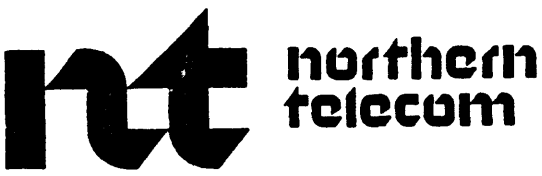
Response to Notice of Inquiry Relating to Establishment of New Personal Communications Services

Federal Communications Commission
Docket No. 90-314

October 1, 1990



Before the
Federal Communications Commission
Washington, D.C. 20554

In the matter of	)	
	)	
	)	
Amendment of the Commission's Rules	)	Gen. Docket No. 90-314
to Establish New Personal	)	RM-7140
Communications Services	)	RM-7175

Comments of Northern Telecom Inc.

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SUMMARY

The Federal Communications Commission initiative in enhancing telecommunications by assigning radio spectrum to provide a broad range of new advanced mobile personal communications services will provide benefits for millions of Americans. Personal communications services are expected to benefit the communications industry as a whole, end-users, existing service providers, and new entrants. Personal communications systems, in conjunction with the adoption of a "personal telecommunications number" numbering plan, will allow individuals to place calls and be reached anytime and anywhere. Implementation of these services will require development of an infrastructure that includes radio access, personal communications devices, a unique calling number associated with an individual, voice and narrowband data transport and access to intelligent network signaling and database capabilities.

Northern Telecom Inc. (Northern Telecom) respectfully suggests that the following specific concrete steps should be undertaken now to bring the promise of personal communications to fruition.

1. The immediate allocation of 930-931 MHz and 940-941 MHz on a primary basis, and the adjacent 930-960 MHz on a co-primary sharing basis, for first generation personal communication services. This initial allocation will satisfy the latent demand for low power personal communication services that permit two-way wireless communications within buildings and in transit at various public locations, as well as "priming the pump" by creating a large base of equipment and service providers. Northern Telecom does not agree with the recent proposal to allocate 930-931 MHz for Low Earth Orbit (LEO) mobile satellite systems for reasons provided herein.

2. Adopt the Personal Communications Interface Standard (PCI) as the U.S. standard for providing low-power pedestrian and in-building (work and residential) systems using the spectrum outlined above. The proposed PCI standard incorporates advanced digital architecture with common channel signaling, a common air interface and call handoff to offer a model for low-power, spectrum efficient, two-way communications networks. The PCI standard specifications are attached as an Annex to this document.

3. The Commission should foster the use of digital standards already adopted for cellular mobile radio channel allocation in the 800 MHz band to permit relief of spectrum congestion in a growing number of metropolitan areas. Evolving technologies applied in the band will significantly increase the spectrum density of mobile users who can be served by cellular operators in congested areas.

4. The Commission should further encourage software based network infrastructures that are currently being deployed by carriers. These can cost-effectively provide functionality to permit universal number access to mobile users across both public and private network nodes. Utilization of these infrastructures can contribute to the cost effectiveness of personal communications services.

5. The Commission should examine the feasibility of allocating additional spectrum above 1GHz to meet the demand for personal communications services that are expected to track the explosive growth of cellular telephone services in the U.S. If demand for services meets current projections, the available spectrum below 1 GHz will be exhausted in the mid to late 1990's. The FCC should begin immediately to provide an additional allocation of spectrum above 1 GHz to meet this need. In the short term, the spectrum can be on a shared basis, but in the longer term Northern Telecom believes that primary exclusive allocation of spectrum will be required.

6. The Commission needs to examine allocating spectrum for potentially cost effective wireless distribution of access services for voice and narrowband data in certain applications. Northern Telecom stands ready to assist the Commission in this regard.

7. Alternatives exist for providing personal communications services by means of various radio technologies such as FDMA, CDMA/spread spectrum, TDMA, etc. The Commission should encourage, through the granting of experimental licenses, trial services using these technologies, and the identification of recommended standards to be utilized in bands reserved for personal communications services at the 1992 WARC. Only if the industry is not successful in agreeing on radio technologies to be utilized in these bands within a reasonable time frame, should the Commission intervene. Standards should be adopted to minimize frag-

mentation of the market place and balkanization of the spectrum, thus maximizing the interworking opportunities for personal communications.

8. To permit the rapid evolution of personal communications services in accordance with the road map suggested by Northern Telecom, the Commission should create a regulatory environment that minimizes regulatory restrictions on services, and focuses primarily on necessary requirements for network interoperability, prevention of radio interference, and efficient bandwidth utilization. Although equipment type approval may be required, there should be no individual user licensing of handsets or base stations for customer premise. The Commission should, to the maximum extent possible, allow free-market forces to dictate both the suppliers and availability of services.

9. New licensing policies should favor innovative applications of technology by existing operators and new entrants, maintaining a level playing field that seeks to maximize benefits for the end user. In addition, Northern Telecom recommends that the Commission adopt licensing policies to encourage networking and interoperability on a wide area basis, while optimizing the number of licensees to maximize spectral efficiency. By initiating and/or supervising these activities, the Commission can bring the benefits of PCS to the American public, and speed the development and growth of PCS globally.

In summary, Northern Telecom applauds the Commission for initiating this Notice of Inquiry. Northern Telecom is ready to cooperate fully with the FCC in its attempt to help launch an array of new services to the American public that will enhance communications services for the millions of people who are on the move.

1.0 Introduction

Northern Telecom Inc. (Northern Telecom) hereby submits its comments in response to the Federal Communications Commission Notice of Inquiry on Personal Communications Services.[1] Northern Telecom is the second largest telecommunications manufacturer in the U.S. Northern Telecom is headquartered in Nashville, Tennessee, and has more than 22,000 employees in the U.S. in 12 manufacturing plants, and in marketing, sales and service offices across the nation. Northern Telecom's research subsidiary, Bell Northern Research Inc. (BNR), operates several research and development centers throughout the United States.

Northern Telecom has a strong interest in ensuring the growth and development of mobile telecommunications throughout the world. With this inquiry, the FCC focuses on the role of the radio spectrum in bringing a broad range of Personal Communications Services ("PCS") to fruition, a worthy goal in view of the enormous potential benefits of PCS. Market research conducted by Northern Telecom confirms the extensive demand for Personal Communications Services. Approximately 45% of all U.S. workers require some type of mobile communications. In addition Northern Telecom anticipates the potential for millions of residential units being deployed within five years of the introduction of PCS services.

In its comments, Northern Telecom will attempt to assist the Commission's inquiry by providing a framework in which proposed frequency allocations can be evaluated in the context of an intelligent wireline/wireless infrastructure that permits voice and/or narrowband data communications to and from individuals without regard to physical location. In similar fashion, our framework is also intended to assist in the Commission's understanding of the appropriate role of radio-based connectivity in providing a broader range of switched communications systems ranging from voice and narrowband data to higher bandwidth systems that will be necessitated by the voice, data and image communications requirements of the future.

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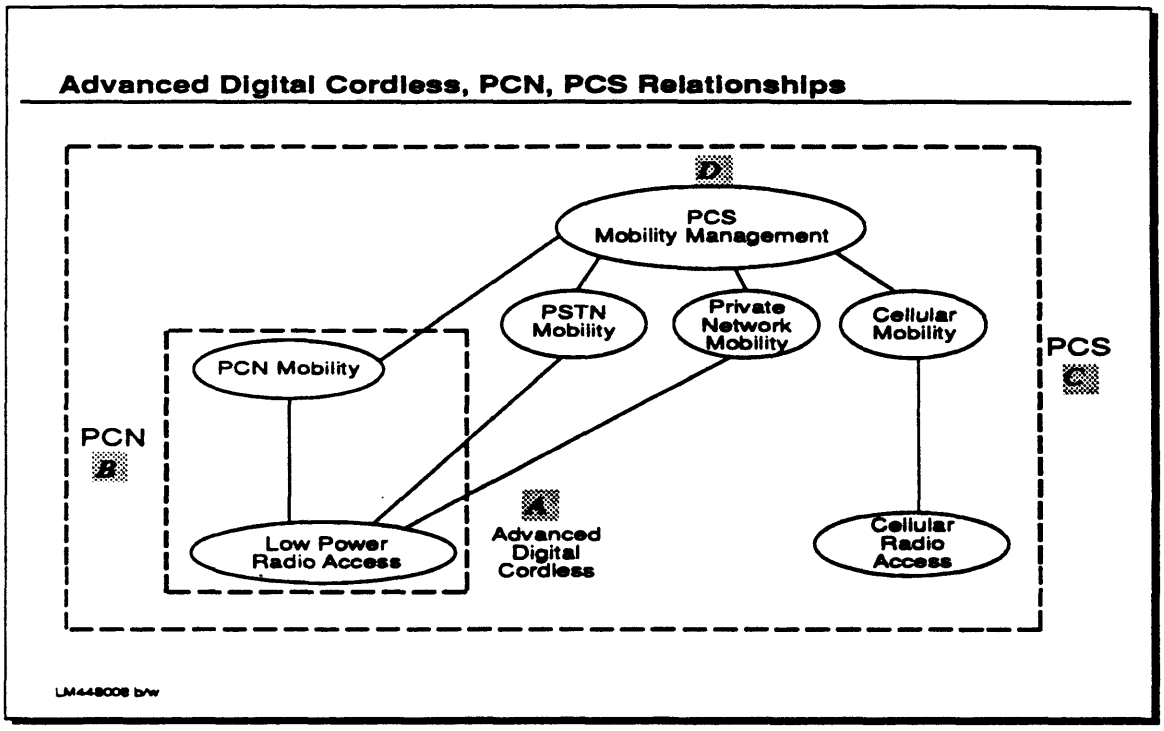
[1] Amendment of the Commission's Rules to Establish New Personal Communications Services, 5 FCC Rcd 3995 (1990) ("NOI"). Many of the comments in this response bear upon activities of the FCC in preparation for the World Administrative Radio Conference in 1992 (WARC-92). Northern Telecom thus requests that these comments also be entered under Gen. Docket 89-554, while respectfully reserving the right to make additional comments in that proceeding.

In order to focus the debate concerning the appropriate technology and standards to support PCS, it is necessary to clarify the terminology "CT-2 type", "PCN type" and "PCS" used by the Commission in the NOI. Advanced Digital Cordless, PCN, and cellular systems are all personal communications systems, but differ in coverage, technology investment and relative deployment price. Figure I.1 illustrates their relationships.

Figure I.1



"CT-2 type" and Advanced Digital Cordless ("a" in Figure I.1) describe the low power radio access systems (including terminals and base stations) which provide wireless extensions to existing systems. "PCN" ("b" in Figure I.1) may utilize the same handset or terminal, but has network capability and expanded service management capabilities so that a user can, for instance, roam between cells. "PCS" ("c" in Figure I.1) has the broadest mobility context, and covers all the various mobile services so that a user can, for instance, be reached using the same number whether he is using his Advanced Digital Cordless type terminal or a mobile service in his car. The key to this seamless personal communication environment is in the PCS Mobility Management ("d" in Figure I.1) function which will provide the necessary linkages among various PCN's; i.e., the public switched telephone network ("PSTN"), private networks and cellular networks.

2.0 Service Requirements for PCS

There are two needs which place demands on radio spectrum that will drive the demand for PCS:

- Mobility
- Loop access functionality-to-cost ratio improvement

We will address each of these needs separately.

2.1 MOBILITY

PCS should be viewed as a robust service; PCS will be able to meet diverse needs in diverse environments. The service requirement for those users who require service in only one building are most easily understood and satisfied. The basic requirement is typically for connectivity to the wireline network via radio spectrum. To date this requirement has largely been satisfied for residential users through analog cordless telephones provided under FCC Part 15. However, business users operate in areas of higher user densities, and demand higher voice quality and communication security than current analog cordless phones offer. As a result, the needs of many individuals who must be in constant two-way voice communications within buildings (e.g., doctors, nurses, service and support staffs) remain unsatisfied.

The need for mobile communications at more than one site adds a requirement for a common number (as well as a common available frequency if wireless communications is required at the different sites). Fortunately, flexible network architectures incorporating advanced intelligence network infrastructure concepts, intelligent signaling such as Signaling System No. 7 (SS7) and network databases can readily evolve to facilitate the use of a common called number to access a user at more than one location.

Users requiring continuous mobility within a larger area demand the next level of intra-network connectivity, which involves handoffs between multiple cells within a broad contiguous geographic area. This requirement for roaming is generally satisfied today by analog cellular technology. As the cost of providing the service decreases and demand increases, existing system and radio spectrum capacity must be increased to satisfy this demand. Although the cellular industry is well positioned to expand its capacity to address this need through advanced digital and microcellular technology, the expected explosive growth of a variety of mobile telecommunications requirements will

open up tremendous opportunities for complementary PCS service providers, and further accelerate advances in PCS technology development. This growth and development will in turn rapidly lead to a seamless PCS environment.

Those users requiring wide area continuous mobility involving multiple cities with multiple carriers -- or a handoff between private wireless PBX network systems and public wireless networks -- require the most sophisticated network capabilities. The handoff between radio base stations connected to the same switching center is relatively simple. The handoff between radio base stations connected to different switching centers requires detailed handoff specifications, e.g. the IS-41 specification for cellular system interconnections developed by TR45. Such specifications must be incorporated and tested between different equipment vendors and networks operators to ensure interoperability. Once such specifications are in place for PCS, intelligent network capabilities incorporated in each network can make the system technically and economically feasible, provided radio spectrum is available.

Mobility needs can thus be placed into four general categories. An understanding of these differing needs can facilitate the Commission's analysis of the service and spectrum requirements of personal communications services.

1. **Single Location - Discrete Mobility** - These users may desire only location-dependent services (e.g., doctors or nurses within a hospital). Such users require only a wireless extension to get local mobility within a single premises.

2. **Coordinated Multiple Locations - Discrete Mobility** - These users want to call from or be reached at multiple locations from a single access number. However, they do not need to be in touch while in transit between these locations. Both wireless or wired terminals can be used. The locations can also be local, within a few city blocks, or across the country.

3. **Continuous Operator Mobility** - These users need to be in touch whenever and wherever they are within a well defined area, such as several city blocks or within a city. This, by definition, requires wireless access. The range of this regional mobility can also be defined from an operator's perspective. For example, the service falls within this category even if it spans multiple cities, as

long as the mobility requirements fall within an operator's continuous service area.

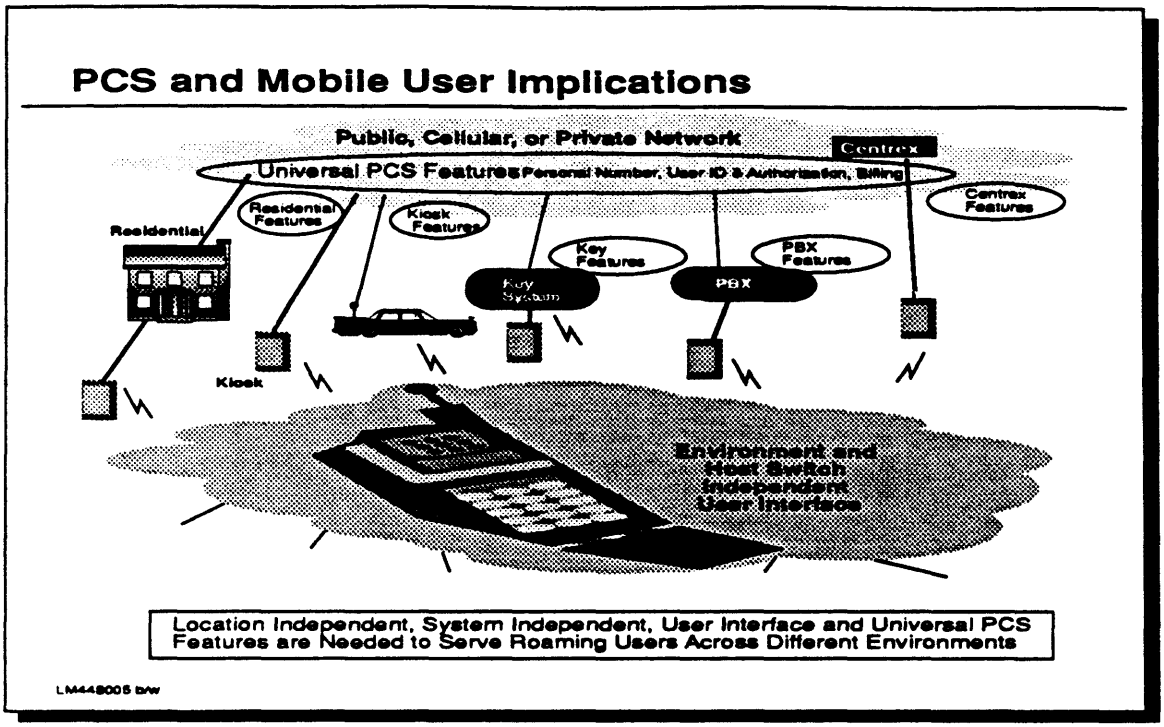
4. **Multiple Operator Continuous Mobility** - These users are similar to the previous set, except they operate over a wider area, for example, multiple cities. From an operator's perspective, it may be considered as Wide Area as soon as it crosses multiple operator system boundaries even within the same city.

There are a multitude of current telecommunications systems and architectures which will be affected by the development and deployment of PCS. PCS will have a significant impact on network intelligence, switching systems, residential access, Centrex, Key Systems, PBX systems, pay telephones and cellular systems.

PCS as it ultimately evolves can be described as the services and capabilities required to enable users to gain access to telecommunications services across different environments and supporting systems in a transparent manner using various wireless access technologies. More broadly, PCS also will permit users to obtain enhanced personal communications capabilities available from wireline networks using both wired and wireless access.

In such an environment, an objective of long term radio spectrum planning should be an integrated, common bandwidth allocation that meets all of the previously described four types of needs. Such an approach would facilitate the use of a common mobile receiver and common handset-to-base station interface, eliminating the need for multiple transceivers as a user moves from indoor to outdoor settings, and between networks. Such a common service interface is outlined in Figure II.1.

Figure II.1



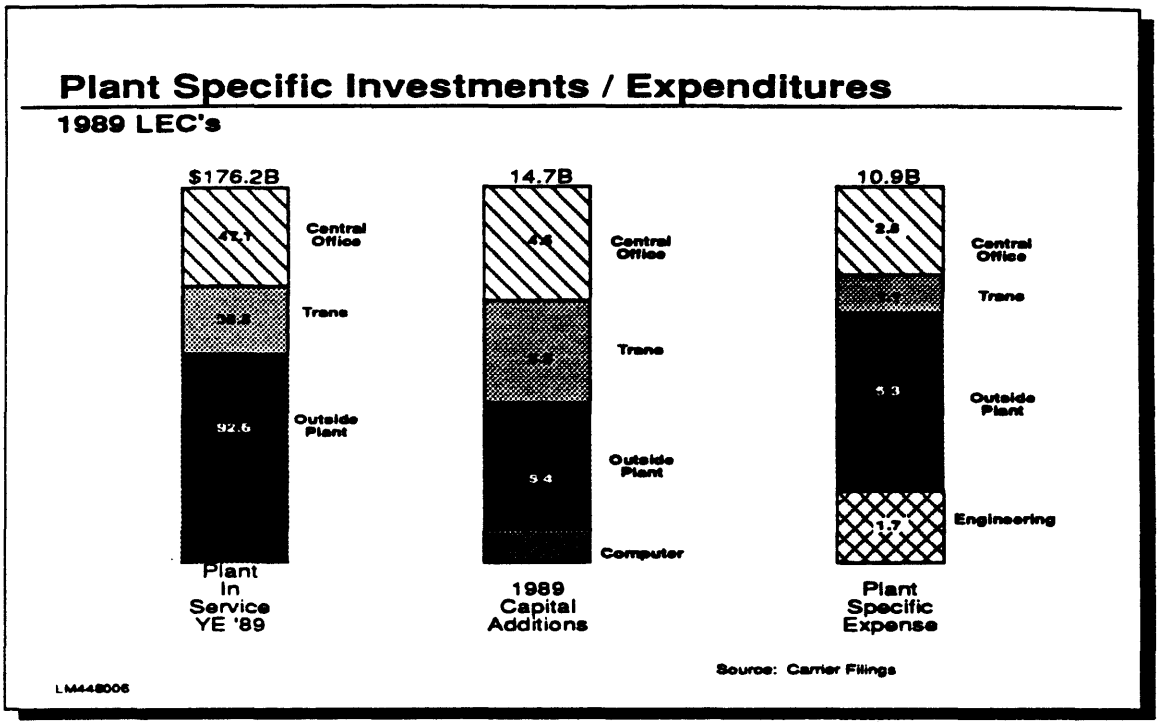
2.2 IMPROVEMENT OF LOOP ACCESS FUNCTIONALITY-TO-COST RATIO

Figure II.2 summarizes local exchange investment in plant in service, plant additions and plant specific operating expenses for year end 1989 and total year 1989 respectively.[2] Outside plant comprises the major portion of both investment and ongoing operating expense of the physical network. These investments include the costs of feeder facilities, distribution facilities, and individual customer drops. The costs of installing and maintaining a loop are greatest closest to the customer, as they tend to be more dedicated as well as subject to more rearrangements and physical damage. Emerging fiber technologies permit cost equivalency to copper while enabling local exchange networks to provide higher bandwidth services on command. This switched broadband capability will be the desired method of connectivity for small business and

[2] These statistics have been extracted from FCC 1989 Statistics of Common Carriers dated July 6, 1990.

residential users, providing concurrent communications utilizing voice, broadband data, image and video.

Figure II.2



There is, however, an important role to be played by radio-based services as the U.S. evolves to a switched, broadband infrastructure and beyond. As an initial matter, radio-based connectivity may possibly provide the "curb to the home" access while fiber is deployed to the curb. As such, PCS would complement, rather than competes with, fiber optic deployment as the telecommunications infrastructure is enhanced over the coming years.

There also are other situations where a broader role may be appropriate for radio-based access. Northern Telecom joins Bellcore in the belief that radio technologies may provide an attractive distribution capability, for example where varied, geographically dispersed customers must be served, or during the early stages of subdivision development where requirements are limited to residential voice and narrowband data services, and where plant is subject to substantial physical damage.

Support for geographically dispersed customers in rural areas may also be attractive with a special high-power PCS product.[3] Spectrum allocated for this purpose may also be made available to users of low power handsets in areas served by wireless local distribution systems, consistent with the expansive PCS model suggested by Northern Telecom.

2.3 PCS and Spectrum Relationship

The Commission should use this proceeding to clarify the relationship between the definition of PCS and the spectrum used to access the services. Northern Telecom believes that PCS should be defined independently of the spectrum and the radio technology used to gain access to the service. PCS should be viewed as an integral part of the telecommunications infrastructure, not merely as an adjunct to (or replacement of) cordless telephones and cellular service.

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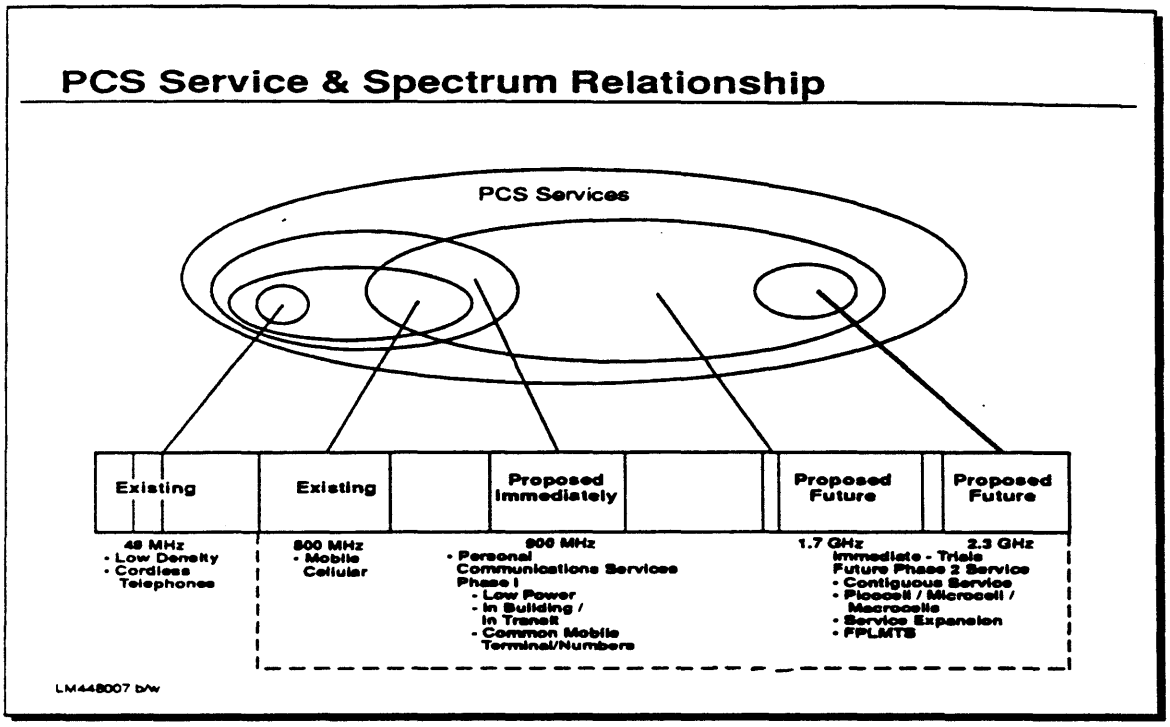
[3] As such, PCS could also incorporate the FCC's BETR service. Basic Exchange Telecommunications Radio Service, 3 FCC Rcd 214 (1988)

Figure II.3



As depicted in Figure II.3, varied radio frequency spectrum allocations will continue to evolve over time. A robust PCS model will allow these various services to be integrated into new contiguous personal communications services by the power of intelligent network components. Network intelligence can permit different network supporting systems, employing different access radios and radio spectrum bands, to connect users with the desired PCS services.

In this manner, PCS is expected to greatly influence the evolution of the current telecommunications network and industry infrastructure. While existing systems support part of the PCS environment, new systems and services can continue to be introduced to address ever changing telecommunications needs.

Paging systems, for example, today provide alerting services. They have a dedicated infrastructure and specific assigned frequencies. Cellular mobile systems, which are optimized to serve users requiring wide area continuous mobility and high speed base station handoff functions, are also part of the PCS ensemble. New low power network

supporting systems, such as those using the proposed PCI standard, create a window into another specific set of PCS services. These particular personal communications services focus on providing in-building communications, and two-way public telepoint requirements. For these services, the users will encounter other users in a relatively close vicinity, and will require high quality, integrity, and security of calls. This initial PCS will provide a low power digital solution to users who do not require high speed, wide area or continuous mobility, and at a lower investment cost than today's cellular. Details on the rationale and technical merits of the PCI standard are included in this submission for consideration.

3.0 SPECTRUM ALLOCATION ISSUES

In the NOI, the Commission asked a series of questions regarding the need for allocations of one or more frequency bands to support the personal communication type services. These include: (i) both general questions regarding the demand for various types of PCS services and the benefits of such services (Paras 13-14), (ii) specific issues associated with spectrum for pedestrian oriented, low power services which the Commission denominated as "CT-2" for purposes of this inquiry, and (iii) questions concerning more comprehensive services which the Commission denominated as "PCN Type services" (Paras 15-22).

As a manufacturer of network and premises equipment for these services, Northern Telecom will focus on the various requirements for spectrum that will fulfill these mobility needs. Specifically, Northern Telecom will address how these needs can be addressed by enhanced low power digital technology, longer term PCS requirements, and some specific recommendations regarding spectrum needs and assignments.

Northern Telecom will demonstrate that a near term allocation of bandwidth in the 900 MHz range is needed for the initial introduction of enhanced low power digital services, with additional bandwidth above 1 GHz being necessary to meet requirements for future service growth, as well as for international roaming, more rapid introduction of newer technology, and consistency with spectrum allocation for similar services internationally. The Commission must act now, however, with regard to both the short term and long term needs in order to ensure the rapid availability of these critical services to the American public.

3.1 Need for an Allocation

There are a number of factors that support an exclusive spectrum allocation for personal communications on a national basis. These advantages include:

- nationwide services, including nationwide customer roaming
- nationwide operation without requiring complex frequency coordination
- common air interface
- no need for terminal user licensing
- large customer base and consequent economies of scale for development and manufacture of equipment and services

Cellular mobile systems are an example of how spectrum allocation, together with radio and equipment standards on a nationwide basis, has led to the rapid deployment of new communications services. A similar allocation for additional PCS services can be expected to lead to the development of innovative national, regional and local personal telecommunications services.

The availability of common spectrum will also foster the development of a common air interface. This will allow the basic interoperability of equipment and services between serving areas. Service providers and customers will be assured of the availability of spectrum in each service area, without the need to compete with other services for the spectrum. In addition, the availability of the same spectrum for private residential, public access, and business (Key System, PBX or Centrex) use will create greater incentives for development of standards and integrated network personal communications services.

An exclusive allocation is also needed to guarantee service availability and performance in all areas. A public access point or wireless PBX serving an office building must be planned to support the communications traffic in the area without concern for interference from other users of the spectrum. Common national spectrum allocation will, in addition, prevent the fragmentation of both the services and the spectrum. With a common allocation, small pockets of individual spectrum will not need to be found and assigned for each regional area, a process that adds delay and uncertainty.

Despite the highly successful allocation of spectrum for cellular mobile service, a new allocation for low power base stations is still necessary. Personal communications encompasses a large ensemble of services and features encompassing, for example, various degrees of mobility, call reception and initiation, numbering, billing, message and data communications. As stated earlier, the cellular mobile system is but one "window" on this ensemble that focuses on ubiquitous coverage, wide area roaming, and high speed mobility.

There are other groupings of features and service requirements which are of interest to customers, and which lead to the need for a different spectrum "window" for personal telecommunications. One set of personal communication services includes motion at pedestrian rates within confined areas (within buildings), roaming between buildings locally and nationwide, very good quality speech, enhanced data services with low error rates and very low call blocking probability. These service requirements lead to optimal design developments for new personal communications services that differ from, but also complement, current cellular mobile system features.

For example, many users may require personal communications mobility service while at the office. Creating a broad, low power PCS will also allow the same handset to be used for cordless telecommunications at home, or while traveling at points such as airport waiting rooms, gasoline service stations, convenience stores and shopping malls. An important distinguishing feature of this PCS from the existing vehicular mobile cellular systems is the multiplicity of service providers. While at the office, the employer could provide the radio base stations and network interfaces. While at home, the user could provide his own base station, or makes use of a direct access base station. While travelling or shopping, the radio base stations could be provided (and interconnected to the network) by many different service providers, including, for example, cellular operators or newly authorized PCS operators. In an ideal network, the users would see the same seamless service regardless of their location.

This new low power personal communications system could also be used in conjunction with other systems such as cellular, mobile satellite or aircraft public correspondence systems to extend coverage to vehicle interiors such as buses, trains, or planes. Under this model, the new PCS would be a "mobile microcell" acting as an access device to other established mobile services.

Finally, the prompt, exclusive allocation of spectrum for low power digital systems will lead to the development of a large customer base and a wide diversity of service providers and service offerings. The result will be economies of scale in manufacture and service delivery, resulting in lower prices to customers. The common spectrum allocation provides the base upon which manufacturers, service providers and customers can build to create new business and services for communications. Conversely, the failure of the Commission to act expeditiously will leave the American public and U.S. manufacturers lagging behind other nations, which have already begun to develop these services.

3.2 How Much Spectrum

In order to determine the spectrum needed to support PCS, it is necessary to estimate the service requirements, the traffic density and the cell sizes, and to make assumptions regarding future radio operating characteristics. From these parameters the needed number of traffic channels can be estimated and the consequent spectrum requirements calculated.

Traffic density is often measured in units of "Erlangs per square mile". In this context, each Erlang can be thought of as representing one continuous full hour telephone call. The highest traffic density typically occurs in urban office buildings where there is heavy communications usage and the subscriber terminals may be spread out over many floors. In these applications the traffic density may be as high as 50,000 Erlangs/mi^2. The lowest traffic density typically will be in rural areas where there may be one or fewer telephones per square mile. The service requirements also affect the amount of spectrum required. A small probability of a call being blocked (due to all radio channels being in use) is essential in all environments. To achieve this low blocking probability, it is necessary to have a minimum number of channels available in each cell. The radio parameters, modulation technique and coding determine the spectrum needed for this minimum number of channels.

The mobile systems envisaged for PCS will use cell-based technology. The size of the cells and the reuse factor will then determine the total number of channels and the total spectrum requirements to support the desired traffic. As there are a great number of variables involved, different approaches are possible. For example, very high traffic capabilities can be achieved by using very small cell sizes. These may have sizes of

only a few hundreds of cubic feet. System design requires the service provider to achieve a balance between cell sizes, the traffic density, the number of radio channels and the cost of installation and operation. One overall measure of spectral efficiency is to express combined parameters as Erlangs/MHz/mi^2. The higher this figure, the more efficient the usage of the spectrum.

A number of organizations have reviewed the service requirements for PCS and estimated the spectrum requirements. One of the most thorough analysis was undertaken by the CCIR Interim Working Party 8/13, which has been studying Future Public Land Mobile Telecommunications Systems (FPLMTS). This future system concept, for introduction in the late 1990's time frame, includes PCS on a global scale. This group has had participation from administrations world wide, and has issued a report which outlines possible FPLMTS services, network and radio interfaces, and spectrum requirements.[4] The CCIR IWP calculated the spectrum requirements by considering possible traffic densities and future radio technology capabilities, and combining these with cellular reuse patterns. Three service environments have been defined: outdoor services, low power indoor services and outdoor personal services. This group estimates a total requirement of 230 MHz, with 60 MHz of this devoted for the exclusive use of low power personal communications services. These estimates assume that the spectrum is exclusively allocated to the personal communications service. However, if the spectrum was being shared with another service or service provider, a wider band may be required.

Estimates of this sort are, of course, strongly influenced by the basic assumptions incorporated in the calculations. The CCIR working party has assumed high traffic densities and reasonable future technology capabilities. The estimates have considered a number of the potential technologies for speech coding, modulation, and various access methods such as FDMA, TDMA, and CDMA. They have not considered any inefficiencies in spectrum usage which may result from, for example, multiple service providers with common coverage areas. Their estimate may, therefore, be regarded as somewhat conservative. Nonetheless, CCIR IWP estimates agree well with others.

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[4] CCIR XVIIth Plenary Assembly Dusseldorf, 1990, Report M/8 (Mod F) "Future Public Land Mobile Telecommunication Systems", Document 8/1014-E, 15 December 1989. [Section 5.4]

The estimate of 60 MHz made by the CCIR working party for personal communications is for an exclusive allocation. If the allocation instead is to be shared with other existing services, a wider amount of spectrum would be necessary. For example, if one half of a shared band is used by another service, then the band would need to be about twice as wide, or roughly 120 MHz. This will depend in detail on channelization of services, compatibility of modulation techniques and the size of the unused portions of the shared band. Practical considerations such as channelization plans, compatibility of emissions and guard bands could require the shared band to be as much as three or four times wider, or about 200 MHz.

The European Technical Standards Institute (ETSI) has also been studying requirements for spectrum as part of their Digital European Cordless Telecommunications (DECT) system development. The DECT system is intended for wireless PBX applications for large business systems. These systems include high density business traffic and take into account current radio technology. The studies indicate that the system can handle a traffic of 440 Erlangs/MHz/km^2/floor[5] . This is equivalent to a requirement for about 45 MHz to handle the 20,000 Erlangs/km^2/floor traffic for a large office application. The spectrum estimate for the DECT is larger than the CCIR study, but it uses current rather than future technology.

The Bell Communications Research (Bellcore) organization has also reviewed the spectrum requirements for a wireless communications system. These studies have been described in the Framework Advisory for Universal Digital Portable Communications.[6]. The report indicates that approximately 40-60 MHz of spectrum would need to be allocated for this service in the 1-3 GHz region. This 40-60 MHz is partly distinct and partly overlaps the FPLMTS allocation, because it also includes radio access for some residential loop access services. Although the CCIR IWP 8/13 committee of FPLMTS

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5 Dr. Heinz Ochsner, "Radio Aspects of DECT", Proc. 4th Nordic Seminar on Digital Mobile Radio Communications, Oslo, 26-28 June 1990, pp 6.4/4.

6 BELLCORE, "Generic Framework for Universal Digital Portable Communications System (PCS)", TA-FSY-001013, March 1990.

has proposed bandwidth requirements for indoor and outdoor stations of 60 MHz, those applications do not include an explicit allocation for loop access services.[7]

There is significant synergy between residential and FPLMTS applications; due to the small cell sizes, some frequency sharing between these applications may be viable in many locations. However, widespread rollout of all of these services could necessitate a requirement for more than the initial 60 MHz. Therefore, Northern Telecom advocates that some contiguous or nearly contiguous spectrum be reserved and made available in the future when the need for this service is clearly demonstrated.

In addition to being largely consistent with each other, these estimates are in general agreement with the studies done internally by the development laboratories of Northern Telecom. As reflected in our proposals below, Bell Northern Research estimates that 30 MHz should be allocated to PCS in the short term, and 120 MHz should be allocated for longer term PCS. However, the Commission must begin to initiate even the longer term allocations expeditiously in order to ensure the timely deployment of PCS in America, particularly in light of the general agreement on the demonstrated need for these services.

3.3 Where in the Spectrum

Considerations of marketing and international developments indicate that a two stage approach is appropriate for spectrum allocation. There needs to be short term "tactical" availability of a band for low power PCS development, as well as long range "strategic" planning for the future development and integration of PCS. As the Commission indicated in the NOI, PCS interest is very high in most of the world, and PCS development has already begun in many locales. Prompt Commission action therefore will benefit not just the U.S., but the entire world. As an initial step, an allocation should be made as soon as possible in the 900 MHz band for the early introduction of low power PCS. This will satisfy the latent demand for higher density, in-building, pedestrian mobile personal communications. This initial allocation will

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[7] To the extent that PCS is used to provide radio loop service to residential users as an compliment to wireline service, it should properly be viewed as an extension of an existing service rather than an additional service. Therefore, should the Commission award spectrum for the provision of such services, Northern Telecom believes that a license should be awarded to the existing service provider.

also permit the development of services and requisite network interfaces in a timely manner, and enable American industry and service providers to compete in worldwide markets. In these comments, Northern Telecom outlines a proposal by which the immediate introduction of low power PCS can be easily and quickly achieved in the 900 MHz band. There should also be an allocation, undertaken promptly, to be completed in the post-1992 time frame, to provide more extensive PCS with global capabilities and with compatibility/integration with other mobile and fixed services.

3.3.1 Short Term

In the short term, there should be an exclusive allocation for low power digital PCS in the 900 MHz band as soon as possible to allow the development of services, markets, network systems and interfaces. The 900 MHz band is particularly well suited for this, given its proximity to the vehicular mobile cellular bands. The large volume sales of cellular equipment make possible the immediate design of inexpensive and reliable personal communications equipment for this region of the spectrum.

As the Commission recognized by releasing the NOI, the U.S. must begin to address PCS now, to ensure the early availability of PCS. In addition, as more fully discussed below, the Commission should work with neighboring countries of North America when planning spectrum assignments to achieve a compatible allocation that fosters the availability of integrated services and North American roaming for the short term PCS development.

3.3.2 Longer Term

In the longer term, the Commission must plan for personal communications on a global scale, taking into account expanded service and traffic capacity, and closer integration with other mobile and network services.

The agenda for the World Administrative Radio Conference (WARC) in 1992 includes consideration of an allocation of a band world-wide for future personal communications services.[8] The preference for the world-wide band is to foster global roaming for

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[8] R No. 995 World Administrative Radio Conference Dealing With Frequency Allocations in Certain Parts of the Spectrum Agenda item 2.2.4 ... "the consideration of an allocation of frequency bands to the mobile and mobile-satellite services and associated feeder-

subscribers, the development of world-wide air interface standards, and the integration of the personal mobile services with the world-wide public communications network. There are precedents for global roaming and service capability. Significant amounts of spectrum are currently designated on a global basis for radio navigation and communications for ships and aircraft. These world-wide standards have been of enormous benefit to the development of international shipping and commerce. With the allocation or designation of a global band for personal communications, these same benefits will accrue to a greater number of people.

To achieve a global allocation for personal communications it will be necessary to study and plan for domestic allocation changes, to work in the international arena to achieve a consensus on the band for designation before the 1992 WARC, and to plan to support the designation of the band at the conference.[9] Thus, while final resolution of these issues may have to await the 1992 WARC, the U.S. should press forward in addressing these longer-term issues now so as to maximize the ability of the U.S. to participate meaningfully in the international allocation processes.

The development of FPLMTS would be greatly accelerated if the future designation were to be in the 1710 MHz - 2290 MHz band. Internationally, this band seems to be preferred for this service. In order that future PCS systems in the U.S. may be technically consistent with PCS systems worldwide, the Commission should allocate spectrum for PCS in this band. Such an action would render U.S. services and equipment compatible with other systems, and maintain the opportunities for American manufacturers to export equipment overseas. Although this band in the international frequency tables for Region 2 is presently allocated co-primary for fixed and mobile service, domestically it is almost the exclusive domain of the fixed services. While a change to accommodate PCS in these bands must consider carefully the impact on

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links : ... c) for the development of the international use of the mobile service for the future public land mobile telecommunications systems, as indicated in Recommendation No. 205(Mob-87), or designate for this use a band already allocated to the mobile service."

[9] In this regard, Northern Telecom will review the suggestions of the Commission and other parties in the proceeding that is addressing the 1992 WARC, and Northern Telecom will comment on the spectrum proposals as appropriate, in light of the differences of opinion that may emerge.

domestic fixed service operators, the public interest would be best served by a longer term PCS allocation in these frequencies.

It is important to also keep in mind the range of travel when considering the requirements for international compatibility of PCS frequency allocations and standards. Currently the countries with the largest amount of trade and travel between the U.S. are Mexico and Canada. Moreover, in light of the Free Trade Agreement with Canada and the negotiations for a similar arrangement with Mexico, the FCC should strive to create a coordinated telecommunications system to match the emerging North American market. As the developments in Europe demonstrate, telecommunications cannot stop at the borders.

The commonality of the telecommunications services in the American region (dialing plan, billing, network standards, etc.) has facilitated much international communications traffic. Similarly, a common North American PCS frequency allocation and common standards would greatly facilitate subscriber roaming, opportunities for service providers and increased markets for manufacturers. As this is the largest travel community, a significant public interest would be served by achieving, at the very least, North American standards. The Commission is urged to continue its work with other regulators in North America to achieve a common PCS spectrum allocation.

There are a number of criteria for selecting suitable new regions of the spectrum for new low power PCS. The CCIR report from Interim Working Party 8/13 outlines a number of these considerations.[10] The three main considerations are radio propagation characteristics, radio equipment technology and technical and functional compatibility. In addition, the Commission should consider the availability of spectrum and the compatibility with existing users and services.

For low power PCS, the need is for relatively short range radio links either within buildings or for pedestrian outdoor environments. It is important to have available a practical and inexpensive technology for the radio components of the PCS equipment. Portable handsets, for example, are very sensitive to the cost and size of the radio

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[10]CCIR XVIIth Plenary Assembly Dusseldorf, 1990, Report M/8 (Mod F) "Future Public Land Mobile Telecommunication Systems", Document 8/1014-E, 15 December 1989. [Section 5.5]

components. There must also be a suitable set of standards available for implementing the PCS both in terms of a common air interface and network services interfaces. Compatibility with existing services and availability of spectrum are also important considerations. The characteristics of existing and neighboring services must be compatible with low power cellular technology. For example, low power PCS systems would have difficulty sharing a spectrum assignment with wide band high power radar signals, and they would have difficulty operating with such high power signals very close to the PCS band. There must also be available sufficient contiguous spectrum to carry the traffic and control signals of the PCS. For these links, many studies have reviewed performance at 900 MHz and 1800 MHz.

Table 3.1 summarizes some of these considerations for several areas of the spectrum. The 46/49 MHz band, where current cordless telephones operate, has available very inexpensive radio technology. It is not practical, however, given the extensive usage of this band, to introduce new PCS here. At the 900 MHz and 1800 MHz bands, the radio technology is more expensive but still quite practical due to the developments made for the cellular mobile systems. Suitable radio standards and network interfaces also exist for operation near these bands. At frequencies above 3 GHz, the situation is less well defined. Current technology does not provide inexpensive, compact and practical components. In sum, PCS would appear to be practical to implement at frequencies below 3 GHz. As there is considerable industrial experience with equipment for the vehicular mobile cellular bands, the PCS is likely to be the least expensive the closer it is to these bands.

Table 3.1
Selection of Frequency Bands

Band	RF Technology	PCS Standards Development
46/49 MHz	very inexpensive	none
900 MHz	inexpensive	yes
1800 MHz	more expensive	yes
>3 GHz	unknown	none

In sum, Northern Telecom recommends a two staged approach to the allocation of spectrum for PCS. There should be an appropriate allocation as soon as possible in the 900 MHz region in order to start the development and introduction of low power digital personal communications services. This should be followed, in concert with the proceedings of the 1992 WARC, by a larger allocation for PCS that will include provision for world-wide compatibility, increased traffic capability and integration with domestic applications such as wireless residential services.

While clearly the Commission must resolve the spectrum allocation as quickly as possible. the Commission must also seek the prompt resolution of licensing and standards-setting. Rapid implementation of PCS, with its attendant benefits for the public and the telecommunications industry, requires that all of these issues be resolved in the short term. As the experience with cellular service demonstrates, regulatory delay can slow the deployment of service for many years. In light of the growing importance of a robust telecommunications infrastructure, including PCS, the U.S. cannot tolerate a similar delay.

3.4 Sharing

New services, such as low power PCS, must be accommodated within the existing spectrum utilization policy and history. The success of any technique for sharing spectrum assignments depends critically on there being "spare" capacity in the existing utilization. This may exist in the form of, for example, dormant assignments or geographic areas where assignments are not used.

3.4.1 Coordinated Sharing

As part of its preparations for the 1992 WARC, the CCIR Interim Working Party 8/13 has prepared a report reviewing the considerations for sharing between the FPLMTS and other services.[11] This report considers the operations of fixed services and the FPLMTS. The report indicates that there are means to facilitate the sharing of band allocations with the fixed services and during the transition phases of PCS introduction. Fixed services operating as point to point links generate and are sensitive to

[11] CCIR Interim Working Party 8/13, "Report on Sharing Criteria between FPLMTS and other services", Doc: IWP 8/13-54, 11 July 1990.

interference on the same frequencies only within the immediate area surrounding the beam path and the antennas.[12] Outside this contour, there is sufficient isolation for a low power PCS to operate without interference to the fixed service. Inside the contour, there is a high probability of interference between operations on the same frequencies. The area covered by the contour will depend on the parameters of the fixed service system. In the case of a high capacity, major telecommunication trunk link, the dimensions of this contour may be as big as sixty miles in length and tens of miles in width. Because the beam path areas of the fixed service cover only a small portion of the total national area, however, the low power PCS may possibly share a band with the fixed service on a geographic basis.

To prevent harmful interference, coordination is required to enforce the restriction that no low power PCS radio station shall be permitted to operate on channels that overlap the operating channels of the fixed system within the geographic region of the fixed system. This may be achieved by designing the low power PCS system such that the portable stations do not transmit without receiving instructions as to suitable local channel assignments from the base stations. The base stations must have knowledge of suitable operating channel assignments for their region. Such an approach is similar to the way the current mobile cellular systems operate, although for different reasons. The mobile cellular systems make use of the channel selection control from the base stations in order to maintain the cellular re-use plans. The advantage of this sharing arrangement is that it potentially permits the PCS to share the whole of a fixed service band, and yet there need be no reduction in the service performance to the current fixed systems. This concept, however, is only workable if there are geographic areas where the fixed service channels are not all in use. Given the distribution of fixed systems (which tend to be in rural areas outside the metropolitan areas), and the major need for personal communications services inside the urban areas, there would appear to be complementary geographic usage. Such a coordinated sharing of bands between the fixed and mobile services appears to be an attractive and practical technique.

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[12] This area may be outlined approximately by the 130dB/20% path loss contour of the links.

3.4.2 CDMA Sharing

In addition to the geographic sharing for TDMA based PCS systems, there may be a possibility of broader sharing through use of CDMA. The Commission has granted experimental authorizations for CDMA based PCS-type systems. Among the possibilities to be explored in these experiments are:

- Sharing the frequency band adhering to FCC Part 15
- Sharing the frequency band on a co-primary basis with existing fixed services

The mutual interference between the services sharing the band depends on specific implementation parameters of the PCS service as well as the relative location and parameters of the sharing system.

The CDMA modulation system for the mobile service spreads the signal over a very wide band. The principle of CDMA operation is that because the band is significantly wider than the fixed service sharing the band, the mobile transmissions appear as a low level of background noise to the fixed system, thus minimizing any adverse effects on the operation of the fixed system. With increased load, the level of the mobile transmissions increases, but is not expected to adversely impact the fixed system in most situations.

Additional methods exist to further minimize the interference between the systems sharing the band:

- Geographical separation of antenna systems
- Highly directional antennas
- High propagation loss for urban areas (where PCS will be deployed)
- Carefully selected micro base station with existing fixed services
- Adaptive measures, such as power control and variable rate coding

The experiments should validate the capability of the fixed services and PCS to co-exist using these sharing methods.

3.5 Cordless Telephones (46-49 MHz)

Currently there is extensive use of "cordless telephones" operating in the 46/49 MHz bands, and extending the number of channels (bandwidth) available to these systems is being considered. These phones are very popular, but perhaps more popular than successful. Many consumers are finding the range limited, the speech quality poor, the risk of eavesdropping very high, and the interference high. As there are no control channels and very few voice channels, spectrum efficient personal communications services such as those attained by using PCI standards cannot be readily provided in this band.

Although considerable improvement in voice quality and capabilities has occurred over the past several years in analog cordless telephony, Northern Telecom does not feel this band should be used for development of enhanced personal communication networks. Rather it should continue to be used, perhaps even expanded, to serve its distinct Part 15 residential cordless applications. Because of the widely established usage and low cost of these telephones, Northern Telecom anticipates continued consumer popularity and increased use of this technology in a limited environment.

3.6 Proposal

In view of the above considerations, and in order to advance the development of PCS, Northern Telecom makes the following proposals. First, the Commission should adopt an allocation in the 900 MHz band for an initial, low power PCS, as soon as possible. Second, the Commission should adopt expanded allocations for future services in concert with global allocations at the 1992 WARC. In addition, the Commission should seek the resolution of the requisite standards setting and licensing, to ensure that these services can be deployed promptly.

3.6.1 Immediate Development

Northern Telecom proposes an allocation of spectrum for personal communications systems, as soon as possible, in the 900 MHz band. Such an allocation will permit the rapid introduction of low power PCS to the market, and permit American service providers and manufacturers to compete in global markets. This will serve an immediate public need, foster development of the network aspects of the service, and

permit American-based manufacturers and service providers to take a leadership role in the global market for PCS products and services. An early introduction is necessary for market development, and for work to begin on putting into place the network support needed for the personal communications services. The availability of spectrum is key to the development of the network services. With the availability of spectrum, coordinated services and standards will be developed.

Northern Telecom's proposal is divided into four parts:

a. The exclusive allocation of the 930-931 MHz and 940-941 MHz bands for the use of low power PCS. These bands would provide control channels and a few traffic channels.
b. The development of a common air interface to assure the compatibility of emissions and the interoperability of equipment using the PCS bands.
c. The allocation of the bands 930-960 MHz on a co-primary basis for the low power PCS to share with the existing users. This includes the development of suitable techniques for preventing interference between services.
d. The Commission should consider sharing between PCS and fixed services when making any further assignments in the 930-960 MHz band.

These items are explained in more detail in the following sections.

3.6.2 930-931 MHz and 940-941 MHz

These two bands are currently "unused", and could be readily allocated for low power PCS use.[13] The bands would be channelized into nine 100 KHz channels with a 50 KHz

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[13] The Commission recently proposed that the 930-931 MHz band be assigned for low Earth orbit satellite services. FCC News Release Report No. DC-1711, September 19, 1990. Northern Telecom does not concur with this proposal. Such an assignment is inconsistent with the international allocation for this band to Fixed and Mobile services on a primary basis. Satellite services are better accommodated elsewhere, and Northern Telecom suggests that the Commission should propose other frequencies at the 1992 WARC.

guard band at each end. One or more of the channels in each band would be designated for "control" channels. The remaining channels in each band would be designated as traffic channels.

These exclusive bands would be for the provision of low power PCS in the residential (home), public access ("telepoint"), and business (wireless PBX, Key Systems or Centrex) environments. The control and traffic channels would be shared among all of the service providers, both public and private, using dynamic channel allocation techniques.

3.6.3 Common Air Interface

In order to ensure the compatibility of emissions and to allow interoperability between various service providers and equipment manufacturers, a Common Air Interface (CAI) standard will be required for equipment utilizing the PCS bands. The standard needs to be made available quickly, and be suitable for the multiple environment, multi-service provider conditions of the American market. Such a standard may be developed rapidly by building on the low power PCS development done elsewhere. The most advanced of the currently available standards is the United Kingdom "MPT1375 CAI".[14] This standard provides a well defined radio interface, modulation and signaling system for basic wireless telephony operations. In addition, this standard makes use of modern highly efficient digital modulation and dynamic channel allocation techniques. In order to guarantee the interoperability of the calling capabilities and features of equipment using the band for the American market, and to permit development of personal communications services, further enhancements have been defined. These cover the assignment of channels, the provision of advanced data services, and additional call features for office environments. Such enhancements are defined in the PCI standard, and a document outlining them is attached as an Annex to these comments. This Annex, together with the MPT1375 CAI documents, form the basis for the PCI CAI which Northern Telecom believes should be adopted as the common air interface for the low power PCS in the 900 MHz band. A PCI CAI compatible standard has been proposed by

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[14] MPT 1375, Common Air Interface Specification", Department of Trade & Industry, Radio Communications Division, London SE1 8UA, May 1989/March 1990.

Northern Telecom as the PCS standard for Canada.[15] This proposal is currently in draft stage and will be further developed based on industry discussion.

There are numerous reasons why this standard is suitable for the low power PCS. The 100 KHz channelization fits neatly into the narrow split bands of the available spectrum. In addition, the channelization plan is well suited to sharing with fixed services in the adjacent bands (as discussed in the next section). The PCI standard has been developed with particular regard to the American low power PCS market, and provides a practical, integrated and cost effective solution for all three service environments (public access, residential and business). The standard achieves high spectral efficiency through digital modulation and dynamic channel allocation technologies. The standard builds upon other international work, and its adoption will provide experience and opportunities for American service providers and manufacturers to participate in overseas markets. This will result in lower investment cost for service providers. In sum, the PCI standard holds out great promise.

3.6.4 Shared Use of 930-960 MHz bands by low power PCS

The 2 MHz of spectrum in the 930-931 MHz and 940-941 MHz bands provides enough capacity for signaling and traffic for some small suburban residential and small public access applications. For metropolitan residential and high traffic office applications, however, more channels will be required.

To provide this needed extra capacity, the low power PCS should be authorized to share the use of the adjacent 931-960 MHz bands on a co-primary basis. Because of existing usage of this band, parts of it will not be available for low power PCS use in many areas. However, in most urban areas, where the need for low power PCS channels is greatest, significant portions of the band are unoccupied. For example, the 941-944 MHz band has only approximately 120 active stations nationwide. Suitable coordination with these and other existing users will thus enable the unoccupied portions of the bands to be utilized by the low power PCS in particular geographic areas. It is worth

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[15] The proposed standard for Canadian frequencies and markets is known as CT2PLUS. PCI is compatible with the Canadian CT2PLUS CAI.

noting in this context that the low power nature of the PCS keeps the emissions of individual in-building stations confined to areas of a few hundred square yards.

A significant portion of the 930-960 MHz band is assigned to studio transmitter link (STL) service. The assignment rules for this service suggest filling the band from the "bottom up".[16] This policy has clustered the unoccupied channels in the upper areas of the band in many places. Although not based on a detailed survey, the unoccupied portion of the 930-960 MHz band may be expected to provide sufficient spectrum to support the initial low power PCS for most metropolitan centers. In areas where the existing fixed service usage is heavy, and there is insufficient room for PCS, it may be desirable for there to be some migration of fixed services to other bands, such as 18 and 31 GHz. In metropolitan areas the Commission may wish to accept no new assignments in the 942-960 MHz bands, and to review carefully renewals in areas where PCS capacity is needed and it is practical for the fixed service to migrate to higher frequency bands. This procedure, of sharing with existing users, coupled with careful review of expansion, should make available sufficient spectrum over the near term without disruption to existing services.

The current domestic allocations of spectrum in the various bands 930 MHz through 960 MHz are assigned to the Fixed service and the Mobile service for Government and non-Government use. However, footnote 705 of the International Table of Frequency Allocations[17] allocates the band 890-942 MHz to the radiolocation service on a primary basis in the United States. The low power PCS may have difficulty sharing with the radiolocation service due to the very high power and wide range of the radiolocation service. The Commission may wish to review the general usage of the 890-942 MHz band by the radiolocation service and to restrict its usage to the 902-928 MHz (ISM band) band, so as to avoid interference with the low power PCS. No new assignments for the radiolocation service should be made in this band (outside of the ISM band), and existing licenses (if any) should not be renewed without careful review of future service requirements.

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16 47 C.F.R. § 74.503(a).

17 705 Different Category of service : in the United States, the allocation of the band 890-942 MHZ to the radiolocation service is on a primary basis (see No. 425) and subject to agreement obtained under the procedure set forth in Article 14.