cell Area (square kilometre) - "a"	(a=0.65*d*d/1,000,000)			41.60	41.60
Traffic Load/user (Erlang)				0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"				0.0000	0.0047
Subscriber Density Factor - "Ds"				1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)			0.0000	0.0047
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)			0.00	0.20
Blocking Probability (%) - "Pb"				2.0	2.0
# Channels/cell (using Erlang B Formula) - "m"				0	2
Effective Single Channel Bandwidth (kHz) - "b"				5.0	5.0
Effective Cell Cluster Size - "n"				24	24
# Frequencies/channel - "c"				2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)			0.0	0.5
Total Spectrum Bandwidth (MHz)		1.3	2.5	3.1	3.8

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Public Cordless Telephony/Personal Outdoor Communications
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

TOTAL POPULATION = .   600,000
POPULATION DENSITY =   217.0
TOTAL AREA (SQUARE KM) =   2,765.0
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	78.0	0.6	50.0	# Adults	468,000	482,209	496,850	511,936
					# Subscribers			68,940	255,968
					Market Penetration			13.9%	50.0%
	INDUSTRIES								
001-099	Primary Industries	1.6	1.1	5.0	# Employees	9,600	10,140	10,710	11,312
					# Subscribers			152	564
					Market Penetration			1.4%	5.0%
101-399	Manufacturing Industry	8.4	1.6	5.0	# Employees	50,400	54,563	59,070	63,949
					# Subscribers			861	3,197
					Market Penetration			1.5%	5.0%
404-421	Construction Industry	3.0	2.1	20.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers			1,325	4,917
					Market Penetration			6.0%	20.0%
501-519	Transportation Industry	2.1	2.3	0.0	# Employees	12,600	14,117	15,817	17,722
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
543-579	Communications & Utilities	1.8	2.7	0.0	# Employees	10,800	12,339	14,097	16,106
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
602-886	Service Industries	19.4	4.4	5.0	# Employees	116,400	144,363	179,043	222,055
					# Subscribers			2,990	11,102
					Market Penetration			1.7%	5.0%
	GOVERNMENT								
902-951	Government Services	4.5	2.7	5.0	# Employees	27,000	30,847	35,243	40,264
					# Subscribers			542	2,012
					Market Penetration			1.5%	5.0%
TOTALS	# Adults & Employees					712,800	768,550	832,988	907,928
	# Subscribers/Users							74,810	277,760

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Public Cordless Telephony/Personal Outdoor Communications
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

TOTAL POPULATION =   600,000
POPULATION DENSITY =   217.0
TOTAL AREA (SQUARE KM) =   2,765.0
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
Cell Diameter (metres) - "d"				200	200
Square Cell Area (square kilometre) - "a"	(a=0.5*d*d/1,000,000)			0.02	0.02
Traffic Load/user (Erlang)				0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"				0.54	2.01
Subscriber Density Factor - "Ds"				100.0	100.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)			54.11	200.91
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)			1.08	4.02
Blocking Probability (%) - "Pb"				1.0	1.0
# Channels/cell (using Erlang B Formula) - "m"				5	10
Effective Single Channel Bandwidth (kHz) - "b"				25.0	25.0
Effective Cell Cluster Size - "n"				16	16
# Frequencies/channel - "c"				2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)			4	8

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FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Public Cordless Telephony/Personal Outdoor Communications
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

TOTAL POPULATION = 36,000
POPULATION DENSITY = 223.1
TOTAL AREA (SQUARE KM) = 161.4
GROWTH OF MOBILE SERVICE = 30 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	75.8	0.6	50.0	# Adults	27,288	28,117	28,970	29,850
					# Subscribers			4,020	14,925
					Market Penetration			13.9%	50.0%
	INDUSTRIES								
001-099	Primary Industries	3.7	1.1	5.0	# Employees	1,332	1,407	1,486	1,570
					# Subscribers			21	78
					Market Penetration			1.4%	5.0%
101-399	Manufacturing Industry	8.5	1.6	5.0	# Employees	3,060	3,313	3,586	3,883
					# Subscribers			53	194
					Market Penetration			1.5%	5.0%
404-421	Construction Industry	2.7	2.1	20.0	# Employees	972	1,078	1,197	1,328
					# Subscribers			72	266
					Market Penetration			6.0%	20.0%
501-519	Transportation Industry	2.0	2.3	0.0	# Employees	720	807	904	1,013
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
543-579	Communications & Utilities	1.4	2.7	0.0	# Employees	504	576	658	752
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
602-886	Service Industries	16.0	4.4	5.0	# Employees	5,760	7,144	8,860	10,988
					# Subscribers			148	549
					Market Penetration			1.7%	5.0%
	GOVERNMENT								
902-951	Government Services	3.5	2.7	5.0	# Employees	1,260	1,440	1,645	1,879
					# Subscribers			26	94
					Market Penetration			1.6%	5.0%
TOTALS	# Adults & Employees					40,896	43,880	47,305	51,261
	# Subscribers/Users							4,340	16,106

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Public Cordless Telephony/Personal Outdoor Communications
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

TOTAL POPULATION =   36,000
POPULATION DENSITY =   223.1
TOTAL AREA (SQUARE KM) =   161.4
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
Cell Diameter (metres) - "d"				200	200
Square Cell Area (square kilometre) - "a"	(a=0.5*d*d/1,000,000)			0.02	0.02
Traffic Load/user (Erlang)				0.02	0.02
Traffic Load/square kilometre (Erlang) - "E"				0.54	2.00
Subscriber Density Factor - "Ds"				50.0	50.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)			26.90	99.81
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)			0.54	2.00
Blocking Probability (%) - "Pb"				1.0	1.0
# Channels/cell (using Erlang B Formula) - "m"				4	7
Effective Single Channel Bandwidth (kHz) - "b"				25.0	25.0
Effective Cell Cluster Size - "n"				16	16
# Frequencies/channel - "c"				2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)			3	6

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Public Cordless Telephony/Personal Indoor Communications
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

TOTAL POPULATION =   600,000
POPULATION DENSITY =   217.0
TOTAL AREA (SQUARE KM) =   2,765.0
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	78.0	0.6	50.0	# Adults	468,000	482,209	496,850	511,936
					# Subscribers			68,940	255,968
					Market Penetration			13.9%	50.0%
	INDUSTRIES								
001-099	Primary Industries	1.6	1.1	5.0	# Employees	9,600	10,140	10,710	11,312
					# Subscribers			152	564
					Market Penetration			1.4%	5.0%
101-399	Manufacturing Industry	8.4	1.6	5.0	# Employees	50,400	54,563	59,070	63,949
					# Subscribers			861	3,197
					Market Penetration			1.5%	5.0%
404-421	Construction Industry	3.0	2.1	20.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers			1,324	4,916
					Market Penetration			6.0%	20.0%
501-519	Transportation Industry	2.1	2.3	0.0	# Employees	12,600	14,117	15,817	17,722
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
543-579	Communications & Utilities	1.8	2.7	0.0	# Employees	10,800	12,339	14,097	16,106
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
602-886	Service Industries	19.4	4.4	5.0	# Employees	116,400	144,363	179,043	222,055
					# Subscribers			2,990	11,102
					Market Penetration			1.7%	5.0%
	GOVERNMENT								
902-951	Government Services	4.5	2.7	5.0	# Employees	27,000	30,847	35,243	40,264
					# Subscribers			542	2,012
					Market Penetration			1.5%	5.0%
TOTALS	# Adults & Employees					712,800	768,550	832,988	907,928
	# Subscribers/Users							74,809	277,759

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Public Cordless Telephony/Personal Indoor Communications
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

TOTAL POPULATION =   600,000
POPULATION DENSITY =   217.0
TOTAL AREA (SQUARE KM) =   2,765.0
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
Cell Diameter (metres) - "d"				30	30
Square Cell Area (square kilometre) - "a"	(a=0.5*d*d/1,000,000)			0.0005	0.0005
Traffic Load/user (Erlang)				0.05	0.05
Traffic Load/square kilometre (Erlang) - "E"				1.4	5.0
Subscriber Density Factor - "Ds"				10,000	10,000
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)			13,528.0	50,228.1
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)			6.09	22.60
Blocking Probability (%) - "Pb"				0.5	0.5
Channels/cell (using Erlang B Formula) - "m"				14	35
Effective Single Channel Bandwidth (kHz) - "b"				25.0	25.0
Effective Cell Cluster Size - "n"				21	21
Frequencies/channel - "c"				2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)			14.7	36.8

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Public Cordless Telephony/Personal Indoor Communications
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

TOTAL POPULATION =   36,000
POPULATION DENSITY =   223.1
TOTAL AREA (SQUARE KM) =   161.4
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	75.8	0.6	50.0	# Adults	27,288	28,117	28,970	29,850
					# Subscribers			4,019	14,922
					Market Penetration			13.9%	50.0%
	INDUSTRIES								
001-099	Primary Industries	3.7	1.1	5.0	# Employees	1,332	1,407	1,486	1,570
					# Subscribers			21	78
					Market Penetration			1.4%	5.0%
101-399	Manufacturing Industry	8.5	1.6	5.0	# Employees	3,060	3,313	3,586	3,883
					# Subscribers			52	193
					Market Penetration			1.4%	5.0%
404-421	Construction Industry	2.7	2.1	20.0	# Employees	972	1,078	1,197	1,328
					# Subscribers			72	266
					Market Penetration			6.0%	20.0%
501-519	Transportation Industry	2.0	2.3	0.0	# Employees	720	807	904	1,013
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
543-579	Communications & Utilities	1.4	2.7	0.0	# Employees	504	576	658	752
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
602-886	Service Industries	16.0	4.4	5.0	# Employees	5,760	7,144	8,860	10,988
					# Subscribers			148	549
					Market Penetration			1.7%	5.0%
	GOVERNMENT								
902-951	Government Services	3.5	2.7	5.0	# Employees	1,260	1,440	1,645	1,879
					# Subscribers			26	94
					Market Penetration			1.6%	5.0%
TOTALS	# Adults & Employees					40,896	43,880	47,305	51,261
	# Subscribers/Users							4,338	16,102

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Public Cordless Telephony/Personal Indoor Communications
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

TOTAL POPULATION =   36,000
POPULATION DENSITY =   223.1
TOTAL AREA (SQUARE KM) =   161.4
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
Cell Diameter (metres) - "d"				30	30
Square Cell Area (square kilometre) - "a"	(a=0.5*d*d/1,000,000)			0.0005	0.0005
Traffic Load/user (Erlang)				0.05	0.05
Traffic Load/square kilometre (Erlang) - "E"				1.3	5.0
Subscriber Density Factor - "Ds"				500.0	500.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)			672.09	2,494.72
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)			0.30	1.12
Blocking Probability (%) - "Pb"				0.5	0.5
# Channels/cell (using Erlang B Formula) - "m"				3	5
Effective Single Channel Bandwidth (kHz) - "b"				25.0	25.0
Effective Cell Cluster Size - "n"				21	21
# Frequencies/channel - "c"				2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)			3.2	5.3

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Public Cordless Telephony/Personal Indoor Communications
CITY/CENSUS AREA: Rural Area

```
TOTAL POPULATION =            600,000
POPULATION DENSITY =              3.4
TOTAL AREA (SQUARE KM) =    176,470.6
GROWTH OF MOBILE SERVICE =       30  % PER YEAR
```

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	74.6	0.6	50.0	# Adults	447,600	461,190	475,193	489,621
					# Subscribers			65,935	244,810
					Market Penetration			13.9%	50.0%
	INDUSTRIES								
001-099	Primary Industries	10.2	1.1	5.0	# Employees	61,200	64,641	68,275	72,114
					# Subscribers			971	3,605
					Market Penetration			1.4%	5.0%
101-399	Manufacturing Industry	6.4	1.6	5.0	# Employees	38,400	41,572	45,006	48,723
					# Subscribers			656	2,436
					Market Penetration			1.5%	5.0%
404-421	Construction Industry	3.0	2.1	20.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers			1,324	4,916
					Market Penetration			6.0%	20.0%
501-519	Transportation Industry	2.2	2.3	0.0	# Employees	13,200	14,789	16,570	18,566
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
543-579	Communications & Utilities	1.0	2.7	0.0	# Employees	6,000	6,855	7,832	8,948
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
602-886	Service Industries	12.0	4.4	5.0	# Employees	72,000	89,297	110,748	137,354
					# Subscribers			1,849	6,865
					Market Penetration			1.7%	5.0%
	GOVERNMENT								
902-951	Government Services	3.4	2.7	5.0	# Employees	20,400	23,307	26,628	30,422
					# Subscribers			410	1,521
					Market Penetration			1.5%	5.0%
TOTALS	# Adults & Employees					676,800	721,622	772,410	830,331
	# Subscribers/Users							71,145	264,154

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Public Cordless Telephony/Personal Indoor Communications
CITY/CENSUS AREA: Rural Area

TOTAL POPULATION =   600,000
POPULATION DENSITY =   3.4
TOTAL AREA (SQUARE KM) =   176,470.6
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
Cell Diameter (metres) - "d"				30	30
Square Cell Area (square kilometre) - "a"	(a=0.5*d*d/1,000,000)			0.0005	0.0005
Traffic Load/user (Erlang)				0.05	0.05
Traffic Load/square kilometre (Erlang) - "E"				0.0	0.1
Subscriber Density Factor - "Ds"				1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)			0.02	0.07
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)			0.00001	0.00003
Blocking Probability (%) - "Pb"				0.5	0.5
# Channels/cell (using Erlang B Formula) - "m"				1	1
Effective Single Channel Bandwidth (kHz) - "b"				25.0	25.0
Effective Cell Cluster Size - "n"				21	21
# Frequencies/channel - "c"				2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)			1	1

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Wireless Office Products
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

```
.OTAL POPULATION =          600,000
POPULATION DENSITY =          217.0
 OTAL AREA (SQUARE KM) =    2,765.0
 ROWTH OF MOBILE SERVICE =       30  % PER YEAR
```

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	78.0	0.6	0.0	# Adults	468,000	482,209	496,850	511,936
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
	INDUSTRIES								
001-099	Primary Industries	1.6	1.1	0.0	# Employees	9,600	10,140	10,710	11,312
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
101-399	Manufacturing Industry	8.4	1.6	5.0	# Employees	50,400	54,563	59,070	63,949
					# Subscribers			861	3,197
					Market Penetration			1.5%	5.0%
404-421	Construction Industry	3.0	2.1	0.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
501-519	Transportation Industry	2.1	2.3	0.0	# Employees	12,600	14,117	15,817	17,722
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
543-579	Communications & Utilities	1.8	2.7	5.0	# Employees	10,800	12,339	14,097	16,106
					# Subscribers			216	802
					Market Penetration			1.5%	5.0%
602-886	Service Industries	19.4	4.4	10.0	# Employees	116,400	144,363	179,043	222,055
					# Subscribers			5,980	22,203
					Market Penetration			3.3%	10.0%
	GOVERNMENT								
902-951	Government Services	4.5	2.7	10.0	# Employees	27,000	30,847	35,243	40,264
					# Subscribers			1,084	4,025
					Market Penetration			3.1%	10.0%
TOTALS	# Adults & Employees					712,800	768,550	832,988	907,928
	# Subscribers/Users							8,141	30,227

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Wireless Office Products
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

```
TOTAL POPULATION =           600,000
POPULATION DENSITY =           217.0
TOTAL AREA (SQUARE KM) =     2,765.0
GROWTH OF MOBILE SERVICE =        30 % PER YEAR
```

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
Cell Diameter (metres) - "d"				30	30
Square Cell Area (square kilometre) - "a"	(a=0.5*d*d/1,000,000)			0.0005	0.0005
Traffic Load/user (Erlang)				0.05	0.05
Traffic Load/square kilometre (Erlang) - "E"				0.15	0.55
Subscriber Density Factor - "Ds"				10,000	10,000
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)			1472.2	5466.0
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)			0.66	2.46
Blocking Probability (%) - "Pb"				0.5	0.5
# Channels/cell (using Erlang B Formula) - "a"				4	8
Effective Single Channel Bandwidth (kHz) - "b"				25.0	25.0
Effective Cell Cluster Size - "n"				21	21
# Frequencies/channel - "c"				2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*a*b*n*c)			4	8

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Wireless Office Products
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

TOTAL POPULATION =   36,000
POPULATION DENSITY =   223.1
TOTAL AREA (SQUARE KM) = 161.4
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	75.8	0.6	0.0	# Adults	27,288	28,117	28,970	29,850
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
	INDUSTRIES								
001-099	Primary Industries	3.7	1.1	0.0	# Employees	1,332	1,407	1,486	1,570
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
101-399	Manufacturing Industry	8.5	1.6	5.0	# Employees	3,060	3,313	3,586	3,883
					# Subscribers			52	193
					Market Penetration			1.4%	5.0%
404-421	Construction Industry	2.7	2.1	0.0	# Employees	972	1,078	1,197	1,328
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
501-519	Transportation Industry	2.0	2.3	0.0	# Employees	720	807	904	1,013
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
543-579	Communications & Utilities	1.4	2.7	5.0	# Employees	504	576	658	752
					# Subscribers			11	38
					Market Penetration			1.7%	5.0%
602-886	Service Industries	16.0	4.4	10.0	# Employees	5,760	7,144	8,860	10,988
					# Subscribers			296	1,099
					Market Penetration			3.3%	10.0%
	GOVERNMENT								
902-951	Government Services	3.5	2.7	10.0	# Employees	1,260	1,440	1,645	.1,879
					# Subscribers			51	188
					Market Penetration			3.1%	10.0%
TOTALS	# Adults & Employees					40,896	43,880	47,305	51,261
	# Subscribers/Users							410	1,517

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Mobile Data
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

TOTAL POPULATION =   600,000
POPULATION DENSITY =   217.0
TOTAL AREA (SQUARE KM) =   2,765.0
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
Cell Diameter (metres) - "d"			25,000	25,000	25,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		487.5	487.5	487.5
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.002	0.006	0.013
Subscriber Density Factor - "Ds"			5.0	5.0	5.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.011	0.028	0.064
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		5.3	13.7	31.1
Maximum Traffic Capacity/cell (Erlang) - "Tc"			1.0	1.0	1.0
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		5	14	31
Effective Single Channel Bandwidth (kHz) - "b"			25.0	12.5	12.5
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		1.9	2.4	5.4

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

YPE OF MOBILE SERVICE: Mobile Data
ITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

TOTAL POPULATION =   36,000
OPULATION DENSITY =   223.1
TOTAL AREA (SQUARE KM) =   161.4
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	75.8	0.6	0.0	# Adults	27,288	28,117	28,970	29,850
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
	INDUSTRIES								
001-099	Primary Industries	3.7	1.1	0.0	# Employees	1,332	1,407	1,486	1,570
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
101-399	Manufacturing Industry	8.5	1.6	0.0	# Employees	3,060	3,313	3,586	3,883
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
404-421	Construction Industry	2.7	2.1	0.0	# Employees	972	1,078	1,197	1,328
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
501-519	Transportation Industry	2.0	2.3	25.0	# Employees	720	807	904	1,013
					# Subscribers		23	85	253
					Market Penetration		2.9%	9.4%	25.0%
543-579	Communications & Utilities	1.4	2.7	0.0	# Employees	504	576	658	752
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
602-886	Service Industries	16.0	4.4	5.0	# Employees	5,760	7,144	8,860	10,988
					# Subscribers		29	108	400
					Market Penetration		0.4%	1.2%	3.6%
	GOVERNMENT								
902-951	Government Services	3.5	2.7	5.0	# Employees	1,260	1,440	1,645	1,879
					# Subscribers		49	82	94
					Market Penetration		3.4%	5.0%	5.0%
TOTALS	# Adults & Employees					40,896	43,880	47,305	51,261
	# Subscribers/Users						101	275	747

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Wireless Office Products
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

TOTAL POPULATION =   36,000
POPULATION DENSITY =   223.1
TOTAL AREA (SQUARE KM) =   161.4
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
Cell Diameter (metres) - "d"				30	30
Square Cell Area (square kilometre) - "a"	(a=0.5*d*d/1,000,000)			0.0005	0.0005
Traffic Load/user (Erlang)				0.05	0.05
Traffic Load/square kilometre (Erlang) - "E"				0.13	0.47
Subscriber Density Factor - "Ds"				500	500
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)			63.5	235.1
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)			0.03	0.11
Blocking Probability (%) - "Pb"				0.5	0.5
# Channels/cell (using Erlang B Formula) - "m"				2	3
Effective Single Channel Bandwidth (kHz) - "b"				25.0	25.0
Effective Cell Cluster Size - "n"				21	21
# Frequencies/channel - "c"				2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)			2	3

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Wireless Office Products
CITY/CENSUS AREA: Rural Area

TOTAL POPULATION = 600,000
POPULATION DENSITY = 3.4
TOTAL AREA (SQUARE KM) = 176,470.6
GROWTH OF MOBILE SERVICE = 30 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	74.6	0.6	0.0	# Adults	447,600	461,190	475,193	489,621
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
	INDUSTRIES								
001-099	Primary Industries	10.2	1.1	0.0	# Employees	61,200	64,641	68,275	72,114
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
101-399	Manufacturing Industry	6.4	1.6	5.0	# Employees	38,400	41,572	45,006	48,723
					# Subscribers			656	2,436
					Market Penetration			1.5%	5.0%
404-421	Construction Industry	3.0	2.1	0.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
501-519	Transportation Industry	2.2	2.3	0.0	# Employees	13,200	14,789	16,570	18,566
					# Subscribers			0	0
					Market Penetration			0.0%	0.0%
543-579	Communications & Utilities	1.0	2.7	5.0	# Employees	6,000	6,855	7,832	8,948
					# Subscribers			120	446
					Market Penetration			1.5%	5.0%
602-886	Service Industries	12.0	4.4	10.0	# Employees	72,000	89,297	110,748	137,354
					# Subscribers			3,699	13,734
					Market Penetration			3.3%	10.0%
	GOVERNMENT								
902-951	Government Services	3.4	2.7	10.0	# Employees	20,400	23,307	26,628	30,422
					# Subscribers			819	3,041
					Market Penetration			3.1%	10.0%
TOTALS	# Adults & Employees					676,800	721,622	772,410	830,331
	# Subscribers/Users							5,294	19,656

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Wireless Office Products
CITY/CENSUS AREA: Rural Area

TOTAL POPULATION =   600,000
POPULATION DENSITY =   3.4
TOTAL AREA (SQUARE KM) =   176,470.6
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
Cell Diameter (metres) - "d"				30	30
Square Cell Area (square kilometre) - "a"	(a=0.5*d*d/1,000,000)			0.0005	0.0005
Traffic Load/user (Erlang)				0.05	0.05
Traffic Load/square kilometre (Erlang) - "E"				0.001	0.006
Subscriber Density Factor - "Ds"				1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)			0.001	0.006
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)			0.000001	0.000003
Blocking Probability (%) - "Pb"				0.5	0.5
Channels/cell (using Erlang B Formula) - "m"				1	1
Effective Single Channel Bandwidth (kHz) - "b"				25.0	25.0
Effective Cell Cluster Size - "n"				21	21
Frequencies/channel - "c"				2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)			1	1

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Two-Way Radio Dispatch
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

TOTAL POPULATION = 600,000
POPULATION DENSITY = 217.0
TOTAL AREA (SQUARE KM) = 2,765.0
GROWTH OF MOBILE SERVICE = 20 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	78.0	0.6	0.0	# Adults	468,000	482,209	496,850	511,936
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
	INDUSTRIES								
001-099	Primary Industries	1.6	1.1	10.0	# Employees	9,600	10,140	10,710	11,312
					# Subscribers		162	403	1,003
					Market Penetration		1.6%	3.8%	8.9%
101-399	Manufacturing Industry	8.4	1.6	25.0	# Employees	50,400	54,563	59,070	63,949
					# Subscribers		3,245	8,075	15,987
					Market Penetration		5.9%	13.7%	25.0%
404-421	Construction Industry	3.0	2.1	25.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers		1,642	4,086	6,146
					Market Penetration		8.2%	18.4%	25.0%
501-519	Transportation Industry	2.1	2.3	50.0	# Employees	12,600	14,117	15,817	17,722
					# Subscribers		2,035	5,064	8,861
					Market Penetration		14.4%	32.0%	50.0%
543-579	Communications & Utilities	1.8	2.7	50.0	# Employees	10,800	12,339	14,097	16,106
					# Subscribers		765	1,904	4,737
					Market Penetration		6.2%	13.5%	29.4%
602-886	Service Industries	19.4	4.4	10.0	# Employees	116,400	144,363	179,043	222,055
					# Subscribers		1,610	4,006	9,969
					Market Penetration		1.1%	2.2%	4.5%
	GOVERNMENT								
902-951	Government Services	4.5	2.7	50.0	# Employees	27,000	30,847	35,243	40,264
					# Subscribers		8,431	17,621	20,132
					Market Penetration		27.3%	50.0%	50.0%
TOTALS	# Adults & Employees					712,800	768,550	832,988	907,928
	# Subscribers/Users						17,890	41,158	66,835

Subscriber Distribution	1991	1996	2001
- Non-trunked Systems (25 kHz spacing)	95.0	26.0	0.0
- Non-trunked Systems (12.5 kHz spacing)	0.0	44.0	60.0
- Trunked Systems (25 kHz spacing)	5.0	30.0	40.0

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Two-Way Radio Dispatch
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

TOTAL POPULATION = 36,000
POPULATION DENSITY = 223.1
TOTAL AREA (SQUARE KM) = 161.4
GROWTH OF MOBILE SERVICE = 20 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	75.8	0.6	0.0	# Adults	27,288	28,117	28,970	29,850
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
	INDUSTRIES								
001-099	Primary Industries	3.7	1.1	10.0	# Employees	1,332	1,407	1,486	1,570
					# Subscribers		40	100	157
					Market Penetration		2.8%	6.7%	10.0%
101-399	Manufacturing Industry	8.5	1.6	25.0	# Employees	3,060	3,313	3,586	3,883
					# Subscribers		151	376	935
					Market Penetration		4.6%	10.5%	24.1%
404-421	Construction Industry	2.7	2.1	25.0	# Employees	972	1,078	1,197	1,328
					# Subscribers		65	162	332
					Market Penetration		6.0%	13.5%	25.0%
501-519	Transportation Industry	2.0	2.3	50.0	# Employees	720	807	904	1,013
					# Subscribers		228	452	506
					Market Penetration		28.3%	50.0%	50.0%
543-579	Communications & Utilities	1.4	2.7	50.0	# Employees	504	576	658	752
					# Subscribers		134	329	376
					Market Penetration		23.3%	50.0%	50.0%
602-886	Service Industries	16.0	4.4	10.0	# Employees	5,760	7,144	8,860	10,988
					# Subscribers		286	712	1,099
					Market Penetration		4.0%	8.0%	10.0%
	GOVERNMENT								
902-951	Government Services	3.5	2.7	50.0	# Employees	1,260	1,440	1,645	1,879
					# Subscribers		490	822	940
					Market Penetration		34.0%	50.0%	50.0%
TOTALS	# Adults & Employees					40,896	43,880	47,305	51,261
	# Subscribers/Users						1,394	2,952	4,344

Subscriber Distribution	1991	1996	2001
- Non-trunked Systems (25 kHz spacing)	95.0	26.0	0.0
- Non-trunked Systems (12.5 kHz spacing)	0.0	44.0	60.0
- Trunked Systems (25 kHz spacing)	5.0	30.0	40.0

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Two-Way Radio Dispatch
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

SPECTRUM REQUIREMENT FORECASTS - Non-trunked Systems (25 kHz spacing)		1986	1991	1996	2001
Cell Diameter (metres) - "d"			25,000	25,000	25,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		487.50	487.50	487.50
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.04	0.02	0.00
Subscriber Density Factor - "Ds"			2.0	2.0	2.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.08	0.05	0.00
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		40.0	23.2	0.0
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.25	0.25	0.25
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		160	93	0
Effective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		56.0	32.5	0.0

SPECTRUM REQUIREMENT FORECASTS - Non-trunked Systems (12.5 kHz spacing)		1986	1991	1996	2001
Cell Diameter (metres) - "d"			25,000	25,000	25,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		487.50	487.50	487.50
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.00	0.04	0.08
Subscriber Density Factor - "Ds"			2.0	2.0	2.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.00	0.08	0.16
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.0	39.2	78.7
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.25	0.25	0.25
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		0	157	315
Effective Single Channel Bandwidth (kHz) - "b"			12.5	12.5	12.5
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.0	27.5	55.1

SPECTRUM REQUIREMENT FORECASTS - Trunked Systems (25 kHz spacing)		1986	1991	1996	2001
Cell Diameter (metres) - "d"			25,000	25,000	25,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		487.50	487.50	487.50
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.00	0.03	0.05
Subscriber Density Factor - "Ds"			2.0	2.0	2.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.00	0.05	0.11
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		2.1	26.8	52.5
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.75	0.75	0.75
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		3	36	70
Effective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		1.0	12.5	24.5
Total Spectrum Bandwidth (MHz)			57.0	72.4	79.6

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Two-Way Radio Dispatch
CITY/CENSUS AREA: Rural Area

TOTAL POPULATION =   600,000
POPULATION DENSITY =   3.4
TOTAL AREA (SQUARE KM) =   176,470.6
GROWTH OF MOBILE SERVICE =   20 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	74.6	0.6	0.0	# Adults	447,600	461,190	475,193	489,621
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
	INDUSTRIES								
001-099	Primary Industries	10.2	1.1	10.0	# Employees	61,200	64,641	68,275	72,114
					# Subscribers		162	403	1,003
					Market Penetration		0.3%	0.6%	1.4%
101-399	Manufacturing Industry	6.4	1.6	25.0	# Employees	38,400	41,572	45,006	48,723
					# Subscribers		3,245	8,075	12,181
					Market Penetration		7.8%	17.9%	25.0%
404-421	Construction Industry	3.0	2.1	25.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers		1,642	4,086	6,146
					Market Penetration		8.2%	18.4%	25.0%
501-519	Transportation Industry	2.2	2.3	50.0	# Employees	13,200	14,789	16,570	18,566
					# Subscribers		2,035	5,064	9,283
					Market Penetration		13.8%	30.6%	50.0%
543-579	Communications & Utilities	1.0	2.7	50.0	# Employees	6,000	6,855	7,832	8,948
					# Subscribers		765	1,904	4,474
					Market Penetration		11.2%	24.3%	50.0%
602-886	Service Industries	12.0	4.4	10.0	# Employees	72,000	89,297	110,748	137,354
					# Subscribers		1,610	4,006	9,969
					Market Penetration		1.8%	3.6%	7.3%
	GOVERNMENT								
902-951	Government Services	3.4	2.7	50.0	# Employees	20,400	23,307	26,628	30,422
					# Subscribers		8,431	13,314	15,211
					Market Penetration		36.2%	50.0%	50.0%
TOTALS	# Adults & Employees					676,800	721,622	772,410	830,331
	# Subscribers/Users						17,890	36,851	58,266

Subscriber Distribution		1991	1996	2001
- Non-trunked Systems (25 kHz spacing)		95.0	26.0	0.0
- Non-trunked Systems (12.5 kHz spacing)		0.0	44.0	60.0
- Trunked Systems (25 kHz spacing)		5.0	30.0	40.0

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Two-Way Radio Dispatch
CITY/CENSUS AREA: Rural Area

SPECTRUM REQUIREMENT FORECASTS - Non-trunked Systems (25 kHz spacing)

		1986	1991	1996	2001
Cell Diameter (metres) - "d"			40,000	40,000	40,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		1248.0	1248.0	1248.0
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.0005	0.0003	0.0000
Subscriber Density Factor - "Ds"			1.0	1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.0005	0.0003	0.0000
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.6	0.3	0.0
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.25	0.25	0.25
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		2	1	0
Effective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.8	0.5	0.0

SPECTRUM REQUIREMENT FORECASTS - Non-trunked Systems (12.5 kHz spacing)

		1986	1991	1996	2001
Cell Diameter (metres) - "d"			40,000	40,000	40,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		1248.0	1248.0	1248.0
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.0000	0.0005	0.001
Subscriber Density Factor - "Ds"			1.0	1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.0000	0.0005	0.001
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.0	0.6	1.2
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.25	0.25	0.25
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		0	2	5
Effective Single Channel Bandwidth (kHz) - "b"			12.5	12.5	12.5
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.0	0.4	0.9

SPECTRUM REQUIREMENT FORECASTS - Trunked Systems (25 kHz spacing)

		1986	1991	1996	2001
Cell Diameter (metres) - "d"			40,000	40,000	40,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		1248.0	1248.0	1248.0
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.00003	0.00031	0.00066
Subscriber Density Factor - "Ds"			1.0	1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.00003	0.00031	0.00066
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.03	0.39	0.82
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.75	0.75	0.75
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		0	1	1
Effective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.0	0.2	0.4
Total Spectrum Bandwidth (MHz)			0.9	1.1	1.2

TYPE OF MOBILE SERVICE: Two-Way Radio Dispatch (Delayed Technology Transition)
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

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TOTAL POPULATION =          600,000
POPULATION DENSITY =          217.0
TOTAL AREA (SQUARE KM) =    2,765.0
GROWTH OF MOBILE SERVICE =       20  % PER YEAR
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SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	78.0	0.6	0.0	# Adults	468,000	482,209	496,850	511,936
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
	INDUSTRIES								
001-099	Primary Industries	1.6	1.1	10.0	# Employees	9,600	10,140	10,710	11,312
					# Subscribers		162	403	1,003
					Market Penetration		1.6%	3.8%	8.9%
101-399	Manufacturing Industry	8.4	1.6	25.0	# Employees	50,400	54,563	59,070	63,949
					# Subscribers		3,245	8,075	15,987
					Market Penetration		5.9%	13.7%	25.0%
404-421	Construction Industry	3.0	2.1	25.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers		1,642	4,086	6,146
					Market Penetration		8.2%	18.4%	25.0%
501-519	Transportation Industry	2.1	2.3	50.0	# Employees	12,600	14,117	15,817	17,722
					# Subscribers		2,035	5,064	8,861
					Market Penetration		14.4%	32.0%	50.0%
543-579	Communications & Utilities	1.8	2.7	50.0	# Employees	10,800	12,339	14,097	16,106
					# Subscribers		765	1,904	4,737
					Market Penetration		6.2%	13.5%	29.4%
602-886	Service Industries	19.4	4.4	10.0	# Employees	116,400	144,363	179,043	222,055
					# Subscribers		1,610	4,006	9,969
					Market Penetration		1.1%	2.2%	4.5%
	GOVERNMENT								
902-951	Government Services	4.5	2.7	50.0	# Employees	27,000	30,847	35,243	40,264
					# Subscribers		8,431	17,621	20,132
					Market Penetration		27.3%	50.0%	· 50.0%
TOTALS	# Adults & Employees					712,800	768,550	832,988	907,928
	# Subscribers/Users						17,890	41,158	66,835

Subscriber Distribution		1991	1996	2001
	- Non-trunked Systems (25 kHz spacing)	100.0	95.0	26.0
	- Non-trunked Systems (12.5 kHz spacing)	0.0	0.0	44.0
	- Trunked Systems (25 kHz spacing)	0.0	5.0	30.0

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Two-Way Radio Dispatch (Delayed Technology Transition)
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

SPECTRUM REQUIREMENT FORECASTS - Non-trunked Systems (25 kHz spacing)

		1986	1991	1996	2001
Cell Diameter (metres) - "d"			25,000	25,000	25,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		487.50	487.50	487.50
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.03	0.07	0.03
Subscriber Density Factor - "Ds"			5.0	5.0	5.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.16	0.35	0.16
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		78.9	172.3	76.6
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.25	0.25	0.25
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		315	689	306
Effective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		110.4	241.3	107.2

SPECTRUM REQUIREMENT FORECASTS - Non-trunked Systems (12.5 kHz spacing)

		1986	1991	1996	2001
Cell Diameter (metres) - "d"			25,000	25,000	25,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		487.50	487.50	487.50
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.00	0.00	0.05
Subscriber Density Factor - "Ds"			5.0	5.0	5.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.00	0.00	0.27
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.0	0.0	129.6
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.25	0.25	0.25
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		0	0	518
Effective Single Channel Bandwidth (kHz) - "b"			12.5	12.5	12.5
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.0	0.0	90.7

SPECTRUM REQUIREMENT FORECASTS - Trunked Systems (25 kHz spacing)

		1986	1991	1996	2001
Cell Diameter (metres) - "d"			25,000	25,000	25,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		487.50	487.50	487.50
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.000	0.004	0.036
Subscriber Density Factor - "Ds"			5.0	5.0	5.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.00	0.02	0.18
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.0	9.1	88.4
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.75	0.75	0.75
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		0	12	118
Effective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.0	4.2	41.2
Total Spectrum Bandwidth (MHz)			110.4	245.5	239.2

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Two-Way Radio Dispatch (Delayed Technology Transition)
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

```
TOTAL POPULATION =          36,000
POPULATION DENSITY =         223.1
TOTAL AREA (SQUARE KM) =     161.4
GROWTH OF MOBILE SERVICE =      20  % PER YEAR
```

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	75.8	0.6	0.0	# Adults	27,288	28,117	28,970	29,850
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
	INDUSTRIES								
001-099	Primary Industries	3.7	1.1	10.0	# Employees	1,332	1,407	1,486	1,570
					# Subscribers		40	100	157
					Market Penetration		2.8%	6.7%	10.0%
101-399	Manufacturing Industry	8.5	1.6	25.0	# Employees	3,060	3,313	3,586	3,883
					# Subscribers		151	376	935
					Market Penetration		4.6%	10.5%	24.1%
404-421	Construction Industry	2.7	2.1	25.0	# Employees	972	1,078	1,197	1,328
					# Subscribers		65	162	332
					Market Penetration		6.0%	13.5%	25.0%
501-519	Transportation Industry	2.0	2.3	50.0	# Employees	720	807	904	1,013
					# Subscribers		228	452	506
					Market Penetration		28.3%	50.0%	50.0%
543-579	Communications & Utilities	1.4	2.7	50.0	# Employees	504	576	658	752
					# Subscribers		134	329	376
					Market Penetration		23.3%	50.0%	50.0%
602-886	Service Industries	16.0	4.4	10.0	# Employees	5,760	7,144	8,860	10,988
					# Subscribers		286	712	1,099
					Market Penetration		4.0%	8.0%	10.0%
	GOVERNMENT								
902-951	Government Services	3.5	2.7	50.0	# Employees	1,260	1,440	1,645	1,879
					# Subscribers		490	822	940
					Market Penetration		34.0%	50.0%	50.0%
TOTALS	# Adults & Employees					40,896	43,880	47,305	51,261
	# Subscribers/Users						1,394	2,952	4,344

Subscriber Distribution	1991	1996	2001
- Non-trunked Systems (25 kHz spacing)	100.0	95.0	26.0
- Non-trunked Systems (12.5 kHz spacing)	0.0	0.0	44.0
- Trunked Systems (25 kHz spacing)	0.0	5.0	30.0

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Two-Way Radio Dispatch (Delayed Technology Transition)
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

SPECTRUM REQUIREMENT FORECASTS - Non-trunked Systems (25 kHz spacing)

		1986	1991	1996	2001
Cell Diameter (metres) - "d"			25,000	25,000	25,000
Circular Cell Area (square kilometre) - "a"	$(a=0.78*d*d/1,000,000)$		487.50	487.50	487.50
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.04	0.09	0.03
Subscriber Density Factor - "Ds"			2.0	2.0	2.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	$(Ep=E*Ds)$		0.09	0.17	0.07
Traffic Load/cell (Erlang) - "Ec"	$(Ec=Ep*a)$		42.1	84.7	34.1
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.25	0.25	0.25
# Channels/cell (based on Erlang B Formula) - "m"	$(m=Ec/Tc)$		168	339	136
Effective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	$(B=0.001*m*b*n*c)$		59.0	118.6	47.8

SPECTRUM REQUIREMENT FORECASTS - Non-trunked Systems (12.5 kHz spacing)

		1986	1991	1996	2001
Cell Diameter (metres) - "d"			25,000	25,000	25,000
Circular Cell Area (square kilometre) - "a"	$(a=0.78*d*d/1,000,000)$		487.50	487.50	487.50
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.00	0.00	0.06
Subscriber Density Factor - "Ds"			2.0	2.0	2.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	$(Ep=E*Ds)$		0.00	0.00	0.12
Traffic Load/cell (Erlang) - "Ec"	$(Ec=Ep*a)$		0.0	0.0	57.7
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.25	0.25	0.25
# Channels/cell (based on Erlang B Formula) - "m"	$(m=Ec/Tc)$		0	0	231
Effective Single Channel Bandwidth (kHz) - "b"			12.5	12.5	12.5
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	$(B=0.001*m*b*n*c)$		0.0	0.0	40.4

SPECTRUM REQUIREMENT FORECASTS - Trunked Systems (25 kHz spacing)

		1986	1991	1996	2001
Cell Diameter (metres) - "d"			25,000	25,000	25,000
Circular Cell Area (square kilometre) - "a"	$(a=0.78*d*d/1,000,000)$		487.50	487.50	487.50
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.00	0.00	0.04
Subscriber Density Factor - "Ds"			2.0	2.0	2.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	$(Ep=E*Ds)$		0.00	0.01	0.08
Traffic Load/cell (Erlang) - "Ec"	$(Ec=Ep*a)$		0.0	4.5	39.4
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.75	0.75	0.75
# Channels/cell (based on Erlang B Formula) - "m"	$(m=Ec/Tc)$		0	6	52
Effective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	$(B=0.001*m*b*n*c)$		0.0	2.1	18.4

		1986	1991	1996	2001
Total Spectrum Bandwidth (MHz)			59.0	120.7	106.6

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Two-Way Radio Dispatch (Delayed Technology Transition)
CITY/CENSUS AREA: Rural Area

```
TOTAL POPULATION =            600,000
POPULATION DENSITY =              3.4
TOTAL AREA (SQUARE KM) =    176,470.6
GROWTH OF MOBILE SERVICE =       20 % PER YEAR
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SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	74.6	0.6	0.0	# Adults	447,600	461,190	475,193	489,621
					# Subscribers		0	0	0
					Market Penetration		.0.0%	0.0%	0.0%
	INDUSTRIES								
001-099	Primary Industries	10.2	1.1	10.0	# Employees	61,200	64,641	68,275	72,114
					# Subscribers		162	403	1,003
					Market Penetration		0.3%	0.6%	1.4%
101-399	Manufacturing Industry	6.4	1.6	25.0	# Employees	38,400	41,572	45,006	48,723
					# Subscribers		3,245	8,075	12,181
					Market Penetration		7.8%	17.9%	25.0%
404-421	Construction Industry	3.0	2.1	25.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers		1,642	4,086	6,146
					Market Penetration		8.2%	18.4%	25.0%
501-519	Transportation Industry	2.2	2.3	50.0	# Employees	13,200	14,789	16,570	18,566
					# Subscribers		2,035	5,064	9,283
					Market Penetration		13.8%	30.6%	50.0%
543-579	Communications & Utilities	1.0	2.7	50.0	# Employees	6,000	6,855	7,832	8,948
					# Subscribers		765	1,904	4,474
					Market Penetration		11.2%	24.3%	50.0%
602-886	Service Industries	12.0	4.4	10.0	# Employees	72,000	89,297	110,748	137,354
					# Subscribers		1,610	4,006	9,969
					Market Penetration		1.8%	3.6%	7.3%
	GOVERNMENT								
902-951	Government Services	3.4	2.7	50.0	# Employees	20,400	23,307	26,628	30,422
					# Subscribers		8,431	13,314	15,211
					Market Penetration		36.2%	50.0%	50.0%
TOTALS	# Adults & Employees					676,800	721,622	772,410	830,331
	# Subscribers/Users						17,890	36,851	58,266

Subscriber Distribution	1991	1996	2001
- Non-trunked Systems (25 kHz spacing)	100.0	95.0	26.0
- Non-trunked Systems (12.5 kHz spacing)	0.0	0.0	44.0
- Trunked Systems (25 kHz spacing)	0.0	5.0	30.0

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Two-Way Radio Dispatch (Delayed Technology Transition)
CITY/CENSUS AREA: Rural Area

SPECTRUM REQUIREMENT FORECASTS - Non-trunked Systems (25 kHz spacing)

		1986	1991	1996	2001
Cell Diameter (metres) - "d"			40,000	40,000	40,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		1248.0	1248.0	1248.0
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.0005	0.0010	0.0004
Subscriber Density Factor - "Ds"			1.0	1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.0005	0.0010	0.0004
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.6	1.2	0.5
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.25	0.25	0.25
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		3	5	2
Effective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.9	1.7	0.7

SPECTRUM REQUIREMENT FORECASTS - Non-trunked Systems (12.5 kHz spacing)

		1986	1991	1996	2001
Cell Diameter (metres) - "d"			40,000	40,000	40,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		1248.0	1248.0	1248.0
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.0000	0.0000	0.001
Subscriber Density Factor - "Ds"			1.0	1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.0000	0.0000	0.001
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.0	0.0	0.9
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.25	0.25	0.25
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		0	0	4
Effective Single Channel Bandwidth (kHz) - "b"			12.5	12.5	12.5
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.0	0.0	0.6

SPECTRUM REQUIREMENT FORECASTS - Trunked Systems (25 kHz spacing)

		1986	1991	1996	2001
Cell Diameter (metres) - "d"			40,000	40,000	40,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		1248.0	1248.0	1248.0
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.00000	0.00005	0.00050
Subscriber Density Factor - "Ds"			1.0	1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.00000	0.00005	0.00050
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.00	0.07	0.62
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.75	0.75	0.75
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		0	0	1
Effective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.0	0.0	0.3
Total Spectrum Bandwidth (MHz)			0.9	1.8	1.7

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

YPE OF MOBILE SERVICE: Aeronautical Mobile
ITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

OTAL POPULATION =   600,000
JPULATION DENSITY =   217.0
TOTAL AREA (SQUARE KM) = 2,765.0
ROWTH OF MOBILE SERVICE =   10 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	78.0	0.6	1.0	# Adults	468,000	482,209	496,850	511,936
					# Subscribers		5	8	13
					Market Penetration		0.0%	0.0%	0.0%
	INDUSTRIES								
001-099	Primary Industries	1.6	1.1	1.0	# Employees	9,600	10,140	10,710	11,312
					# Subscribers		7	11	18
					Market Penetration		0.1%	0.1%	0.2%
101-399	Manufacturing Industry	8.4	1.6	1.0	# Employees	50,400	54,563	59,070	63,949
					# Subscribers		11	18	29
					Market Penetration		0.0%	0.0%	0.0%
404-421	Construction Industry	3.0	2.1	1.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers		20	32	52
					Market Penetration		0.1%	0.1%	0.2%
501-519	Transportation Industry	2.1	2.3	10.0	# Employees	12,600	14,117	15,817	17,722
					# Subscribers		354	570	918
					Market Penetration		2.5%	3.6%	5.2%
543-579	Communications & Utilities	1.8	2.7	1.0	# Employees	10,800	12,339	14,097	16,106
					# Subscribers		1	2	3
					Market Penetration		0.0%	0.0%	0.0%
602-886	Service Industries	19.4	4.4	1.0	# Employees	116,400	144,363	179,043	222,055
					# Subscribers		55	89	143
					Market Penetration		0.0%	0.0%	0.1%
	GOVERNMENT								
902-951	Government Services	4.5	2.7	1.0	# Employees	27,000	30,847	35,243	40,264
					# Subscribers		9	14	23
					Market Penetration		0.0%	0.0%	0.1%
TOTALS	# Adults & Employees					712,800	768,550	832,988	907,928
	# Subscribers/Users						462	744	1,198

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Aeronautical Mobile
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

```
TOTAL POPULATION =        600,000
POPULATION DENSITY =        217.0
TOTAL AREA (SQUARE KM) =  2,765.0
GROWTH OF MOBILE SERVICE =     10 % PER YEAR
```

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
Cell Diameter (metres) - "d"			100,000	100,000	100,000
Circular Cell Area (square kilometre) - "a"	$(a=0.78*d*d/1,000,000)$		7800.00	7800.00	7800.00
Traffic Load/user (Erlang)			0.0025	0.0025	0.0025
Traffic Load/square kilometre (Erlang) - "E"			0.0004	0.0007	0.0011
Subscriber Density Factor - "Ds"			0.40	0.40	0.40
Peak Traffic Load/square kilometre (Erlang) - "Ep"	$(Ep=E*Ds)$		0.0002	0.0003	0.0004
Traffic Load/cell (Erlang) - "Ec"	$(Ec=Ep*a)$		1.3	2.1	3.4
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.1	0.1	0.1
# Channels/cell (based on Erlang B Formula) - "m"	$(m=Ec/Tc)$		13	21	34
Effective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
Effective Cell Cluster Size - "n"			44	44	44
# Frequencies/channel - "c"			1	1	1
Spectrum Bandwidth (MHz) - "B"	$(B=0.001*m*b*n*c)$		14	23	37

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Aeronautical Mobile
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

TOTAL POPULATION =   36,000
POPULATION DENSITY =   223.1
TOTAL AREA (SQUARE KM) = 161.4
GROWTH OF MOBILE SERVICE =   10 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	75.8	0.6	1.0	# Adults	27,288	28,117	28,970	29,850
					# Subscribers		1	2	3
					Market Penetration		0.0%	0.0%	0.0%
	INDUSTRIES								
001-099	Primary Industries	3.7	1.1	1.0	# Employees	1,332	1,407	1,486	1,570
					# Subscribers		1	2	3
					Market Penetration		0.1%	0.1%	0.2%
101-399	Manufacturing Industry	8.5	1.6	1.0	# Employees	3,060	3,313	3,586	3,883
					# Subscribers		1	2	3
					Market Penetration		0.0%	0.0%	0.1%
404-421	Construction Industry	2.7	2.1	1.0	# Employees	972	1,078	1,197	1,328
					# Subscribers		2	3	5
					Market Penetration		0.2%	0.3%	0.4%
501-519	Transportation Industry	2.0	2.3	10.0	# Employees	720	807	904	1,013
					# Subscribers		22	35	57
					Market Penetration		2.7%	3.9%	5.6%
543-579	Communications & Utilities	1.4	2.7	1.0	# Employees	504	576	658	752
					# Subscribers		1	2	3
					Market Penetration		0.2%	0.2%	0.3%
602-886	Service Industries	16.0	4.4	1.0	# Employees	5,760	7,144	8,860	10,988
					# Subscribers		4	6	10
					Market Penetration		0.1%	0.1%	0.1%
	GOVERNMENT								
902-951	Government Services	3.5	2.7	1.0	# Employees	1,260	1,440	1,645	1,879
					# Subscribers		1	2	3
					Market Penetration		0.1%	0.1%	0.1%
TOTALS					# Adults & Employees	40,896	43,880	47,305	51,261
					# Subscribers/Users		33	53	86

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

YPE OF MOBILE SERVICE: Aeronautical Mobile
ITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

OTAL POPULATION =	36,000
OPULATION DENSITY =	223.1
TOTAL AREA (SQUARE KM) =	161.4
GROWTH OF MOBILE SERVICE =	10 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
Cell Diameter (metres) - "d"			100,000	100,000	100,000
Circular Cell Area (square kilometre) - "a"	$(a=0.78*d*d/1,000,000)$		7800.0	7800.0	7800.0
Traffic Load/user (Erlang)			0.0025	0.0025	0.0025
Traffic Load/square kilometre (Erlang) - "E"			0.001	0.001	0.001
Subscriber Density Factor - "Ds"			0.02	0.02	0.02
Peak Traffic Load/square kilometre (Erlang) - "Ep"	$(Ep=E*Ds)$		0.00001	0.00002	0.00003
Traffic Load/cell (Erlang) - "Ec"	$(Ec=Ep*a)$		0.1	0.1	0.2
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.1	0.1	0.1
# Channels/cell (based on Erlang B Formula) - "m"	$(m=Ec/Tc)$		1	1	2
Effective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
Effective Cell Cluster Size - "n"			44	44	44
# Frequencies/channel - "c"			1	1	1
Spectrum Bandwidth (MHz) - "B"	$(B=0.001*m*b*n*c)$		1	1	2

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Aeronautical Mobile
CITY/CENSUS AREA: Rural Area

TOTAL POPULATION =   600,000
POPULATION DENSITY =   3.4
TOTAL AREA (SQUARE KM) =   176,470.6
GROWTH OF MOBILE SERVICE =   10 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	74.6	0.6	1.0	# Adults	447,600	461,190	475,193	489,621
					# Subscribers		5	8	13
					Market Penetration		0.0%	0.0%	0.0%
	INDUSTRIES								
001-099	Primary Industries	10.2	1.1	1.0	# Employees	61,200	64,641	68,275	72,114
					# Subscribers		7	11	18
					Market Penetration		0.0%	0.0%	0.0%
101-399	Manufacturing Industry	6.4	1.6	1.0	# Employees	38,400	41,572	45,006	48,723
					# Subscribers		11	18	29
					Market Penetration		0.0%	0.0%	0.1%
404-421	Construction Industry	3.0	2.1	1.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers		20	32	52
					Market Penetration		0.1%	0.1%	0.2%
501-519	Transportation Industry	2.2	2.3	10.0	# Employees	13,200	14,789	16,570	18,566
					# Subscribers		354	570	918
					Market Penetration		2.4%	3.4%	4.9%
543-579	Communications & Utilities	1.0	2.7	1.0	# Employees	6,000	6,855	7,832	8,948
					# Subscribers		1	2	3
					Market Penetration		0.0%	0.0%	0.0%
602-886	Service Industries	12.0	4.4	1.0	# Employees	72,000	89,297	110,748	137,354
					# Subscribers		55	89	143
					Market Penetration		0.1%	0.1%	0.1%
	GOVERNMENT								
902-951	Government Services	3.4	2.7	1.0	# Employees	20,400	23,307	26,628	30,422
					# Subscribers		9	14	23
					Market Penetration		0.0%	0.1%	0.1%
TOTALS					# Adults & Employees	676,800	721,622	772,410	830,331
					# Subscribers/Users		462	744	1,198

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

YPE OF MOBILE SERVICE: Aeronautical Mobile
.ITY/CENSUS AREA: Rural Area

```
TOTAL POPULATION =          600,000
OPULATION DENSITY =             3.4
TOTAL AREA (SQUARE KM) =   176,470.6
GROWTH OF MOBILE SERVICE =       10  % PER YEAR
```

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
ell Diameter (metres) - "d"			240,000	240,000	240,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		44928.0	44928.0	44928.0
Traffic Load/user (Erlang)			0.0025	0.0025	0.0025
raffic Load/square kilometre (Erlang) - "E"			0.00001	0.00001	0.00002
subscriber Density Factor - "Ds"			1.0	1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.00001	0.00001	0.00002
raffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.3	0.5	0.8
laximum Traffic Capacity/cell (Erlang) - "Tc"			0.1	0.1	0.1
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		3	5	8
ffective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
ffective Cell Cluster Size - "n"			44	44	44
# Frequencies/channel - "c"			1	1	1
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		3	5	8

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Maritime Mobile
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

```
TOTAL POPULATION =          600,000
POPULATION DENSITY =          217.0
TOTAL AREA (SQUARE KM) =    2,765.0
GROWTH OF MOBILE SERVICE =     10  % PER YEAR
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SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	78.0	0.6	5.0	# Adults	468,000	482,209	496,850	511,936
					# Subscribers		2,503	4,031	6,492
					Market Penetration		0.5%	0.8%	1.3%
	INDUSTRIES								
001-099	Primary Industries	1.6	1.1	1.0	# Employees	9,600	10,140	10,710	11,312
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
101-399	Manufacturing Industry	8.4	1.6	0.0	# Employees	50,400	54,563	59,070	63,949
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
404-421	Construction Industry	3.0	2.1	0.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
501-519	Transportation Industry	2.1	2.3	5.0	# Employees	12,600	14,117	15,817	17,722
					# Subscribers		196	316	508
					Market Penetration		1.4%	2.0%	2.9%
543-579	Communications & Utilities	1.8	2.7	0.0	# Employees	10,800	12,339	14,097	16,106
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
602-886	Service Industries	19.4	4.4	0.0	# Employees	116,400	144,363	179,043	222,055
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
	GOVERNMENT								
902-951	Government Services	4.5	2.7	1.0	# Employees	27,000	30,847	35,243	40,264
					# Subscribers		42	68	109
					Market Penetration		0.1%	0.2%	0.3%
TOTALS					# Adults & Employees	712,800	768,550	832,988	907,928
					# Subscribers/Users		2,741	4,414	7,109

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

YPE OF MOBILE SERVICE: Maritime Mobile
∪ITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area – CMA)

OTAL POPULATION =	600,000
OPULATION DENSITY =	217.0
TOTAL AREA (SQUARE KM) =	2,765.0
⌐ROWTH OF MOBILE SERVICE =	10 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
₋ell Diameter (metres) – "d"			75,000	75,000	75,000
Circular Cell Area (square kilometre) – "a"	$(a=0.78*d*d/1,000,000)$		4387.50	4387.50	4387.50
⌐raffic Load/user (Erlang)			0.0025	0.0025	0.0025
⌐raffic Load/square kilometre (Erlang) – "E"			0.002	0.004	0.006
Subscriber Density Factor – "Ds"			0.50	0.50	0.50
ᵖeak Traffic Load/square kilometre (Erlang) – "Ep"	$(Ep=E*Ds)$		0.001	0.002	0.003
⌐raffic Load/cell (Erlang) – "Ec"	$(Ec=Ep*a)$		5.4	8.8	14.1
Aaximum Traffic Capacity/cell (Erlang) – "Tc"			0.1	0.1	0.1
# Channels/cell (based on Erlang B Formula) – "m"	$(m=Ec/Tc)$		54	88	141
Effective Single Channel Bandwidth (kHz) – "b"			25.0	25.0	25.0
Effective Cell Cluster Size – "n"			4	4	4
# Frequencies/channel – "c"			1.2	1.2	1.2
Spectrum Bandwidth (MHz) – "B"	$(B=0.001*m*b*n*c)$		6.5	10.5	16.9

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

'PE OF MOBILE SERVICE: Maritiae Mobile
TY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

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)TAL POPULATION =        36,000
'PULATION DENSITY =       223.1
TOTAL AREA (SQUARE KM) =  161.4
ROWTH OF MOBILE SERVICE =    10  % PER YEAR
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SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	75.8	0.6	5.0	# Adults	27,288	28,117	28,970	29,850
					# Subscribers		151	243	392
					Market Penetration		0.5%	0.8%	1.3%
	INDUSTRIES								
)01-099	Primary Industries	3.7	1.1	1.0	# Employees	1,332	1,407	1,486	1,570
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
101-399	Manufacturing Industry	8.5	1.6	0.0	# Employees	3,060	3,313	3,586	3,883
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
404-421	Construction Industry	2.7	2.1	0.0	# Employees	972	1,078	1,197	1,328
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
501-519	Transportation Industry	2.0	2.3	5.0	# Employees	720	807	904	1,013
					# Subscribers		12	19	31
					Market Penetration		1.5%	2.1%	3.1%
543-579	Communications & Utilities	1.4	2.7	0.0	# Employees	504	576	658	752
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
602-886	Service Industries	16.0	4.4	0.0	# Employees	5,760	7,144	8,860	10,988
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
	GOVERNMENT								
902-951	Government Services	3.5	2.7	1.0	# Employees	1,260	1,440	1,645	1,879
					# Subscribers		3	5	8
					Market Penetration		0.2%	0.3%	0.4%
TOTALS					# Adults & Employees	40,896	43,880	47,305	51,261
					# Subscribers/Users		166	267	431

TYPE OF MOBILE SERVICE: Maritime Mobile
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

TOTAL POPULATION =   36,000
POPULATION DENSITY =   223.1
TOTAL AREA (SQUARE KM) =   161.4
GROWTH OF MOBILE SERVICE =   10 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
Cell Diameter (metres) - "d"			75,000	75,000	75,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		4387.5	4387.5	4387.5
Traffic Load/user (Erlang)			0.0025	0.0025	0.0025
Traffic Load/square kilometre (Erlang) - "E"			0.003	0.004	0.007
Subscriber Density Factor - "Ds"			0.05	0.05	0.05
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.0001	0.0002	0.0003
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.6	0.9	1.5
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.1	0.1	0.1
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		6	9	15
Effective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
Effective Cell Cluster Size - "n"			4	4	4
# Frequencies/channel - "c"			1.2	1.2	1.2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.7	1.1	1.8

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Maritime Mobile
CITY/CENSUS AREA: Rural Area

TOTAL POPULATION =	600,000
POPULATION DENSITY =	3.4
TOTAL AREA (SQUARE KM) =	176,470.6
GROWTH OF MOBILE SERVICE =	10 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	74.6	0.6	5.0	# Adults	447,600	461,190	475,193	489,621
					# Subscribers		2,503	4,031	6,492
					Market Penetration		0.5%	0.8%	1.3%
	INDUSTRIES								
001-099	Primary Industries	10.2	1.1	1.0	# Employees	61,200	64,641	68,275	72,114
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
101-399	Manufacturing Industry	6.4	1.6	0.0	# Employees	38,400	41,572	45,006	48,723
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
404-421	Construction Industry	3.0	2.1	0.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
501-519	Transportation Industry	2.2	2.3	5.0	# Employees	13,200	14,789	16,570	18,566
					# Subscribers		196	316	508
					Market Penetration		1.3%	1.9%	2.7%
543-579	Communications & Utilities	1.0	2.7	0.0	# Employees	6,000	6,855	7,832	8,948
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
602-886	Service Industries	12.0	4.4	0.0	# Employees	72,000	89,297	110,748	137,354
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
	GOVERNMENT								
902-951	Government Services	3.4	2.7	1.0	# Employees	20,400	23,307	26,628	30,422
					# Subscribers		42	68	109
					Market Penetration		0.2%	0.3%	0.4%
TOTALS	# Adults & Employees					676,800	721,622	772,410	830,331
	# Subscribers/Users						2,741	4,414	7,109

TYPE OF MOBILE SERVICE: Maritime Mobile
CITY/CENSUS AREA: Rural Area

TOTAL POPULATION =   600,000
POPULATION DENSITY =   3.4
TOTAL AREA (SQUARE KM) =   176,470.6
GROWTH OF MOBILE SERVICE =   10 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
Cell Diameter (metres) - "d"			75,000	75,000	75,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		4387.5	4387.5	4387.5
Traffic Load/user (Erlang)			0.0025	0.0025	0.0025
Traffic Load/square kilometre (Erlang) - "E"			0.00004	0.0001	0.0001
Subscriber Density Factor - "Ds"			1.0	1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.00004	0.00006	0.00010
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.2	0.3	0.4
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.1	0.1	0.1
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		2	3	4
Effective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
Effective Cell Cluster Size - "n"			4	4	4
# Frequencies/channel - "c"			1.2	1.2	1.2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.2	0.3	0.5

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

YPE OF MOBILE SERVICE: Paging
ITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

```
TOTAL POPULATION =        600,000
OPULATION DENSITY =         217.0
TOTAL AREA (SQUARE KM) =  2,765.0
GROWTH OF MOBILE SERVICE =     25 % PER YEAR
```

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	78.0	0.6	5.0	# Adults	468,000	482,209	496,850	511,936
					# Subscribers		2,748	8,386	25,593
					Market Penetration		0.6%	1.7%	5.0%
	INDUSTRIES								
001-099	Primary Industries	1.6	1.1	0.0	# Employees	9,600	10,140	10,710	11,312
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
101-399	Manufacturing Industry	8.4	1.6	5.0	# Employees	50,400	54,563	59,070	63,949
					# Subscribers		343	1,047	3,194
					Market Penetration		0.6%	1.8%	5.0%
404-421	Construction Industry	3.0	2.1	10.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers		264	806	2,458
					Market Penetration		1.3%	3.6%	10.0%
501-519	Transportation Industry	2.1	2.3	0.0	# Employees	12,600	14,117	15,817	17,722
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
543-579	Communications & Utilities	1.8	2.7	5.0	# Employees	10,800	12,339	14,097	16,106
					# Subscribers		86	262	801
					Market Penetration		0.7%	1.9%	5.0%
602-886	Service Industries	19.4	4.4	10.0	# Employees	116,400	144,363	179,043	222,055
					# Subscribers		2,384	7,275	22,203
					Market Penetration		1.7%	4.1%	10.0%
	GOVERNMENT								
902-951	Government Services	4.5	2.7	5.0	# Employees	27,000	30,847	35,243	40,264
					# Subscribers		216	659	2,012
					Market Penetration		0.7%	1.9%	5.0%
TOTALS	# Adults & Employees					712,800	768,550	832,988	907,928
	# Subscribers/Users						6,041	18,436	56,261

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Paging
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

TOTAL POPULATION =   600,000
POPULATION DENSITY =   217.0
TOTAL AREA (SQUARE KM) =   2,765.0
GROWTH OF MOBILE SERVICE =   25 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
Cell Diameter (metres) - "d"			25,000	25,000	25,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		487.5	487.5	487.5
Traffic Load/user (Erlang)			0.00002	0.00002	0.00002
Traffic Load/square kilometre (Erlang) - "E"			0.0000	0.0001	0.0004
Subscriber Density Factor - "Ds"			5.0	5.0	5.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.0002	0.0007	0.0020
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.1	0.3	1.0
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.02	0.02	0.02
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		5	16	50
Effective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			1	1	1
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		1	3	9

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

YPE OF MOBILE SERVICE: Paging
_ITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

TOTAL POPULATION =   36,000
OPULATION DENSITY =   223.1
TOTAL AREA (SQUARE KM) =   161.4
GROWTH OF MOBILE SERVICE =   25 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	75.8	0.6	5.0	# Adults	27,288	28,117	28,970	29,850
					# Subscribers		160	488	1,490
					Market Penetration		0.6%	1.7%	5.0%
	INDUSTRIES								
001-099	Primary Industries	3.7	1.1	0.0	# Employees	1,332	1,407	1,486	1,570
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
101-399	Manufacturing Industry	8.5	1.6	5.0	# Employees	3,060	3,313	3,586	3,883
					# Subscribers		21	64	194
					Market Penetration		0.6%	1.8%	5.0%
404-421	Construction Industry	2.7	2.1	10.0	# Employees	972	1,078	1,197	1,328
					# Subscribers		15	46	133
					Market Penetration		1.4%	3.8%	10.0%
501-519	Transportation Industry	2.0	2.3	0.0	# Employees	720	807	904	1,013
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
543-579	Communications & Utilities	1.4	2.7	5.0	# Employees	504	576	658	752
					# Subscribers		4	12	37
					Market Penetration		0.7%	1.9%	5.0%
602-886	Service Industries	16.0	4.4	10.0	# Employees	5,760	7,144	8,860	10,988
					# Subscribers		118	360	1,099
					Market Penetration		1.7%	4.1%	10.0%
	GOVERNMENT								
902-951	Government Services	3.5	2.7	5.0	# Employees	1,260	1,440	1,645	1,879
					# Subscribers		10	31	93
					Market Penetration		0.7%	1.9%	5.0%
TOTALS	# Adults & Employees					40,896	43,880	47,305	51,261
	# Subscribers/Users						328	1,001	3,046

TYPE OF MOBILE SERVICE: Paging
CITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

TOTAL POPULATION =   36,000
POPULATION DENSITY =   223.1
TOTAL AREA (SQUARE KM) =   161.4
GROWTH OF MOBILE SERVICE =   25 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
Cell Diameter (metres) - "d"			25,000	25,000	25,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		487.5	487.5	487.5
Traffic Load/user (Erlang)			0.00002	0.00002	0.00002
Traffic Load/square kilometre (Erlang) - "E"			0.00004	0.00012	0.00038
Subscriber Density Factor - "Ds"			2.0	2.0	2.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.0001	0.0002	0.0008
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.04	0.12	0.37
Maximum Traffic Capacity/cell (Erlang) - "Tc"			0.02	0.02	0.02
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		2	6	18
Effective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			1	1	1
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.3	1	3

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Paging
CITY/CENSUS AREA: Rural Area

TOTAL POPULATION =   600,000
POPULATION DENSITY =   3.4
TOTAL AREA (SQUARE KM) =   176,470.6
GROWTH OF MOBILE SERVICE =   25 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	74.6	0.6	5.0	# Adults	447,600	461,190	475,193	489,621
					# Subscribers		2,628	8,020	24,475
					Market Penetration		0.6%	1.7%	5.0%
	INDUSTRIES								
001-099	Primary Industries	10.2	1.1	0.0	# Employees	61,200	64,641	68,275	72,114
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
101-399	Manufacturing Industry	6.4	1.6	5.0	# Employees	38,400	41,572	45,006	48,723
					# Subscribers		261	797	2,431
					Market Penetration		0.6%	1.8%	5.0%
404-421	Construction Industry	3.0	2.1	10.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers		264	806	2,458
					Market Penetration		1.3%	3.6%	10.0%
501-519	Transportation Industry	2.2	2.3	0.0	# Employees	13,200	14,789	16,570	18,566
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
543-579	Communications & Utilities	1.0	2.7	5.0	# Employees	6,000	6,855	7,832	8,948
					# Subscribers		48	146	447
					Market Penetration		0.7%	1.9%	5.0%
602-886	Service Industries	12.0	4.4	10.0	# Employees	72,000	89,297	110,748	137,354
					# Subscribers		1,474	4,498	13,728
					Market Penetration		1.7%	4.1%	10.0%
	GOVERNMENT								
902-951	Government Services	3.4	2.7	5.0	# Employees	20,400	23,307	26,628	30,422
					# Subscribers		163	497	1,518
					Market Penetration		0.7%	1.9%	5.0%
TOTALS	# Adults & Employees					676,800	721,622	772,410	830,331
	# Subscribers/Users						4,838	14,764	45,057

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Paging
ITY/CENSUS AREA: Rural Area

TOTAL POPULATION =   600,000
JPULATION DENSITY =   3.4
IOTAL AREA (SQUARE KM) =   176,470.6
GROWTH OF MOBILE SERVICE =   25 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
ell Diameter (metres) - "d"			40,000	40,000	40,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		1248.0	1248.0	1248.0
Traffic Load/user (Erlang)			0.00002	0.00002	0.00002
raffic Load/square kilometre (Erlang) - "E"			0.000001	0.000002	0.000005
Subscriber Density Factor - "Ds"			1.0	1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.000001	0.000002	0.000005
raffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.001	0.002	0.006
axiaua Traffic Capacity/cell (Erlang) - "Tc"			0.02	0.02	0.02
# Channels/cell (based on Erlang B Formula) - "a"	(a=Ec/Tc)		0.03	0.10	0.32
ffective Single Channel Bandwidth (kHz) - "b"			25.0	25.0	25.0
ffective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			1	1	1
pectrum Bandwidth (MHz) - "B"	(B=0.001*a*b*n*c)		0.01	0.02	0.06

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Mobile Data
CITY/CENSUS AREA: Metropolitan Area (Census Metropolitan Area - CMA)

TOTAL POPULATION = 600,000
POPULATION DENSITY = 217.0
TOTAL AREA (SQUARE KM) = 2,765.0
GROWTH OF MOBILE SERVICE = 30 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	78.0	0.6	0.0	# Adults	468,000	482,209	496,850	511,936
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
	INDUSTRIES								
001-099	Primary Industries	1.6	1.1	0.0	# Employees	9,600	10,140	10,710	11,312
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
101-399	Manufacturing Industry	8.4	1.6	0.0	# Employees	50,400	54,563	59,070	63,949
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
404-421	Construction Industry	3.0	2.1	0.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
501-519	Transportation Industry	2.1	2.3	25.0	# Employees	12,600	14,117	15,817	17,722
					# Subscribers		204	757	2,812
					Market Penetration		1.4%	4.8%	15.9%
543-579	Communications & Utilities	1.8	2.7	0.0	# Employees	10,800	12,339	14,097	16,106
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
602-886	Service Industries	19.4	4.4	5.0	# Employees	116,400	144,363	179,043	222,055
					# Subscribers		161	598	2,220
					Market Penetration		0.1%	0.3%	1.0%
	GOVERNMENT								
902-951	Government Services	4.5	2.7	5.0	# Employees	27,000	30,847	35,243	40,264
					# Subscribers		844	1,762	2,013
					Market Penetration		2.7%	5.0%	5.0%
TOTALS	# Adults & Employees					712,800	768,550	832,988	907,928
	# Subscribers/Users						1,209	3,117	7,045

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Mobile Data
ITY/CENSUS AREA: Urban Area (Census Agglomeration - CA)

TOTAL POPULATION =   36,000
POPULATION DENSITY =   223.1
TOTAL AREA (SQUARE KM) =   161.4
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
Cell Diameter (metres) - "d"			25,000	25,000	25,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		487.5	487.5	487.5
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.003	0.009	0.023
Subscriber Density Factor - "Ds"			2.0	2.0	2.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.006	0.017	0.046
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		3.1	8.3	22.6
Maximum Traffic Capacity/cell (Erlang) - "Tc"			1.0	1.0	1.0
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		3	8	23
Effective Single Channel Bandwidth (kHz) - "b"			25.0	12.5	12.5
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		1.1	1.5	3.9

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

TYPE OF MOBILE SERVICE: Mobile Data
CITY/CENSUS AREA: Rural Area

TOTAL POPULATION =   600,000
POPULATION DENSITY =   3.4
TOTAL AREA (SQUARE KM) =   176,470.6
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SIC CODES	POTENTIAL USER GROUPS	#EMPLOYEES AS % OF POPULATION	% ANNUAL GROWTH OF USER GROUP	MAX % MARKET PENETRATION OF MOBILE SERVICE	SUBSCRIBER GROWTH FORECASTS	1986	1991	1996	2001
	CONSUMERS								
N/A	Adults (15 years & over)	74.6	0.6	0.0	# Adults	447,600	461,190	475,193	489,621
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
	INDUSTRIES								
001-099	Primary Industries	10.2	1.1	0.0	# Employees	61,200	64,641	68,275	72,114
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
101-399	Manufacturing Industry	6.4	1.6	0.0	# Employees	38,400	41,572	45,006	48,723
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
404-421	Construction Industry	3.0	2.1	0.0	# Employees	18,000	19,971	22,158	24,584
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
501-519	Transportation Industry	2.2	2.3	25.0	# Employees	13,200	14,789	16,570	18,566
					# Subscribers		204	757	2,812
					Market Penetration		1.4%	4.6%	15.1%
543-579	Communications & Utilities	1.0	2.7	0.0	# Employees	6,000	6,855	7,832	8,948
					# Subscribers		0	0	0
					Market Penetration		0.0%	0.0%	0.0%
602-886	Service Industries	12.0	4.4	5.0	# Employees	72,000	89,297	110,748	137,354
					# Subscribers		161	598	2,220
					Market Penetration		0.2%	0.5%	1.6%
	GOVERNMENT								
902-951	Government Services	3.4	2.7	5.0	# Employees	20,400	23,307	26,628	30,422
					# Subscribers		844	1,331	1,521
					Market Penetration		3.6%	5.0%	5.0%
TOTALS	# Adults & Employees					676,800	721,622	772,410	830,331
	# Subscribers/Users						1,209	2,687	6,553

FORECASTS OF SUBSCRIBER GROWTH AND SPECTRUM REQUIREMENTS

YPE OF MOBILE SERVICE: Mobile Data
ITY/CENSUS AREA: Rural Area

TOTAL POPULATION =   600,000
OPULATION DENSITY =   3.4
TOTAL AREA (SQUARE KM) =   176,470.6
GROWTH OF MOBILE SERVICE =   30 % PER YEAR

SPECTRUM REQUIREMENT FORECASTS		1986	1991	1996	2001
ell Diameter (metres) - "d"			40,000	40,000	40,000
Circular Cell Area (square kilometre) - "a"	(a=0.78*d*d/1,000,000)		1248.0	1248.0	1248.0
Traffic Load/user (Erlang)			0.005	0.005	0.005
Traffic Load/square kilometre (Erlang) - "E"			0.00003	0.00008	0.00019
Subscriber Density Factor - "Ds"			1.0	1.0	1.0
Peak Traffic Load/square kilometre (Erlang) - "Ep"	(Ep=E*Ds)		0.00003	0.00008	0.00019
Traffic Load/cell (Erlang) - "Ec"	(Ec=Ep*a)		0.04	0.09	0.23
Maximum Traffic Capacity/cell (Erlang) - "Tc"			1.0	1.0	1.0
# Channels/cell (based on Erlang B Formula) - "m"	(m=Ec/Tc)		0.0	0.1	0.2
Effective Single Channel Bandwidth (kHz) - "b"			25.0	12.5	12.5
Effective Cell Cluster Size - "n"			7	7	7
# Frequencies/channel - "c"			2	2	2
Spectrum Bandwidth (MHz) - "B"	(B=0.001*m*b*n*c)		0.01	0.02	0.04

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PAGING SYSTEMS

(Reference: CCIR Report 900-1)

- ### Types
  - On-site: hospitals, colleges, buildings
  - Wide Area: metropolitan, national

- ### Signal Types
  - Tones (alerting);
  - Numeric messages (10 characters);
  - Alphanumeric messages (40 characters);
  - Message length limited by channel capacity and storage capacity in the pager receivers. Ultimate length probably 64 characters.

- ### Transmission Rate   512 bps (UK and CCIR standards)
                            200 - 600 bps (others)
  - Based on transmission rate of 512 bps and 8 bits per character, the message lengths become:
    - numeric messages: $(10 \times 8)/512 = 0.16$ seconds
    - alphanumeric messages: $(40 \times 8)/512 = 0.63$ seconds

- ### Capacity
  - Call rate per subscriber =   0.1 calls per busy hour (UK system designed on this)
  - Erlangs per subscriber =   numeric messages: $0.016/3600 = 4.4 \times 10^{-6}$ E

    $$\frac{\text{Calls} \times \text{message length}}{3600}$$
           alphanumeric messages: $0.063/3600 = 1.75 \times 10^{-5}$ E

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- **Number of Possible Subscribers**
  - France suggested that, on a national basis, there is likely to be 20 pagers for every 1000 people in the population.

- **RF Channelization**
  - Two channel spacings are used: 25 kHz (North American)

    12.5 kHz
  - The modulations used:

	25 kHz	12.5 kHz
Peak frequency deviation	±4.5 kHz	±2.5 kHz
RF channel bandwidth	16 kHz	8 kHz
Modulation	FSK	FSK

- **Frequency Bands Allocated (CCIR)**   26.1 - 50 MHz

  68   - 88 MHz

  146 - 174 MHz

  450 - 470 MHz

  806 - 960 MHz

  USA use 30 MHz, 150 MHz, 450 MHz, 930 MHz

  UK use   150 MHz, 470 MHz

  Bandwidth allocation is 450 kHz at 150 MHz

- **Future Improvements**
  - Use 1200 bps
  - Use longer messages

- **Performance Criteria**
  - Blocking Probability = 2%

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MOBILE DATA SYSTEMS

- **Message Characteristics**
    - The message is received in alphanumeric characters on a visual panel;
    - Most messages are of a standard form which can be generated by a code word; the sender merely presses the appropriate push buttons which represent the code word.

- **Users**
    - dispatch services: taxis, distributors of produce or mail, etc.
    - public safety: police, firemen, etc.
    - public utilities: public transportation, etc.

- **Architecture**
    - From dispatch office to mobile and vice versa. Mobile-to-Mobile not generally possible except via the dispatcher;
    - Therefore all mobiles transmit on the same frequency (or group of frequencies) while all mobiles receive on another frequency or sets of frequencies from the dispatcher;
    - The direction of transmission from the mobile to the dispatcher is called the reverse link and that from the dispatcher to the mobile is called the forward link;
    - A particular system could consist of one channel in the reverse link (in which case the mobiles contend for its use) and one channel in the forward link (no contention necessary as only the dispatcher uses it);
    - Large systems use trunking.

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ANNEX C
References

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