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Converging Industries Research Foundation

Practical Solutions for Communications Policy

Cellular to PCS: A Wireless Primer

December 21, 1995

Presentation at the February 1996 NARUC Meeting, Washington, DC

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Telecommunications Industries Analysis Project:

Cellular to PCS: A Wireless Primer

Carol Weinhaus, Charlene Lagerwerff, Bob Lock, *et al*.
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The Telecommunications Industries Analysis Project is associated with the Public Utility Research Center at the University of Florida College of Business Administration.

In addition to the work of project participants, the project appreciates the reviews of this primer by Jim McConnaughey, Karl Nebbia, Jim Vorhies, and Joe Gattuso of the National Telecommunications and Information Administration, and by Doug Weiss of the Corporation for Public Broadcasting.

Graphics were produced by Erika Jobson, Cedar Designs.

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Project Information

List of Participants in the Telecommunications Industries Analysis Project

State Regulators	NARUC representatives from: Illinois Commerce Commission Iowa Utilities Board Massachusetts Department of Public Utilities New York Public Service Commission Ohio Public Utilities Commission Washington Utilities and Transportation Commission
Regional Holding Companies	Ameritech Bell Atlantic BellSouth NYNEX Pacific Telesis SBC Communications Inc. US WEST
Independents	Anchorage Telephone Utility GTE Sprint Local Telecom Division
Interexchange Carriers	AT&T Sprint
Cellular and Wireless Carriers	Sprint Cellular
Foreign Domestics	InfoCom Research, Inc. NTT America
Local, National, and International Services	BT France Telecom North America
Materials Manufacturers	Corning
Telecommunications Equipment Manufacturers	Nortel

Sponsors:

Corporation for Public Broadcasting

Assisting with *public* data:

Bellcore
Federal Communications Commission
National Exchange Carrier Association
National Telecommunications and Information Administration

Background on the Telecommunications Industries Analysis Project

The goal of the Telecommunications Industries Analysis Project is to provide information to support the development of alternative communications policies to meet the needs of stakeholders in an environment that includes competitive and non-competitive markets, federal and state regulatory jurisdictions, and a proliferation of new services made possible by technological advances. The purpose of the project is to produce research and analysis which will assist policy makers in making informed decisions.

The project is a neutral forum of communications industry stakeholders exploring multiple viewpoints of selected issues. This forum incorporates the following elements:

- **Broad representation:** The current forum includes foreign and domestic local exchange carriers (LECs), interexchange carriers (IXCs), materials and equipment manufacturers, and federal and state regulators. The project actively seeks expansion of this forum to include other communications industry representatives such as competitive access providers, cable television companies, computer companies, electric power utilities, or publishers.

- **Multiple viewpoints:** Participants are required to play an active role in the research and analysis, to represent their own interests, to understand and to assist in developing others' perspectives, and to work toward the common goal of representing multiple views. Since papers reflect multiple viewpoints and ideas, authors and reviewers may not agree with particular views or approaches expressed in the papers. The objective is to lay out ideas and options to assist policy makers in their decisions.

- **Analysis and results of alternative policies:** Research tools, including a jointly produced data base and computer software models, and data analysis developed by this forum create a common language for examining issues. The common language allows the participants to focus on underlying issues. Appropriate computer software tools, including modifications to existing tools, are developed.

- **All data, analysis methods, and results are public:** Data used by this project must be publicly available on a nationwide basis. Research products become public domain information.

- **Neutral setting:** The project resides in a neutral setting, free of partiality, thereby ensuring objective and independent research.

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List of Acronyms

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AIN	Advanced Intelligent Network
ALT	Alternative Access
AM	Amplitude Modulation
AMPS	Advanced Mobile Phone Service
APC	American Personal Communications
APCO	Association of Public Safety Communications Officers
ATIS	Alliance for Telecommunications Industry Solutions
BB	Broadband
BTA	Basic Trading Area
CAI	Common Air Interface
CAP	Competitive Access Provider
CBO	Congressional Budget Office
CD	Compact Disc
CDMA	Code Division Multiple Access
CDPD	Cellular Digital Packet Data
CMRS	Commercial Mobile Radio Services
CT-2	Cordless Telephone 2
CTIA	Cellular Telecommunications Industry Association
DBS	Direct Broadcast Satellite
DCS	Digital Cellular Service
DECT	Digital European Cordless Telephone
E911	Emergency 911 Services
EC	European Community
ECSP	Electronic Communications Service Providers
ESMR	Emergency Specialized Mobile Radio
ESP	Enhanced Service Provider
ETACS	Enhanced Access Communications Systems
ETSI	European Technical Standards Institute
FCC	Federal Communications Commission
FDMA	Frequency Division Multiple Access
FM	Frequency Modulation
FSS	Fixed Satellite Services
GATT	General Agreement of Tariffs and Trade
GHz	Gigahertz (billion cycles per second)
GSM	Global System for Mobile Communications
GSO	Geostationary Orbit
HDTV	High-Definition Television
Hz	Hertz (cycles per second)
IEEE	Institute of Electrical and Electronics Engineers, Inc.
IMTS	Improved Mobile Telephone Service
ITU	International Telecommunication Union
IXC	Interexchange Carrier
JTC	Joint Technical Committee on Wireless Access
kHz	Kilohertz (thousand cycles per second)
LEC	Local Exchange Carrier
LEO	Low Earth Orbit

List of Acronyms, cont.

LMDS	Local Multipoint Distribution Service
mm	Millimeter
MHz	Megahertz (million cycles per second)
MMDS	Multipoint Multichannel Distribution Service
MSA	Metropolitan Statistical Area
MTA	Major Trading Area
Mtel	Mobile Telecommunication Technologies Corporation
NARUC	National Association of Regulatory Utility Commissioners
NASNA	National Association of State 911 Agencies
NB	Narrowband
NENA	National Emergency Numbers Association
NTIA	National Telecommunications and Information Administration
OST	Office of Science and Technology, FCC
OTA	Office of Technology Assessment
PACS	Personal Access Communications System
PCIA	Personal Communications Industry Association
PCN	Personal Communications Network
PCS	Personal Communications Services
PHS	Personal Handy-phone Service
PN	Pseudo-random Noise
PSN	Public Switched Network
RSA	Rural Service Area
SMR	Specialized Mobile Radio
SS7	Signaling System 7
TDMA	Time Division Multiple Access
TIA	Telecommunications Industry Association
TILU	Telecommunications Industry Liaison Unit (Federal Bureau of Investigation)
TRS	Telephone Relay Service
TV	Television
WACS	Wireless Access Communications System
WARC	World Administrative Radio Conference
U.S.	United States

I. Introduction

Introduction

The objective of this primer is to provide a basic reference manual for ***personal communications services (PCS)***. In this primer, words that are in both boldface and italics indicate key concepts. Since PCS is part of an ongoing evolution of ***mobile services***, also called ***wireless services*** (communications services where the customer is not tethered by a wire to the communications network),[1] this primer provides background on ***cellular*** and ***paging services*** as well. While the focus of this paper is on PCS in the United States, the international context is also provided.

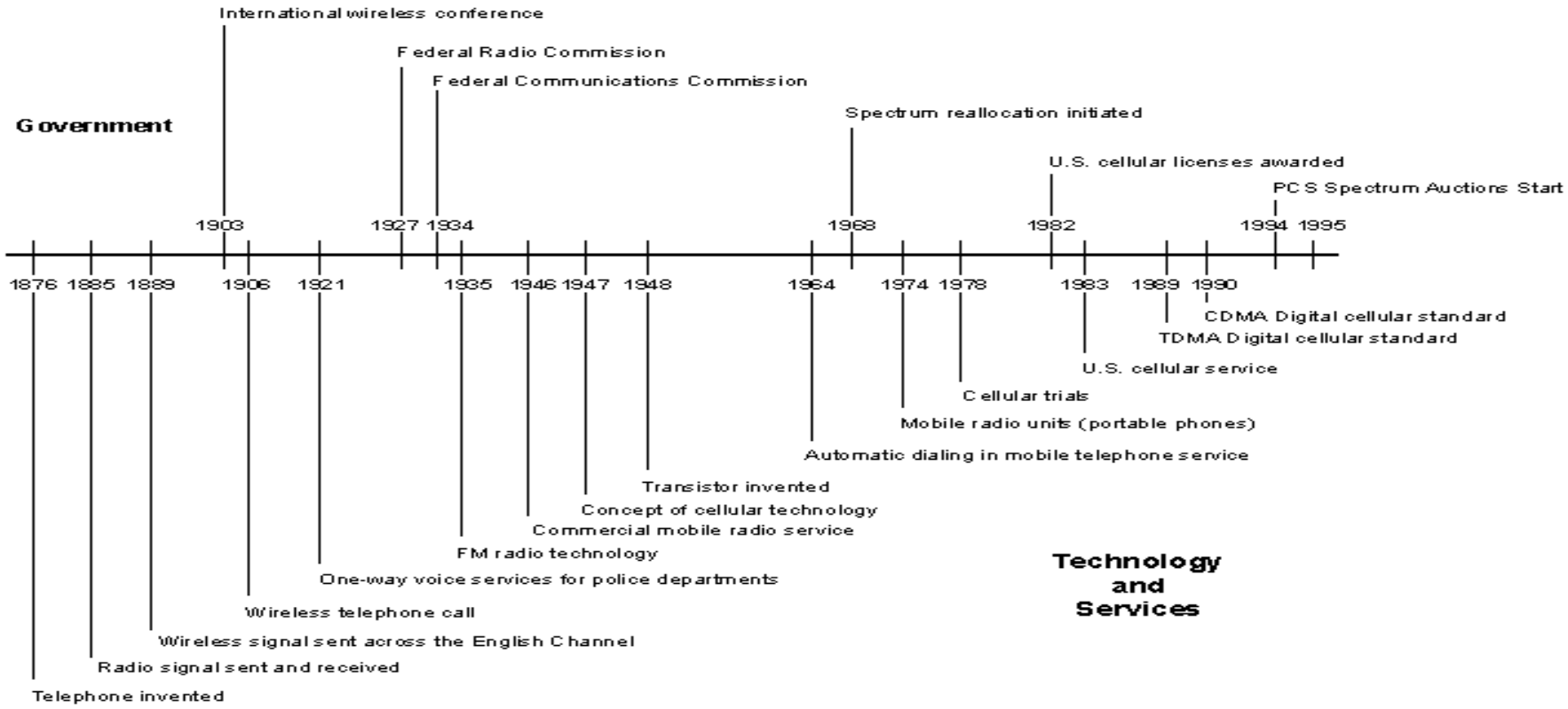
This primer reflects the state of PCS and cellular industries as of December 1995. However, many of the technology and regulatory issues discussed are still evolving and may not be resolved for some time. Since the fledgling PCS industry is in a state of flux, many issues may be resolved in ways that are very different from what is currently envisioned. PCS implementation may also change the shape of the cellular industry. Furthermore, new issues will arise as these industries grow. **Figure 1** provides a time-line indicating the major events in the evolution of mobile communications services.

This primer is formatted to address the questions most frequently asked of the Federal Communication Commission's (FCC) PCS staff. The answers to these questions cover basic concepts and definitions, the differences between ***narrowband PCS*** and ***broadband PCS***, what makes broadband PCS different from cellular services, and policy issues. The objective of this primer is to provide the basics. For more detailed information, see the regulatory documents and the literature cited throughout this primer. The sections in the primer cover the following items:

- **Section II, PCS Basics:** Answers the questions: What is PCS? Why would an average citizen want it? What are the buzz words? And what's going on with PCS in other countries?
- **Section III, Spectrum Allocation:** Defines the radio spectrum, narrowband PCS, and broadband PCS. It also explains the reasons for selecting the PCS locations on the radio spectrum.
- **Section IV, What is the Relation between PCS/Cellular Services and Technologies?:** Explains differences between PCS and cellular services and describes debates over various standards for sending messages and data over the air.
- **Section V, PCS Auctions:** Explains why the FCC is auctioning licenses for pieces of the spectrum. It also provides an overview of the various auctions, defines PCS pioneer's preference licenses, explains why cell site real estate prices are so high, and discusses microwave relocation and resale of licenses.
- **Section VI, Policy Issues:** Lists PCS policy issues that will need to be resolved in the future.
- **Section VII, Notes:** Provides sources and additional technical background.

I. Introduction, cont.

Figure 1: U.S. Mobile Services Time Line, 1976-1995



Source: Cellular Telecommunications Industry Association (CTIA), *Bringing Information to the People,* Washington, DC, 1993, pages 2-5.

II. PCS Basics

What is PCS?

The FCC defines PCS "as a family of mobile or portable radio communications services which could provide services to individuals and business, and be integrated with a variety of competing networks."[2] PCS brings new entrants to the mobile communications markets, and expands competition for existing mobile service companies. PCS may also be viewed as new services as competitors find ways to differentiate themselves from current companies with respect to what they offer.

All the technologies being considered for PCS have either been used before for cellular services, or are new and could be deployed in cellular locations on the airwaves.[3] Manufacturers design systems and equipment for mobile services in general, which are not necessarily unique to the PCS locations.[4]

PCS, as defined by the FCC, combines individual customer mobility with various communications services. PCS may provide alternatives to the traditional telephone network (called the ***Public Switched Network****, or* ***PSN***). Today, PCS in the United States (U.S.) is in the early stages of development and deployment C the theory is present, some technology trials are in place, some licenses have been auctioned, but standards and technology are in flux and the commercial deployment of technology and the evolution into services is not yet a reality.

Where did PCS come from?

PCS in the U.S. is a response to a number of different influences: economic, international, and domestic. The view as to which force played the largest role varies. In general, PCS is the result of two major forces:

1. Industry demand for more mobile licenses:
   This is the main reason for the creation of PCS. Each cellular market was restricted to two companies C creating a duopoly.[5] While this ensured that customers would have a choice of carriers, the choice was nonetheless limited. Many potential mobile service providers had not been able to obtain cellular licenses. Therefore, the FCC hoped that PCS competition would create new services and lower the price of existing cellular services.[6]
2. The potential for worldwide mobile services:
   The U.S. had already located its cellular services in a different spectrum location from the location used by cellular services in Europe and Asia (i.e., Japan, Hong Kong).[7] There was pressure from global equipment manufacturers and from customers for the U.S. to use the same standard location in the spectrum as these other countries. PCS is the U.S. response to this pressure. There was also a perceived opportunity for the U.S. to participate in a billion dollar industry.

II. PCS Basics, cont.

What are PCS services?

Mobile services advance current communications beyond traditional applications - for example, linking health care and emergency services with communications services. It is possible to send electrocardiogram readings from an ambulance to a doctor in the hospital who can view the readings and talk to the patient as the ambulance speeds to the emergency room.[8]

No one knows exactly what mobile services, including PCS, will look like in the future. There is a range of views as to what PCS will be in terms of services. PCS is seen as supplementing existing mobile services, such as cellular and paging. It is likely that some of the early PCS services will be similar to current services, making such services cheaper due to a larger number of competitors and to increased availability of air waves for these services. The technologies underlying PCS and other mobile services may also be used to support traditional non-mobile (fixed) services. Furthermore, PCS deployment is envisioned as enhancing fledgling services and encouraging the development of new features. For example, two-way paging and data transmission for business applications might produce a PCS service that combines security, inventory control, and messaging (e-mail, faxing).

Some examples of evolving mobile services (such as PCS and cellular) in general are:

- **Terminal Mobility:** The customer's equipment is not tethered to a location. For example, a customer can walk or drive through the city using a PCS handset.
- **Personalized Service Profile:** Services are tailored to the customer (the handset held by the customer) instead of the location (i.e., household or office). One example is a family where only the adults can accept collect calls and can call anyone, anywhere, anytime. The children in this same family might have limited calling (by price, by time, or by location). Some family members may have handsets; others may have pagers.
- **Universal Address:** With this feature, each individual customer has a personal telephone number and can move anywhere and use any communications company. However, to implement a universal address, changes are needed in current industry and government structures for *all* communications networks. Changes include implementation of data bases, standards, administration procedures, and rules for number portability.

Why did communications companies want PCS?

Communications companies wanted PCS for one or more of the following reasons:

1. Ability to fill in holes in their existing cellular market areas.
2. Ability to gain a nationwide footprint C to provide services nationwide (by owning spectrum licenses and facilities, by leasing facilities and services from other companies, or by some mix of the two).

3. Opportunity to enter new markets (including entry into the local exchange market), to use new technologies, to offer new services, to gain more customers - all of which translates into the opportunity to make money.

Why would an average citizen want PCS?

Some of the reasons an average citizen would want PCS are specific to PCS:

1. Potential for cheaper alternatives to current services, such as cellular service and local telephone service. However, it is not clear if this will occur and, if so, when. The underlying assumption is that competitive forces will drive prices down.
2. Greater availability of two-way paging and potential for advanced wireless services. For example, within an office park, a company might want each of its workers to have a light-weight mobile phone. There is already demand for a cellular version.

In addition, an average citizen would want PCS for the same reason he or she wants cellular and paging services C mobility. **Figure 2** indicates some examples of consumer mobile equipment use. **Figure 2A** indicates the primary reasons why consumers purchased cellular telephones in 1995: 40% for safety, 38% for business, 21% for calls to family and friends, and 2% for other reasons. Also, portable electronic equipment is already in over half of U.S. households **(Figure 2B)**.

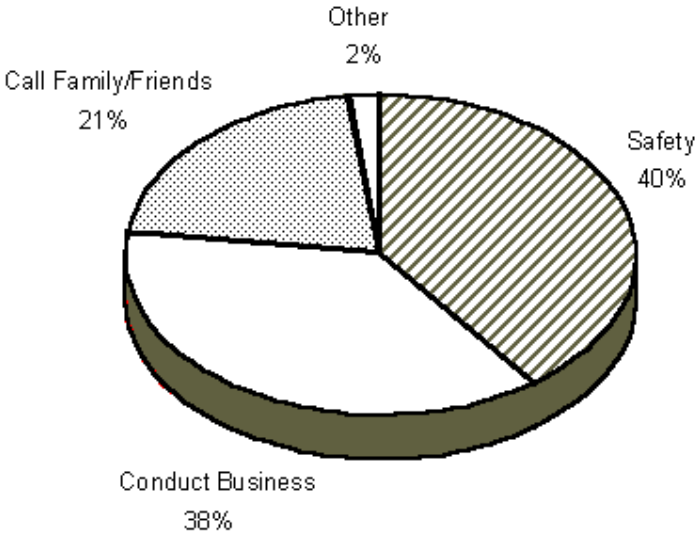
Demand for mobile, two-way telephone services existed even before cellular services. According to the FCC studies that led to cellular services, in the 1960s the average wait for mobile services was two to three years. In some cities, such as Chicago and Detroit, the wait was as much as 12 to 15 years.[9] In addition, those customers with service often were unable to get a free channel. Cellular services were the FCC's response to this early consumer demand. From 1984 until 1994, the number of cellular subscribers **(Figure 3A)** and cellular networks have grown rapidly **(Figure 3B)**. Paging services have also experienced similar growth patterns **(Figure 4A)**. Current paging services primarily convey data by numeric display **(Figure 4B)**.

What are the buzz words? How can I sound like an expert?

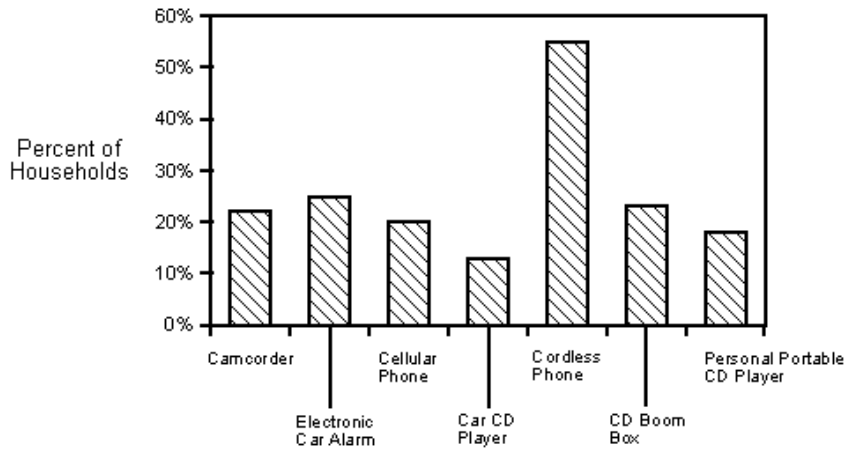
- **Wireline/Wireless** and **Corded/Cordless:** While these terms appear to be the same, they indicate different equipment markets (different classifications based on the type of technology):

  1. ***Wireline/wireless*** facilities refer to the network owned or used by a company providing communications services. "Wireline", also referred to as "wired", indicates that the communications path from the company's switch to and from the customer is a wire (copper, coaxial cable, or fiber optic), commonly called the ***local loop***. "Wireless" indicates that there is an over-the-air component in this pathway. The path may be entirely wireless or may have both wire and over-the-air components. Wireline networks include the traditional telephone network and

Figure 2: Some Examples of Mobile Consumer Equipment Use, 1995



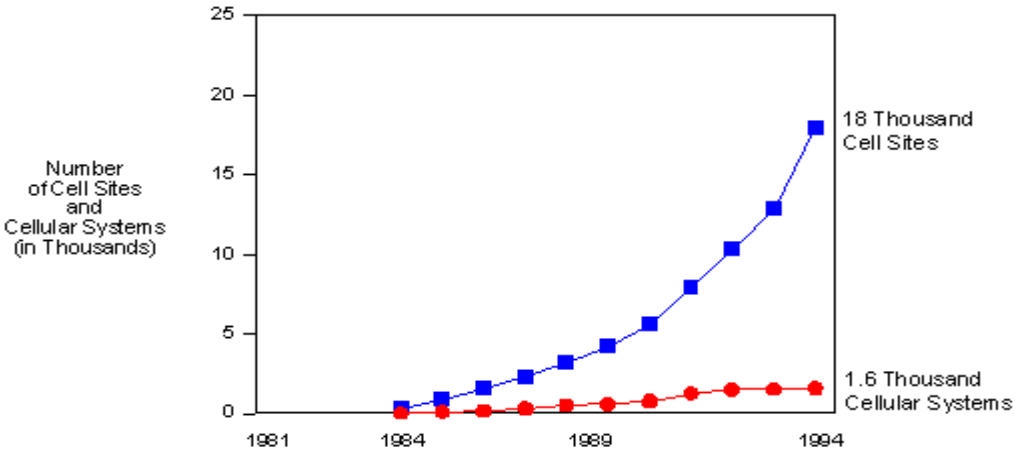
A: Primary Reason for Purchase of Cellular Phones, Mid-Year 1995



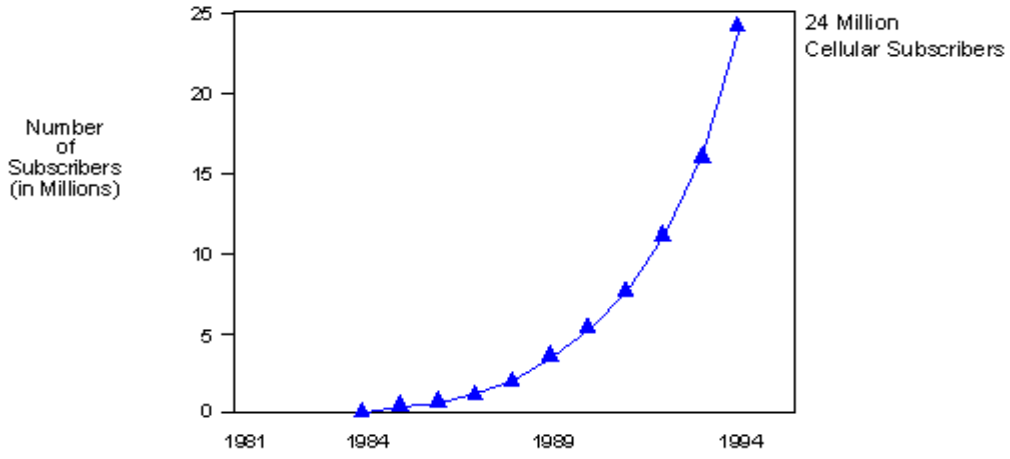
B: Portable Electronic Equipment: Percent of U.S. Households, June 1995

Sources: Figure 2A: *Wireless Week*, "Safety First," October 1995, page 18. Figure 2B: Electronic Industries Association, Consumer Electronics Group, *U.S. Consumer Electronics Sales & Forecasts,* 1991-1996, Arlington VA; chart on back cover "U.S. Household Penetration of Consumer Electronics Products."

Figure 3: U.S. Cellular Growth, 1981-1994



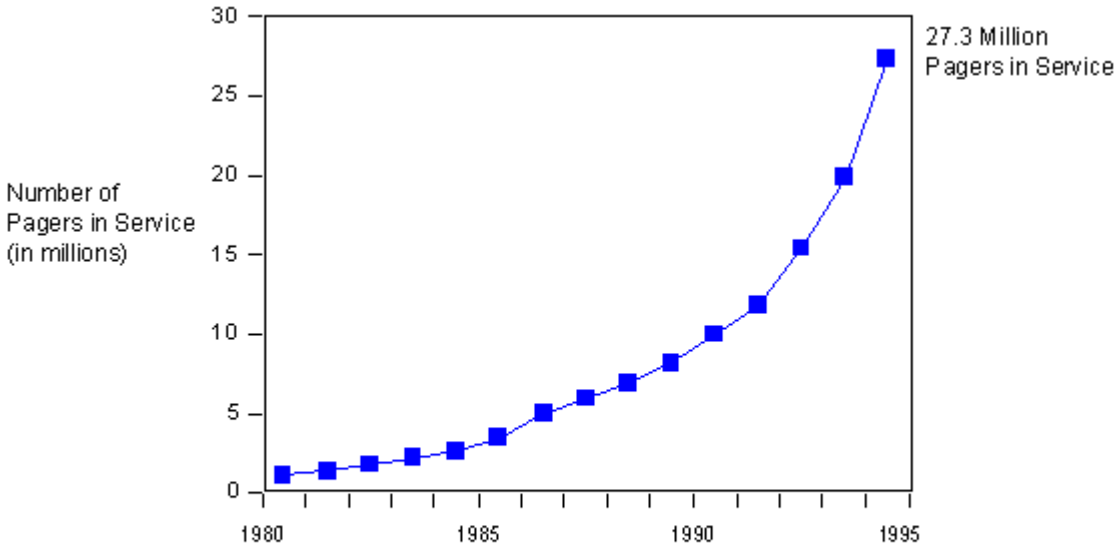
B: Number of Cellular Systems and Cell Sites



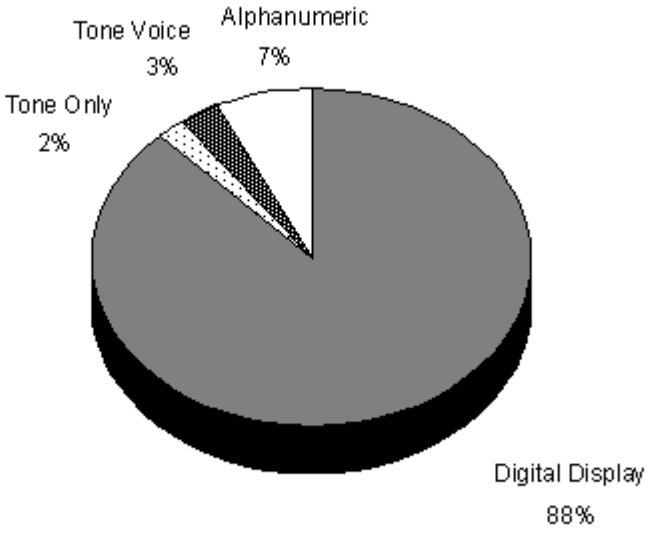
A: Number of Cellular Subscribers

Source: Cellular Telecommunications Industry Association (CTIA), "Infofax from CTIA," CTIA, Washington, DC, September 21, 1995, page 4.

Figure 4: U.S. Pager Growth



A: Number of U.S. Pagers in Service, 1980-1994



B: Percent of Pagers by Type, 1994

Source: Personal Communications Industry Association (PCIA), "U.S. Pagers in Service, 1980-1999," Table 3.1, page 27, and "Pagers in Service by Type, 1987-1995 (Projected), All Survey Respondents," Table 4.1, page 41. PCIA data based on EMCI, Inc., paging surveys 1988-1995.

public data networks, such as the Internet. Wireline networks may also form the backbone for mobile services. Wireless networks provide services such as cellular, paging, and mobile radio.

2. ***Corded/cordless*** equipment refers to appliances owned by the customer. Here the difference is whether the customer's equipment (telephone, fax, or computer) is tethered to the network by a telephone wire (corded) or whether the customer has mobility through the handset (cordless) - even though the telephone base that the handset rests on uses a wire to connect to the network.

- **Cell and cell sites: Figure 5** illustrates the basics that distinguish mobile communications technologies from the wireline networks: the ***cell*** (an area covered by a single transmitter that sends and receives the communications signals over the air) and the transmission equipment located within each cell. The transmitter's location is called the ***cell site***. The equipment at the cell site functions like an air-traffic controller, communicating with traffic in the control tower's range and making sure that there are no "collisions" (various calls don't interfere with one another). Each call is on a different channel, or each channel is subdivided, to prevent interference.

- **Handoff, or handover:** When a customer crosses the border of a cell **(Figure 5A)**, it is necessary to ***handoff*** the transmission from the transmitter in one cell to the transmitter in the adjacent cell. This handoff allows the customer to move beyond the limits of one calling area into an adjacent calling area while talking to the same person. In fact, one of the most important events in the evolution from early two-way mobile services to cellular services was the technical ability to handoff calls, without interruption, between cells.

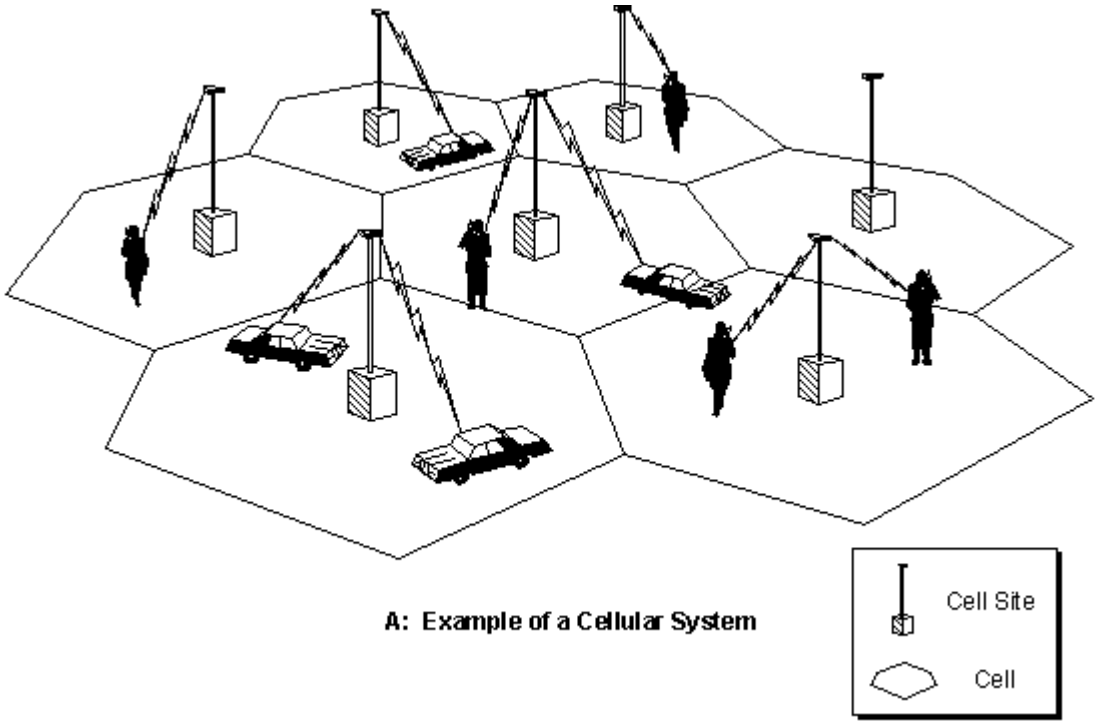
- **Roaming:** When the customer or the equipment moves outside of the home system's service area, this is called ***roaming***. Today, intercompany arrangements enable customers to receive service outside their home base.[10]

- **Blocking:** This occurs when a call never gets through, not even to get a busy signal. Another way to look at this arrangement is that the over-the-air transmission is a highway and the channels are lanes. If all lanes are full, the call is **blocked** and can't go through. Blocking can occur in both wireline and wireless communications.

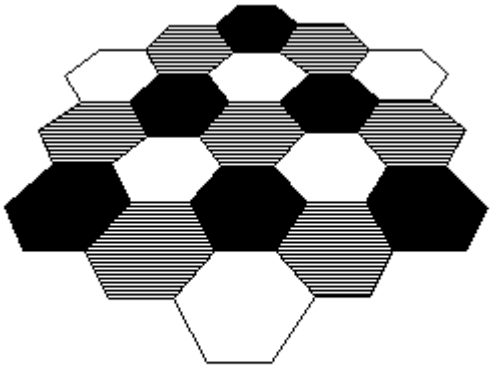
  Limited channel capacity means that sometimes customers don't get a channel. Cellular customers in some locations may experience this problem at certain times of day. For example, in Italy the intense demand for spectrum at seaside and mountain resorts during the traditional end-of-summer vacation period has resulted in vacationers not being able to use their beloved "telefonini" - or little telephones. These systems simply were not built to accommodate the volume of calls to which they are subjected in the summertime, particularly during hours when rates are lowest.[11]

  There are instances where limited spectrum, linked with consumer demand, has driven the implementation of new technologies.[12] In large cities such as Los Angeles, Chicago,

Figure 5: Cellular Architecture



A: Example of a Cellular System



B: Frequency Re-Use Cellular Architecture

Sources: Figure 5B: U.S. Congress, Office of Technology Assessment (OTA), *Wireless Technologies and the National Information Infrastructure,* OTA-ITC-622, U.S. Government Printing Office, Washington, DC, July 1995, page 83.

and New York, these factors underlie the decision to replace the standard analog technology with digital cellular technology.[13]

- **Frequency Re-Use:** In 1947, the idea of a technology to expand system capacity arose with Bell Lab's concept of ***frequency re-use*** in which systems are subdivided into cells.[14] Each subdivision has its own transmission equipment and uses a different transmission channel from its neighbors. In the 1960s, frequency re-use was made possible by technological developments in another area - the development of an intelligent control device. After ***Electronic switching system (ESS)*** technology was developed to route calls for traditional wireline telephone services, this technology could also be used for mobile services.

  Over time, advances in technology made it possible to squeeze more information over the same amount of frequency. The result was more efficient use of the air waves resulting in more services for more customers. **Figure 5B** indicates cells with channels that differ from neighboring cells. Advanced switching technology allows the handoff of a call from a channel in one cell to a channel in an adjacent cell.

- **Analog/Digital Systems:** Communications systems that transmit voice waves in their original form are called ***analog***. In these systems, the voice signal varies in a continuous manner. By analogy, in an analog watch, the hands continuously sweep around the numbers on the dial without interruption. The information is in the continuously varying representation of time C the position of the moving hands in relation to the stationary dial. Currently, most mobile communications systems continue to use analog technology because customers would be required to replace their existing equipment.

  Digital systems transform the voice wave into digital form C short bursts of information that represent the height of the voice wave by a number. By analogy, in a digital watch, the time is displayed by numbers replacing one another at regular intervals. In this case, the information is in numerical form. Digital transmissions may also use complex mathematical manipulations to drastically reduce the amount of information needed to be sent for speech recognition at the other end of the call.[15]

Has any other country experienced success in PCS-Like services?

Other countries deployed cellular and PCS-like services before the U.S. For example, Japan deployed the world's first cellular system in 1979. Also, Japan and Europe already have PCS-like commercial services.[16] Furthermore, in parts of some countries, such China or Eastern Europe, cellular is the only telephone service available for the ordinary consumer. This advance deployment provides information on what succeeded, what failed, what limitations apply, how a particular technology performed, and what government policies hindered or helped deployment of new services.

Within Europe, three different mobile technology/service concepts are in play: a cordless pay phone service, cellular services, and an indoor wireless technology that augments wired technology in offices and factories (employees frequently move around and

it is expensive to keep rewiring stationary telephones).[17] Both England and France use ***Cordless Telephone 2 (CT-2)***, which is a cordless pay phone service. These services are lower in power than cellular and are designed for walking rather than for high speeds (cars, bikes, and roller blades).[18] The French success in CT-2, atypical in Europe, is primarily due to a competitive pricing policy and to the fact that France Telecom has rapidly deployed the two-way capability as an optional feature.

Japan and Hong Kong use a different cordless technology, ***Personal Handy-phone Service (PHS)***. This technology allows customers to use a single piece of equipment indoors as a cordless phone and outdoors as a PHS handset.[19]

A U.S. objective in developing PCS is to have the benefits of these earlier systems without the drawbacks. Some European countries decided to deploy CT-2 as a one-way service: calls can go out but cannot be received. In Japan and in England, there are also current limits on customer speeds (not greater than walking speed) with PCS. The "low mobility" of CT-2 and PHS cannot be used in U.S. markets because most of its cities are not contiguous enough for this type of cordless pay phone service to work. Therefore, most PCS services currently envisioned for the U.S. include wide area mobility as opposed to the islands of coverage that CT-2 and PHS systems require.

III. Spectrum Allocation

Spectrum Allocation?

Spectrum allocation is a technical and legal process which attempts to balance competing public and private industry needs. The U.S. government, through the FCC, assigns various locations in the air waves for public services (such as police departments and emergency preparedness systems) and for private services (such as broadcast TV, citizens band radio, and paging systems). In addition, National Telecommunications and Information Administration (NTIA) authorizes locations for federal government agencies (such as air traffic control systems, national defense, and federal law enforcement). What spectrum is available, and who can use it, has an impact that cuts across local, state, national, and international boundaries.

What is the radio spectrum?

The band at the top of **Figure 6** shows the location of the most common commercial communications services on the radio spectrum and their assigned transmission **frequencies**.[20] A frequency is energy in the form of an electromagnetic wave commonly measured in Hertz (cycles per second, or Hz). A band of frequencies is a range between two defined limits.[21]

The earlier technologies tend to lie at the low end of the spectrum (AM and FM radio, broadcast TV) and the newer technologies tend to lie at the high end of the spectrum (satellite and broadband PCS). The band at the bottom of **Figure 6** provides detail on the various PCS licenses.

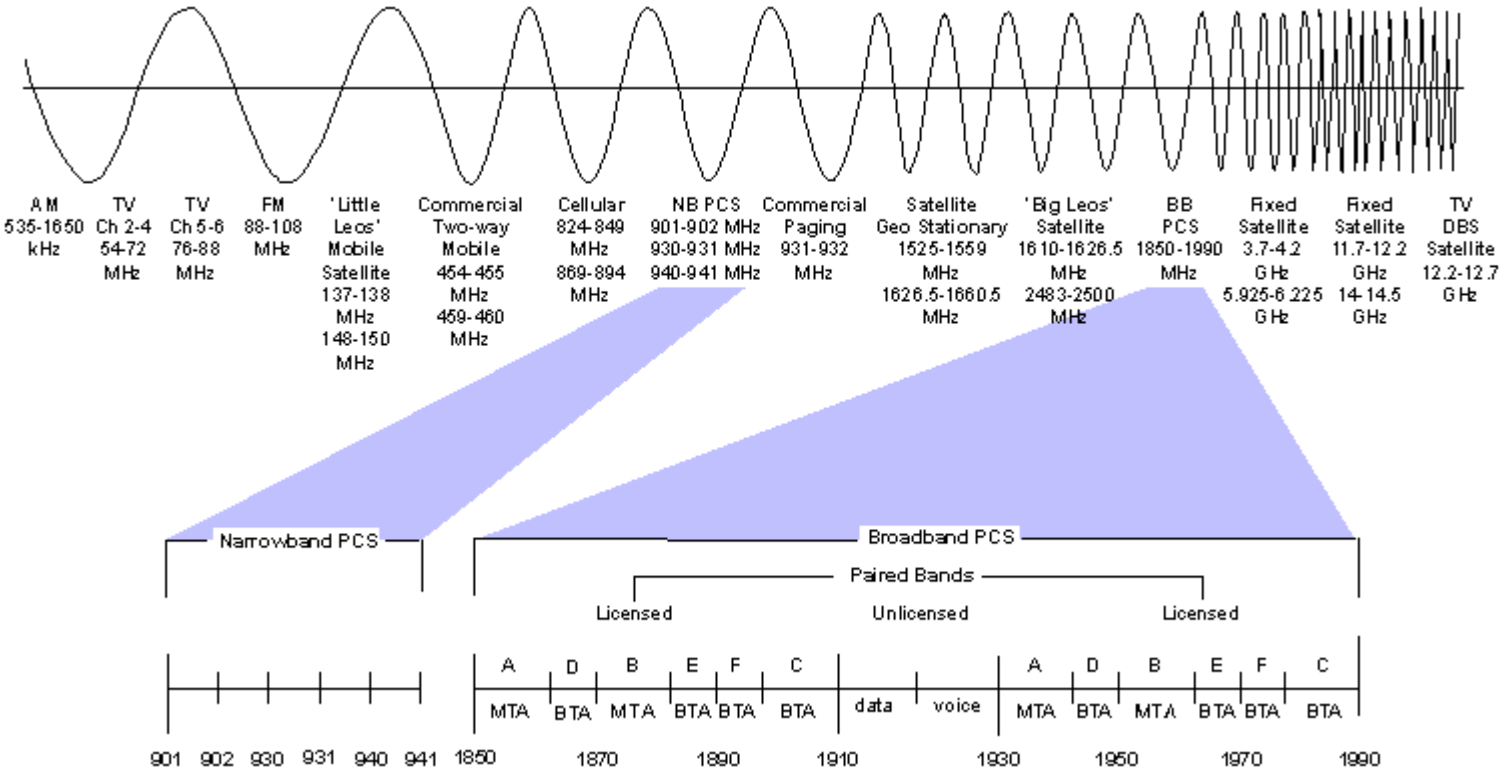
Why did the FCC place PCS where it is in the spectrum?
What is the difference between narrowband PCS and broadband PCS?

Narrowband PCS was designed for advanced paging services (both one-way and two-way) and new wireless messaging services. The position of narrowband PCS in the spectrum (900 MHz range) allows existing commercial paging companies operating in the 931-932 MHz range to purchase licenses for the adjacent narrowband PCS spectrum and offer two-way data services and use existing technology and equipment.

U.S. cellular frequencies were different from other countries' mobile frequencies. **"Figure 7** shows the international spectrum locations of cellular and **broadband PCS** services for a number of countries. The placement of broadband PCS grew out of the 1992 international **World Administrative Radio Conference (WARC)** and the need for worldwide coordination of mobile communications services.

The U.S. Congress passed the **Omnibus Budget Reconciliation Act of 1993**. This act included provisions that preempted state authority over market entry and rates of **Commercial Mobile Radio Services (CMRS)**, thereby giving primary oversight of private and commercial radio service providers C such as paging and two-way radio - to a single regulatory authority, the FCC.[23] In addition, the act removed artificial distinctions between

Figure 6:
U.S. Radio Spectrum: Location of Commercial Services

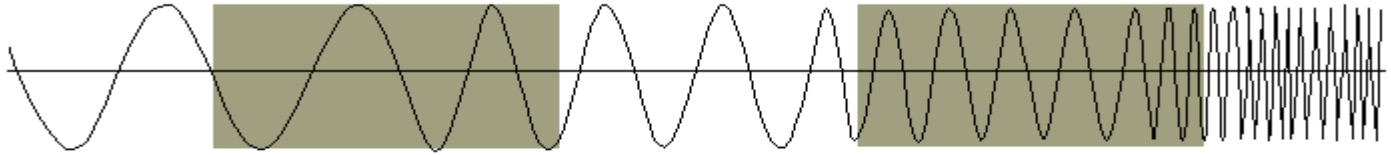


Source: Personal communications with the Federal Communications Commission (FCC), National Telecommunications and Information Administration (NTIA), and Nortel

Figure 7: Location of Cellular and Broadband PCS Services: U.S. and Some International Examples

United States

United States	824-849 MHz 869-894 MHz	Cellular
United States	1850-1919 MHz 1930-1990 MHz	Broadband PCS



International

Canada	944-948 MHz 948-952 MHz	Digital Cordless Telephone
China	890-915 MHz 935-960 MHz	Cellular
France	864-868 MHz	CT-2/CAI, "Bi-Bop"
Germany	864-868 MHz	CT-2
	890-915 MHz 935-960 MHz	Cellular
India	890-915 MHz 935-960 MHz	Cellular
Kenya	900 MHz Range	Enhanced Total Access Communications Systems (ETACS)
Mexico	840-860 MHz 920-940 MHz	Cellular
Russia	900 MHz Range	Cellular (Global System for Mobile Communications, or GSM)
Thailand	897.5-905 MHz 942.5-950 MHz	Cellular (GSM)
United Kingdom	864-868 MHz	CT-2

France	1880-1900 MHz	Digital European Cordless Telephone (DECT) Standard
Global	1800-1900 MHz	GSM-Derivative DCS-1800
Germany	1800-1900 MHz	DECT
Japan	1429-1525 MHz	Digital Cellular
Japan	1535-2655 MHz 1895-1918.1 MHz	Next Generation Portable Telephone Personal Handy-phone Service (PHS)
Thailand	1710-1785 MHz 1805-1880 MHz	PCN
Pan-European	1800-1900 MHz	DECT
United Kingdom	1710-1785 MHz 1805-1880 MHz	PCN

Note: This chart provides examples and is not all inclusive. For example, many countries (including Germany, Russia, and Thailand) have additional spectrum allocations not listed in this chart. Also, countries may have more than one wireless standard in use. For Russia and Kenya the specific frequencies were unavailable as of publication time.
Sources: FCC. Ramona Vassar Isbell, "World Report '95," *Cellular Business*, April 1995, pages 30-38. Also, personal communications with the U.S. International Trade Administration, December 1995; U.S. Department of Commerce, NTIA, December 1995; and Michael Berlage, Eutelis Consult GMBH, Ratingen Germany, October 1995.

"private" and "commercial" radio services and regulate essentially equal services the same way.

Broadband spectrum bands enable wireless voice and moderate speed data applications. The position in the spectrum of broadband PCS (1850-1990 MHz range) aligns it with the international range for worldwide mobile services (2-GHz range).

The terms "broadband" and "narrowband" indicate that one has greater capacity than the other. An analogy is a stream (broadband, or 30 MHz of spectrum per license) versus a garden hose (narrowband, or 50 kHz per license).

What is the difference between broadband PCS and broadband (fiber optic)?

As noted above, "broadband" PCS is named to distinguish it from "narrowband" PCS. Broadband PCS should not be confused with "broadband" fiber optic wireline services. Fiber optic services use advanced light-wave technology and have greater transmission capacity. Optical fiber has the capacity of many thousands MHz compared to broadband PCS which has the capacity of 10-30 MHz. Wireless systems provide mobility. Fiber (wireline) systems don't - unless a wireless device is attached to the end of a fiber.

Broadband PCS and broadband fiber are technologies for different applications and different markets. Broadband PCS carries voice-grade signals which use only a fraction of a broadband fiber. If broadband PCS is a stream, then broadband fiber is an ocean.

IV. What is the Relation between PCS/Cellular Services and Technologies?

What is the difference between PCS and cellular services?

1. The market areas are different for PCS. Instead of cellular's **Metropolitan Statistical Area (MSA)** and **Rural Service Area (RSA)** markets, the FCC selected a different definition of the market areas for PCS based on the Rand McNally **Basic Trading Areas (BTAs)** and **Major Trading Areas (MTAs)** geographic boundaries.[24] Some PCS areas are larger, and encompass major economic centers. This was done to encourage the development of regional and national services.

2. Initial PCS technology will be digital as opposed to cellular technology, which is evolving from analog to digital. However, cellular providers have an advantage with their existing customer base. PCS providers are at an advantage because they have no existing analog subscribers.[25]

3. Current PCS handsets often weigh less than older cellular phones. This may not be true for newer cellular phones or if a single handset contains more than one PCS technology to accommodate multiple standards.

4. Transmission frequencies for PCS and cellular are different (see **Figure 6**).

5. Broadband PCS providers must be able to serve a substantial amount of the population in the PCS markets within five years.[26]

Which companies are going to compete with PCS services?

Cellular and other types of wireless companies already exist and PCS will compete with some of them. **Figure 8** shows the potential range of competitors and technologies for wireless services in 1994. However, each of these companies has limitations, such as limited space (bandwidth) or high deployment costs.

Will the PCS handset work like a telephone? Will it work everywhere?

For PCS, the problems are the same as those of existing cellular companies and customers. In some cases, the home company for a cellular customer does not have a roaming agreement with cellular companies in other cities. This means that when the customer travels to these cities, the cellular handset cannot automatically send or receive calls. These are administrative rather than technical limits that are handled individually (the customer calls the local cellular company in the new city to set up an account). In cases where a company operates in many areas or has roaming agreements with other companies, calls can be made with the same mobile handset as the customer moves from city to city. However, competing technologies may require mobile handsets to work with both PCS and cellular systems.

IV. What is the Relation between PCS/Cellular Services and Technologies?, cont.

Figure 8:
Potential Range of Competitors and Technologies Providing Wireless Services, 1994

Service:	Service: Providers	Spectrum Allocation:	Type of Technology:	Analog or Digital:	Technology Limitations:	Availability of Services to Consumers:
Specialized Mobile (SMR, ESMR)	Nextel, MCI	806-824 MHz 900-901 MHz 902-928 MHz	TDMA	Analog	Analog, Low frequency, Slow transmissions.	Available
Radio-Based Networks	ARDIS, RAM Mobile, Data, EMBARC, SkyTel, Radio Mail (Motorola, IBM, Fujitsu, BellSouth)		Packet-Switched Radio	Digital	Very limited bandwidth, Store and forward technology, Not good for real-time transactions.	Available
Cellular Analog	RHCs, GTE, AT&T, Sprint Cellular	824-849 MHz 869-894 MHz	Cellular Microwave	Analog	Analog, Limited bandwidth Limited reliability for data.	Available
Cellular Digital Packed Data (CDPD)			TDMA	Digital	Slow Development	Available
			CDMA	Digital	Future Development	Not Available
Broadband PCS	Numerous: existing communications companies and new ones.	1850-1900 MHz	TDMA, CDMA, GSM, Omnipoint, etc.	Digital	Unknown	Not Available

IV. What is the Relation between PCS/Cellular Services and Technologies?, cont.

Service:	Service: Providers	Spectrum Allocation:	Type of Technology:	Analog or Digital:	Technology Limitations:	Availability of Services to Consumers:
Narrowband PCS	Numerous: existing communications companies and new ones	901-902 MHz 930 MHz 940 MHz	CDMA	Digital	More expensive than alternative messaging technologies, Not useful for voice	Limited Availability
Mobile Satellite Service above 1GHz	Motorola (Iridium) Ellipsat, Constellation, Loral/Qualcomm (Goldstar), TRW (Odyssey)	1610-1626.5 MHz 2483-2500 MHz	TDMA, CDMA, LEO Satellite	Digital	High-cost deployment, Untested technology for wireless application.	Currently available to companies and government for TV and radio. Envisioned as voice/data services for consumers
Fixes Satellite Services (FSS)	Teledesic, Hughes Spaceway	3.7-4.2 GHz 5.925-6.225 GHz 11.7-12.2 GHz 14-14.5 GHz	GSO and LEO Satellite	Digital	High-Cost deployment, Technology at concept stage.	Not Available. Potential for voice/data services for consumers.
Wireless Cable (Multichannel Multipoint Distribution Service (MMDS)	People's Choice, Preferred Entertainment, ACS Enterprises	2500-2690 MHz	Microwave	Digital	Currently one-way transmission.	Not Available
Cellular TV (Local Multipoint Distribution Service or LMDS)	Suite 12, CellularVision, Hughes	28 GHz	1mm Wave/ Microwave, Microcellular	Digital	Technology at trial stage, Deployment costs unpredictable.	Not Available

Source: Adapted from research by Doug Weiss, Corporation for Public Broadcasting, October 2, 1995.

IV. What is the Relation between PCS/Cellular Services and Technologies?, cont.

There is an additional, much larger issue: how to interconnect all the communications companies with everyone in the U.S. and the world. In the traditional telephone network, the telephone is tethered to the PSN, allowing everyone to reach everyone else even though many different companies provide the facilities that route the calls. This universal reach is accomplished by regulatory rules for hooking up, or interconnecting, with the PSN. In fact, with the increasing number of new types of communications companies wanting to interconnect with the PSN, there is a need to revise *all* the interconnection rules and not just those for mobile services.[27]

PCS companies are similar to other communications companies in that they may own an entire network (radio ports, switching centers, and transport facilities) or may only own a portion (only radio ports and the towers and antennas which actually radiate the signals to the customers' hand held units). In this second case, the PCS company would then purchase the switching and transport functions from another entity, such as a local telephone company, cable TV company, or some other company.

What's going on with standards?

There are a number of different communications standards organizations - governmental, academic and industrial; national and international. In general, standard setting is a mix of government and company interests driven by technology and unpredictable markets. **Figure 9** indicates the organizations involved with setting PCS standards. Since standard setting is a technical field, all the groups have acronyms that are unintelligible to the ordinary citizen. Therefore, the accompanying chart provides what each acronym stands for and describes each group's role in setting PCS standards.

While there are many standards issues (such as how to design the systems for keeping track of calls for billing purposes), there is a major debate over what is the standard for PCS multiple access technique - a method that allows more than one call on the same channel. Differences are over how big the channel is and how that channel is shared. The digital PCS and cellular standards committees have not agreed on one common standard. Instead, they have agreed on a number of choices. In other words, they have agreed to disagree. The fight is in the market place as each company tries to convince customers that its standard is best. Each company wants its prototypes to become the national standard, which would enable the company to reap the rewards through intellectual property rights and a head start on the technology.[28]

There are competing standards for multiple access. **Figure 10** indicates three technologies that underlie the debates over broadband PCS and cellular standards: ***Frequency Division Multiple Access (FDMA)***, ***Time Division Multiple Access (TDMA)***, and ***Code Division Multiple Access (CDMA)***. An analogy for comparing FDMA, TDMA, and CDMA is a room full of people, all talking, but only in pairs. If each pair spoke at different

pitches, this would be FDMA. If each pair spoke at different times, this would be TDMA. And, if each pair spoke in different languages, this would be CDMA.[29]

- **FDMA:** A format[30] for multiple access common in most cellular systems today. Information is sent through a channel which is divided into frequencies. The name for the 1970s analog cellular technology that uses FDMA is ***Advanced Mobile Phone Service (AMPS)***. In large cities, some AMPS systems have reached the capacity limit, requiring a change to a digital cellular technology.

- **TDMA:** A 1989 update of the current analog cellular systems to a digital format. Several customers use a single channel, each taking up the entire channel for a fraction of time. With TDMA, many more calls can be made from the same base station than with AMPS.

- **CDMA:** An alternative standard to divide up a single channel among several customers. Each customer's transmission has a unique code, or language.[31] The equipment at the receiving end is given this code. Like TDMA, the goal of CDMA is to allow more calls from the same base station.

Each of these above technologies may give rise to multiple standards. For example, some cellular systems in other parts of the world use a TDMA technology for their ***Global Systems for Mobile communications (GSM)*** standard. When modified to work at U.S. PCS frequencies, the standard is called ***PCS-1900***. Another TDMA-based standard used in the U.S. is ***IS-136 TDMA***. Differences in these standards are in channel size and in the way calls are split over time.

There is difficulty in assessing strengths and weaknesses of the various standards: PCS systems are fledgling and the competitive nature of the various industries works against compromise.

IV. What is the Relation between PCS/Cellular Services and Technologies?, cont.

Figure 9:
PCS Standards Organizations

Boldface text indicated that the key focus of the standards body is PCS. Regular text indicated that the standards body covers PCS issues in their general work.

Acronym:	Name:	Area:
Industry:		
-	Various ad hoc groups	Within the PCS community, various ad hoc groups form, last for a few meetings, perform their objective, and then disappear.
ATIS:	Alliance for Telecommunications Industry Solutions	Produces technical standards and operational guidelines for telecommunications networks.
T1	ATIS - Committee T1	An ATIS umbrella committee focusing on telecommunications interconnection and interoperability standards. Its subcommittee T1P1 works on PCS specifically. However, other subcommittees (T1M1 and T1S1) also provide input for PCS standards.
T1M1	ATIS - Technical Subcommittee of Committee T1, also called TSC T1M1	Works on standards for internetwork planning and engineering and for testing and operations systems and protocols. Provides some PCS standards.
T1P1	**ATIC - Technical Subcommittee of Committee T1, also called TSC T1P1**	**Works on standards for personal communications, wireless access and terminal mobility, and program management and standards. Main focus for T1 setting of PCS standards.**
T1S1	ATIS - Technical Subcommittee of Committee T1, also called TSC T1S1	Works on standards for architecture and services, switching and signaling protocols, and broadband ISDN. Provides some PCS standards
-	Bellcore	Develops requirements for air interfaces for small cell, low mobility wireless applications - Personal Access Communications System (PACS) and Wireless Access Communications System (WACS) technologies.
CTIA	Cellular Telecommunications Industry Association	A trade association that promotes standards for wireless services

IV. What is the Relation between PCS/Cellular Services and Technologies?, cont.

JTC	**Joint Technical Committee on Wireless Access**	**In 1992, the T1P1.4 and TR46.3.3 committees combined to work jointly on air-interface standards. The JTC has approved six different U.S. PCS air interface-standards.**
TIA	Telecommunications Industry Association:	A trade association that sponsors standards committees for telecommunications
TR41	**TIA Committee TR41**	**Works on unlicensed PCS 1800 MHz standards.**
TR45	**TIA Committee TR45**	**Originally worked just on cellular 800 MHz standards but currently has expanded scope to include some PCS 180-0 MHz.**
TR46	**TIA Committee TR46**	**Works on PCS 1800 MHz standards.**
PCIA	**Personal Communications Industry Association**	**A trade association comprised of potential PCS service providers and manufacturers. Represents interests of the PCS industry in regulatory forums. Identifies areas that need standards and submits industry recommendations to the various standards bodies.**

U. S. Government:

APCO	Association of Public Safety Communication Officers	Provides input by police and other law enforcement departments into standards bodies for PCS support of E911 (Emergency 911) services.
DOD	U.S. Department of Defense	Has various organizations in which submit positions and work with other standards bodies.
ECSP	Electronic Communications Service Providers	Industry and government group that socializes proposed standards on authorized electronic surveillance (intercept access) and submits them to TR45, TR46, and T1P1.
FCC	**Federal Communications Commission**	**Determines U.S. spectrum allocation for communications services. Generally leaves standards to the industries.[a]**
NASNA	National Association of State 911 Agencies	Provides input by state agencies into standards bodies for PCS support of E911 (Emergency 911) services.

[a]One exception to this rule is the FCC's active role in High Definition Television (HDTV).

IV. What is the Relation between PCS/Cellular Services and Technologies?, cont.

NENA	National Emergency Numbers Association	Provides input into standards bodies for PCS support of E911 (Emergency 911) services.
NTIA	**National Telecommunications and Information Administration**	**Has responsibility for the federal government's use of the spectrum. In addition, NTIA's Institute for Telecommunications Sciences helps to develop PCS standards and NTIA's policy office analyzes PCS market and regulatory issues for the Executive branch of the federal government.**
TILU	Federal Bureau of Investigation's Telecommunications Industry Liaison Unit	Works on standards for authorized electronic surveillance (intercept access). Contributes to the ECSP
-	U.S. State Department	Forges national positions with industry for submission to the ITU

International:

EC	European Community	Develops common policies for spectrum allocation and standards for it 12 member nations: Belgium, Britain, Denmark, Germany, Greece, France, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. Influences other European countries as well
ETSI	European Technical Standards Institute	Works closely with EC technical experts.
IEEE	Institute of Electrical and Electronics Engineers, Inc.	An international professional organization of engineers (electrical, electronics, and computer) from industry, academia, and government. Develops and disseminates voluntary consensus-based industry standards. **The ITU's 1990 World Administrative Radio Conference set spectrum standards near the 2-GHz band to allow worldwide mobile radio services.**
IEEE C/S-LMSC	**IEEE Computer Society Local and Metropolitan Networks Standards Committee - Wireless LAN Working Group (802.11)**	**Developing a wireless local area network (LAN) standard.**
ITU	International Telecommunication Union	Intergovernmental organization responsible for regulation, standardization , and development of telecommunications.

IV. What is the Relation between PCS/Cellular Services and Technologies?, cont.

ITU-R	International Telecommunication Union - Radio	Makes recommendations on regulations and standards for the use of the radio frequency spectrum, including spectrum allocation.
ITU-T	International Telecommunication Union - Telecommunications	Studies technical, operating, and tariff questions related to standardization. Recommends telecommunications standards.

Sources:

Personal communications with Randy Coleman, CTIA, December 13, 1995; Cliff Halevi, Bellcore, October 10, 1995; Jim Staats, Bellcore, October 11, 1995.

OTA, *WirelessTechnologies* and the *National Information Infrastructure*, pages 172 and Box 6-4, page 177.

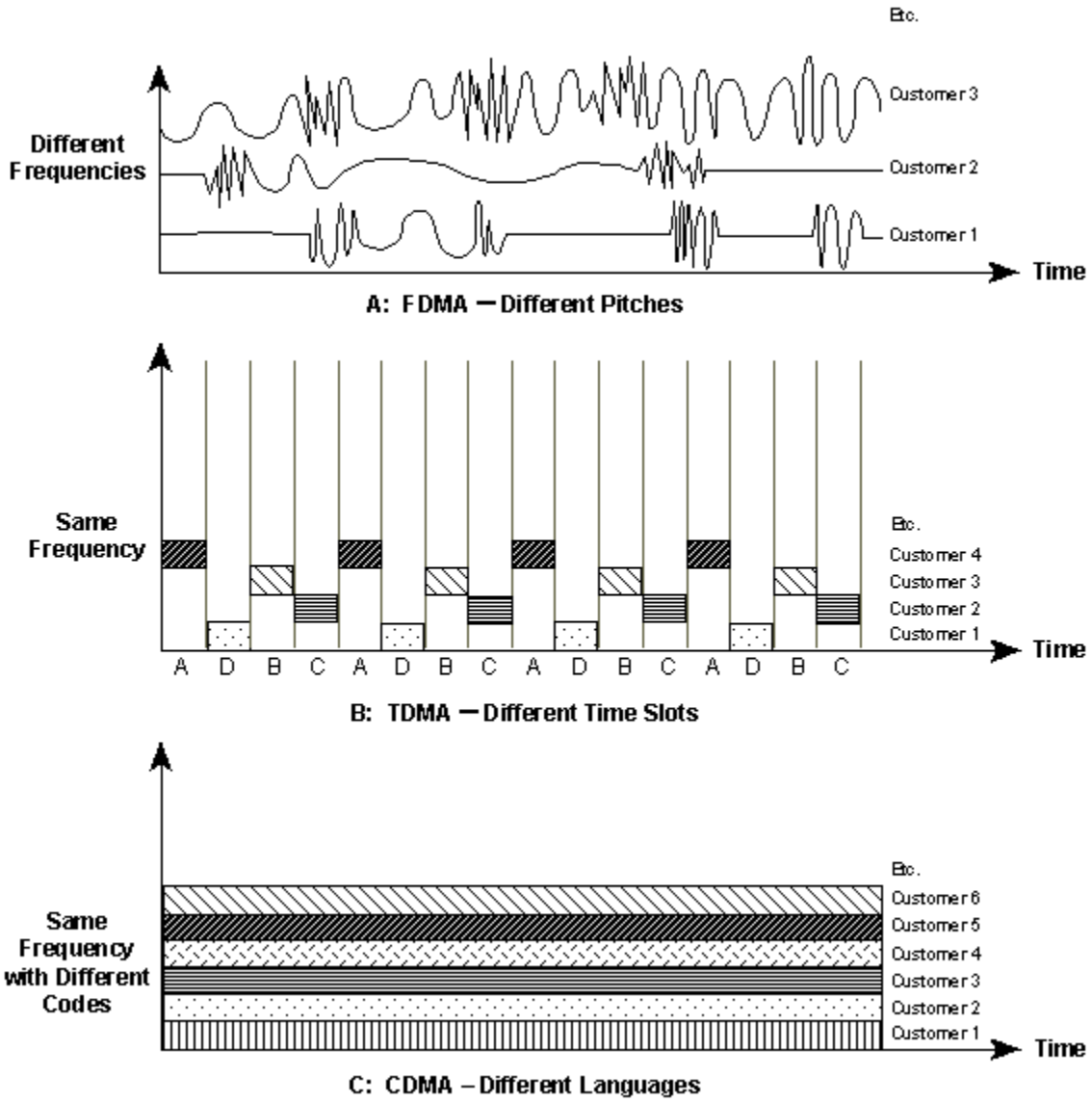
Pearce, British PCN *Policy* (see note 17), page 25.

ITU: Celebrating 130 Years, 1865-1995 (London: International Systems and Communications, Ltd.; 1995), Page 26ff.

Minimizing Regulatory and Legislative Intervention in Your Business by Resolving Complex Issues through Consensus, Alliance for Telecommunications Industry Solutions (Washington, DC; 1995).

IV. What is the Relation between PCS/Cellular Services and Technologies?, cont.

Figure 10:
Multiple Access Standards: Methods for More than One Call on the Same Channel



V. PCS Auctions

Why is the FCC auctioning licenses for pieces of the spectrum?

There are two reasons for the PCS auctions: to have a better system for granting spectrum licenses in a situation where demand exceeds the available licenses and to generate dollars to reduce the federal budget deficit.[32] It had become obvious that fraud and speculation in the cellular license lottery was wasting a significant resource and source of revenue for the public.[33] **Figure 11** indicates the various PCS auction blocks and the money raised by each auction.

How much has been auctioned? How much more will be auctioned?

As of October, the total amount raised by the PCS auctions was $8.8 billion with $7.7 billion from the broadband PCS auctions and $1.1 billion from the narrowband PCS auctions (**Figure 11**). Of this total, $8.1 billion was for standard licenses and $0.7 billion was for pioneer's preference licenses. The entrepreneur's license auctions will be held in the near future.

What are entrepreneur's licenses?

The FCC created entrepreneur's licenses to fulfill the Congressional mandate to "encourage small businesses, rural telephone companies, and businesses owned by members of minority groups and women (collectively known as 'designated entities')" to provide wireless services.[34] Entrepreneur's licenses are for the C and F blocks for broadband PCS (**Figures 6 and 11**). Small businesses may pay for their licenses through installment payment plans[35] and are eligible for a 25 percent bidding credit (a 25 percent reduction in the price of the winning bid).[36] The rules for cross-ownership of PCS licenses by cellular and CMRS providers are relaxed for entrepreneur companies, allowing a greater percent to be owned (40% instead of 20%).[37]

What is a pioneer's preference and why did some companies get them?

The FCC awarded four pioneer's preference licenses "to foster the development of new services and improve existing services by reducing the delays and risks for innovators."[38] The companies receiving these licenses had to demonstrate that the proposed PCS services would meet the following technology and service criteria:[39]

1. Constitutes a significant innovation or an advance in technology.

2. The license holder is responsible for the innovation.

3. The license holder has made a significant contribution to developing the innovation.

4. The innovation should create a new service or substantially enhance existing services.

V. PCS Auctions, cont.

Figure 11: PCS Auctions

Broadband PCS

Channel Block:	Channel Size:	Spectrum Frequency:	Markets:	Number of Type of Licenses:	Auction Period:	Dollars Raised:
A, B	30 MHz	1850 - 1865 and 1930 - 1945 MHz 1870 - 1885 and 1950 - 1965 MHz	51 MTAs	99 Standard 3 Pioneer's Preference	Dec. 5, 1994 - Mar. 13, 1995	$7,034,240,010 $701,780,374
C	30 MHz	1895 - 1910 and 1975 - 1990 MHz	493 BTAs	493 Entrepreneur	Dec. 18, 1995	
D, E, F	10 MHz	1865 - 1870 and 1945 - 1950 MHz 1885 - 1890 and 1965 - 1970 MHz 1890 - 1895 and 1970 - 1975 MHz	493 BTAs	986 Standard 793 Entrepreneur		
Total		1850 - 1990 MHz				$7,736,020,384

Narrowband PCS

1,2,3,4,5	50 KHz paired with 50 KHz	940.00 - 940.05 and 901.00 - 901.05 MHz 940.05 - 940.10 and 901.05 - 901.10 MHz 940.10 - 940.15 and 901.10 - 901.15 MHz 940.15 - 940.20 and 901.15 - 901.20 MHz 940.20 - 940.25 and 901.20 - 901.25 MHz	5 Nationwide	5 Standard	Jul. 25, 1994 - Jul. 19, 1994	$400,000,000 ($80,000,000 for each license)
12,13	50 KHz paired with 50 KHz	940.25 - 940.30 and 901.25 - 901.40 MHz 940.40 - 940.45 and 901.40 - 901.45 MHz	5 Regions	10 Standard	Oct. 16, 1994 - Nov. 18, 1994	$92,599,020 $151,544,001
18,19	50 KHz paired with 50 KHz	940.35 - 940.40 and 901.35 - 901.40 MHz 940.40 - 940.45 and 901.40 - 901.45 MHz	51 MTAs	102 Standard		
6,7,8	50 KHz paired with 12.5 KHz	930.40 - 930.45 and 901.7500 - 901.7625 MHz 930.45 - 930.50 and 901.7625 - 901.7750 MHz 930.50 - 930.55 and 901.7750 - 901.7875 MHz	3 Nationwide	3 Standard	Jul. 25, 1994 - Jul. 19, 1994	$47,001,001 $47,505,673 $47,500,000

V. PCS Auctions, cont.

Channel Block:	Channel Size:	Spectrum Frequency:	Markets:	Number and Type of Licenses:	Auction Period:	Dollars Raised:
14, 15, 16, 17	**50 KHz paired with 12.5 KHz**	930.55 - 930.60 and 901.7875 - 901.8000 MHz 930.60 - 930.65 and 901.8000 - 901.8125 MHz 930.65 - 930.70 and 901.8125 - 901.8250 MHz 930.70 - 930.75 and 901.8250 - 901.8375 MHz	**5 Regions**	**20 Standard**	**Oct. 26, 1994 - Nov. 8, 1994**	**$53,6999,092 $53,621,666 $48,718,014 $88,621,007**
20, 21, 22	**50 KHz paired with 12.5 KHz**	930.75 - 930.80 and 901.8375 - 901.8500 MHz 930.80 - 930.85 and 901.8500 - 901.8625 MHz 930.85 - 930.90 and 901.8625 - 901.8750 MHz	**51 MTAs**	**153 Standard**		
25, 26	**50 KHz paired with 12.5 KHz**	930.90 - 930.95 and 901.8750 - 901.8875 MHz 930.95 - 930.00 and 901.8875 - 901.9000 MHz	**493 BTAs**	**986 Standard**		
9, 10, 11	**Unpaired 50 KHz**	**940.75 - 940.80 MHz 940.80 - 940.85 MHz 940.85 - 940.90 MHz**	**3 Nationwide**	**2 Standard 1 Pioneer**	**Jul. 25, 1994 - Jul. 29, 1994**	**$37,000,000 $38,000,000 $33,300,000**
23, 24	**Unpaired 50 KHz**	**940.90 - 940.95 MHz 940.95 - 941.00 MHz**	**51 MTAs**	**102 Standard**		
Total						**$1,139,109,474**

Unlicensed PCS

	1.25 MHz	**1910 - 1930 MHz**				

Total for PCS Auctions

						$8,875,129,858

Sources: Personal communications with the FCC. Also, FCC, *In the Matter of Amendment of the Commission's Rules to Establish new Personal Communications Services* (hereinafter referred to as the *PCS Docket),* GEN Docket No. 90-314, *Notice of Proposed Rule Making and Tentative Decision,* FCC No. 92-333, August 14, 1992, footnote 42, p. 25; *Memorandum Opinion and Order,* FCC No. 94-144, June 13, 1994, ¶ 17b, page 7, and ¶ 75-76, page 31; *First Report and Order,* FCC No. 93-329, July 23, 1993, ¶ 77, pages 32-33; and *Third Report and Order,* FCC No. 93-550, February 3, 1994, ¶ 36, pages 16-17; ¶ 51, page 21; and ¶ 74, page 28; and *FCC Broadband PCS Auction Submission Round Results,* March 13, 1995.

The pioneer's preferences were awarded to the following companies:[40]

- Mtel (Mobile Telecommunication Technologies Corporation) received a nationwide narrowband PCS license for developing an advance in digital (bit rate) transmission that was ten times greater than existing rates. The benefit of this innovation is "a broad range of two-way data communications services, acknowledgment paging, encryption, error correction, and general determination of subscriber location."[41]

- American Personal Communications (APC) received a broadband PCS license for the Washington, DC/Baltimore MTA (Channel Block A) for developing technology that permits the location of "PCS base stations and use of the spectrum for PCS without an immediate need to relocate existing microwave service providers."[42] The benefit of this innovation is that it allows spectrum sharing at 2 GHz. PCS services may be introduced without disrupting other service providers.

- Cox Enterprises, Inc. received a broadband PCS license for the Los Angeles/San Diego MTA (Channel Block A) for developing technology that uses cable distribution facilities as the backbone for a PCS network for PCS microcell equipment (small, inexpensive passive antennas). The benefit of this innovation is the use of existing cable facilities to speed the deployment of PCS and the substitution of wire facilities for increasingly scarce spectrum.[43]

- Omnipoint Communications, Inc. received a broadband PCS license for the New York/northern New Jersey MTA (Channel Block A) for developing and producing the first "practical, working 2 GHz equipment for PCS."[44] The benefit of this innovation is a handset with two modes that permits the use of unlicensed frequencies in business and residential environments and the use of licensed PCS frequencies in public or mobile environments. The dual modes also allow the transmission of long data messages within a shorter time frame by assigning portions of the same message to each frequency.[45]

How did companies pay for the pioneer's preference licenses?

Mtel, the winner of the narrowband pioneer's preference license, initially was required to pay the lesser of two options: 90% of the lowest winning bid for a comparable license or $3 million less than the lowest winning bid. After the July narrowband auctions, the FCC required Mtel to pay the 90% discounted rate, or $33.3 million (see **Figure 11**).[46]

Initially the FCC was to award the three broadband PCS pioneer's preference licenses for free. The FCC later required APC, Cox, and Omnipoint to pay a discount rate. These companies chose the method used for the Mtel narrowband license instead of their other option (participate in the auctions with a discounted rate). In December 1994, Congress superseded the FCC's payment formula in the General Agreement on Tariffs and Trade (GATT) legislation.[47]

Why are the PCS companies having to pay such high prices for cell site real estate?

PCS systems will need more cells than do cellular systems covering the equivalent area. Current cellular systems use 18,000 cell sites **(Figure 3B)**. Projected national PCS cell sites are 100,000.[48] In order to provide services, PCS providers must negotiate real estate leases and obtain local ordinances for building cell sites.[49]

Given the nature of PCS technology, only certain sites can be used. With the smaller cells (such as those in high-density, urban areas), the central area for the cell site where the antenna resides is also smaller. Antenna placement must account for congestion (high consumer demand) and for geographic characteristics (mountains, buildings). Also, some of these cell sites already have existing cellular companies present. Unless the PCS company is already providing cellular services from the site, these cellular companies are potential competitors. There's no advantage for them to share the site. Furthermore the PCS providers have just paid large amounts of money for their licenses. And the FCC requires them to build out their networks within a five-year time period.[50] The real estate owners recognize these forces and value their property accordingly. PCS companies are left with a weak hand at the negotiating table.

What if someone already occupies a place in the PCS spectrum?

If a service already occupies one of the broadband PCS channels or blocks, the company awarded the license must negotiate with the current occupant. The negotiation process could be complicated and lengthy. For example, one issue is payment for moving the current occupant elsewhere on the spectrum. An existing occupant may delay negotiations by arguing that their new location on the spectrum is not comparable to their current one. If this occupant provides public safety services, where any interruption of service is unacceptable, delays for PCS services may be even longer.

What's the FCC policy on reselling a license?

Congress requires the FCC "to prevent unjust enrichment due to trafficking in licenses obtained" in the PCS auctions. The intent is to have the companies bidding for licenses roll out services to customers and to not treat the license alone as a commodity to be traded. The FCC has rules for the resale of licenses. Within the first five years after a license had been granted, the buyer and seller must file the "transfer application, the associated contracts for sale, option agreements, management agreements, and all other documents disclosing the total consideration received in return for the transfer of license."[51]

VI. Policy Issues

What issues need to be resolved?

While Congress has determined the lion's share of issues surrounding the entry and rate regulation of PCS services, many additional policy issues remain. Many of the issues facing PCS are identical to those facing the existing cellular industry, and many of the cellular solutions are applicable to PCS. However, the overall environment has changed with increased competition and the convergence of traditional communications industries. Therefore, all mobile services, not just PCS, may require new solutions, including a potential change in the rules governing the cellular and other frequencies. The following is a list of PCS issues that need to be resolved:

1. Interconnection
    a. Appropriate technology, including standards
    b. Economically efficient pricing
    c. Appropriate rules regarding the provision of resold services and interconnection of networks
    d. Numbering resources
    e. Access to E911

2. Fraud
    a. Licensing applications
    b. Consumer fraud, including cloning (diminishes with digital), theft, and calling-party-pays

3. Security/Privacy

4. Portability

5. Billing structures, including payments (such as calling-party-pays) and administration systems

6. Effect of failure of license holder to build-out in conformity with the FCC's five-year guidelines

7. Ownership restrictions

8. Relocation of microwave tenants currently occupying PCS spectrum

9. International Trade

10. Manufacturing
    a. Inability to produce infrastructure in sufficient quantities to satisfy demand for cellular, let alone PCS
    b. Inability to produce consumer technologies in sufficient quantities to satisfy consumer demand

VI. Policy Issues, cont.

11. Jurisdiction
    a. Federal
    b. State
        1. States preempted with regard to market entry and rate regulation
        2. Consumer protection/quality of service
        3. Facilities siting (towers/zoning)
        4. Bundling of PCS services with wireline
        5. Operator/emergency services/Telephone Relay Service (TRS)
        6. Impact of MTA's/BTA's overlapping state boundaries on preemption issue
    c. Municipal
        a. Environmental/tower siting
        b. Taxation (such as per customer or by percent of total revenues)
        c. Construction/right-of-way

12. Site Acquisition
    a. Impact on communities
    b. Real estate availability and cost

13. Universal Service Role

VII. Notes

Notes

1. Conversely, with ***wireline services***, the communications appliance used by the customer is linked to a network by wires, such as copper wire, coaxial cable, and/or fiber optic cable.

2. FCC, *In the Matter of Amendment of the Commission's Rules to Establish new Personal Communications Services* (hereinafter referred to as the *PCS Docket*), GEN Docket No. 90-314, *Notice of Proposed Rule Making and Tentative Decision*, FCC No. 92-333, August 14, 1992, & 29, page 14. Also, *Memorandum Opinion and Order*, FCC No. 94-144, June 13, 1994, & 2, page 3.

3. There is the potential for competition between broadband PCS and cellular services (see **Figure 8**).

4. For example, ***Signaling System 7 (SS7)*** technologies allow efficient network connections, faster call set up, calling line identification services, and efficient interconnections between neighboring service providers. ***Advanced intelligent network (AIN)*** technologies will provide additional capabilities. Some concrete examples are mobile services inside buildings and number portability (customers keep the same telephone numbers even if they switch to a different company to carry their calls).

5. The cellular duopoly was a compromise between the most efficient use of the spectrum (one carrier) and the benefits of competition (many carriers). One license in each market was given to the resident local telephone company to ensure that cellular services would be deployed.

6. *PCS Docket*, *Memorandum Opinion and Order*, & 3-6, pages 3-4.

7. U.S. cellular technology is used in many other countries (China, Singapore, Korea, Australia, and many South Amercian countries). See **Figure 7** for a comparison of U.S. cellular and broadband PCS spectrum locations with some international examples. Also, see **Figure 6** for the details on the spectrum location of U.S. commercial mobile services.

8. AT&T Wireless already provides these types of services in many communities. See also "Future Vision" (videotape), trademark 1990 Motorola Inc.

9. FCC, *An Inquiry Into the Use of Bands 825-845 MHz and 870-890 MHz for Cellular Communications Systems; and Amendment of Parts 2 and 22 of the Commission's Rules to Cellular Communications Systems* (hereinafter referred to as *Cellular Docket*), CC Docket No. 79-318, *Report and Order*, FCC No. 81-161, May 4, 1981, Footnote 50.

10. For a discussion of roaming issues, see U.S. Congress, Office of Technology Assessment (OTA), *Wireless Technologies and the National Information Infrastructure*, OTA-ITC-622, U.S. Government Printing Office, Washington, D.C, July 1995, Box 3-1, page 73. Also see **Section IV, "Will the PCS handset work like a telephone?"**

11. "Phones Are Not So Mobile On The Beaches Of Italy", *Chicago Tribune*, August 28, 1995, Section 4, page 2. Solutions are a trade off between investing in more efficient (and expensive) technology or more spectrum (also expensive).

12. In the 1950s, the introduction of automatic dialing with ***Improved Mobile Telephone Service (IMTS)*** technology reduced some problems associated with blocking. This technology seeks out a channel for the consumer and connects the customer to the traditional wireline telephone network automatically, thus eliminating the need for an operator. Stan Prentiss, *Introducing*

Cellular Communications: The New Mobile Telephone System,Tab Books Inc., Blue Ridge Summit, PA, page 1.

13. For a discussion of standards, see **Section IV, What's going on with standards?**

14. Early mobile systems were limited to a small number of channels in a given cell. It was impossible for a call to be handed off. Furthermore, signal interference occurred if the transmission towers were closer than 80 miles (the calling areas could not overlap). For example, before cellular, there were approximately twenty IMTS channels in the 150 MHz band, and the same amount in the 450 MHz band. However, since most were used in towns less than 80 miles apart, only 4 or so from each band were available in any one town. That is why only eight channels were available in New York City.

15. OTA, page 84. It should be noted that with cellular and with broadband PCS there's a tradeoff between high-quality speech recognition and signal compression.

16. See **Section III, What is the radio spectrum?**, for a discussion of international influences on PCS spectrum location. Also, see **Figure 7**.

17. Alan Pearce, *British PCN Policy* Pitfalls*: Implications and Lessons for the U.S.*, Report of the Cellular Telecommunications Industry Association, Information Age Economics, Inc., March 1993, page 30.

18. Pearce, page 14.

19. "MPT Announces Final Policy on PHS Business," *New Area of Telecommunications in Japan*, November 15, 1994, No. 220, page 1.

20. **Figure 6** is an extremely simplified version of the allocation of the radio spectrum. For a more detailed explanation of the allocation of the spectrum for air traffic control, law enforcement, broadcasting, and communications, see the National Telecommunications and Information Administration (NTIA) spectrum charts: U.S. Department of Commerce, NTIA, *United States Frequency Allocations: The Radio Spectrum*, Omega Engineering Inc., 1991. Even greater detail can be found in the U.S. Dept. Of Commerce, NTIA, *Tables of frequency allocations and other Extracts from: Manual of Regulations and Procedures for Federal Radio Frequency Management*, September 1995. In addition, NTIA develops various spectrum policy issues as part of its telecommunications responsibility. See U.S. Department of Commerce, NTIA, Spec. Pub. No. 91-23, *U.S. Spectrum Management Policy: Agenda for the Future 92*, February 1991. NTIA also has responsibility for the federal government's use of the spectrum.

21. Harry Newton, *Newton's Telecom Dictionary, 9th Edition*, Flatiron Publishing, Inc., New York, NY, 1995, pages 139 and 511.

22. U.S. cellular services are in the 800 MHz band because these frequencies were available and had transmission characteristics suitable for cellular mobile services. Other countries vary with respect to where they've placed cellular services. Some are near the U.S. cellular spectrum location. Other countries have cellular around the 2-GHz location (1700 MHz-2300MHz). *PCS Docket*, *Notice of Inquiry*, FCC No. 90-232, June 28, 1990, & 12, page 7. The placement of broadband PCS in the 1850 to 1990 MHz band of the spectrum indicates the U.S. government's support of establishing worldwide PCS operations in the 2 GHz band. *Ibid.*, & 1, page 1; and *PCS Docket*, *Notice of Proposed Rule Making and Tentative Decision*, & 134, page 55. The International Telecommunications Union (ITU) sponsors WARC.

23. The *Omnibus Act Reconciliation Act of 1993*, Pub. L. No. 103-66, 107 Stat. 312 (1993), directed the FCC to create a comprehensive framework for all current and future mobile radio services. This allowed the creation of PCS spectrum licenses and the removal of artificial distinctions between services and among companies. All CMRS companies now use the same rules that apply to cellular companies for interconnection with local telephone companies (local hook up to the PSN). *Cellular Docket*, *Report and Order*, 86 FCC 2d, 469, 496 (1981), Footnote 2.

24. There are 51 MTAs which are roughly the size of states (including Puerto Rico). There are a total of 493 BTAs, each roughly the size of several counties. The MTAs and BTAs follow county lines, making PCS boundaries match municipal boundaries while still following economic boundaries to a large degree. Boundaries are based on the *Rand McNally 1992 Commercial Atlas & Marketing Guide, 123th Edition*, Rand McNally & Company, December 1991; see page 4 for definitions, see pages 38 and 39 for MTA and BTA boundaries. There are a few exceptions and additions for Alaska and other non-contiguous territories, such as Guam and Puerto Rico.

    MSAs are used by the U.S. government for census data and for other government statistics. U.S. Bureau of the Census, *Statistical Abstract of the United States: 1994 (114th edition)*, Washington, D.C., 1994; see page pages 926-928 for current definitions and for changes in population of metropolitan and nonmetropolitan areas. The FCC rejected the MSA/RSA boundaries because they were too small for regional or nationwide services. The FCC wanted to minimize the costly, time-consuming aggregation period that had occurred in the cellular industry and to reduce the market advantage of current cellular service providers. *PCS Docket*, *Memorandum Opinion and Order*, & 17b, page 7, and & 75-76, page 31.

25. Cellular formerly was required to operate with the FCC's Office of Science and Technology (OST) Bulletin 53 Standards (Narrowband FM), July 1983. This restriction was lifted (FCC, *In the Matter of Amendment of Parts 2 and 22 of the Commission's Rules to Permit Liberalization of Technology and Auxiliary Service Offerings in the Domestic Public Cellular Radio Telecommunications Service*, GEN Docket 87-390, *Report and Order*, December 12, 1988, & 5, page 5). This allowed cellular providers to change technology in order to offer services like packet data transmission (notification restrictions lifted December 1993). However, cellular providers are still required to maintain sufficient conventional (OST 53) service to meet existing demand (*Cellular Docket*).

26. The FCC requires that within five years after the granting of broadband PCS licenses, the service providers must reach specific benchmarks for availability of service: one-third of the population in a 30 MHz license area and one-fourth of the population in a 10 MHz license area must have services available. Providers with 10 MHz blocks have an alternative C they can demonstrate to the FCC "that they are providing substantial service." There is also a ten-year benchmark: two-thirds of the population must have broadband services available in this time frame. *PCS Docket*, *Memorandum Opinion and Order*, & 155-156, page 63.

27. Definitions as to what constitutes interconnection vary. Current interconnection rules depend on the type of service, the type of company C ***local exchange carrier (LEC)***, ***interexchange carrier (IXC)***, ***competitive access provider (CAP)***, ***alternative access provider (ALT)***, which includes ***cable TV***, private network, and ***enhanced service provider (ESP)*** C and the historical framework. Attitudes about competition, pricing, subsidies, universal service, and other issues have changed since the creation of the telephone monopolies earlier this century.

28. OTA, *Wireless Technologies*, page 176.

29. Definitions of the various standards are based on OTA, *Wireless Technologies*, pages 84-86, 113, 174-177; Box 3-3, page 85.

30. Generally the format is analog but it can be digital.

31. The code is a unique pseudo-random noise (PN) sequence assigned to the call.

32. For background on auction proposals, see U.S. Congress, Congressional Budget Office (CBO), *Auctioning Radio Spectrum Licenses*, Washington, DC, March 1992. Also see, U.S. Dept. of Commerce, *U.S. Spectrum Management Policy*.

33. On June 2, 1982, the FCC received 194 applications for cellular licenses to serve the top 30 MSA markets. The numbers increased for the second set of 30 markets to approximately 600 applications and for the subsequent set to approximately 1200 applications. Prior to this point, the government realized that it was impossible to apply the comparative analysis process on a large scale and authorized lotteries. After the lotteries, it became apparent that some license holders had no intention of providing cellular service to consumers. On the contrary, the licenses were obtained with the sole intent of profiting from the scarcity of the spectrum resource. The auctions coupled with the requirements to provide service within five years were seen as a solution to these problems.

34. *Omnibus Budget Reconcillation Act*; and *In the matter of Implementation of Section 309(j) of the Communications Act C Competitive Bidding*, PP Docket No. 93-253; *Implementation of Sections 3(n) and 332 of the Communications Act Regulatory treatment of Mobile Services*, GN Docket No. 93-252; and the *PCS Docket*; *Sixth Report and Order*, FCC No. 95-301, & 2, page 3.

35. *PCS Docket*; *Sixth Report and Order*, & 39 and 40, pages 23 and 24. See also *Further Notice*.

36. *Ibid.*, & 47, pages 26.

37. *Ibid.*, & 49-52, pages 27-29.

38. *PCS Docket*, *Notice of Proposed Rule Making and Tentative Decision*, FCC Order No. 92-33, August 14, 1992, & 140, pages 57-58.

39. *Ibid.,* & 146-147, page 59.

40. For the narrowband license, see, *PCS Docket*, *First Report and Order*, FCC No. 93-329, July 23, 1993, & 77, pages 32-33. For the broadband licenses, see, *Third Report and Order*, FCC No. 93-550, February 3, 1994, & 36, pages 16-17; & 51, page 21; and & 74, page 28.

41. *PCS Docket*, *Notice of Proposed Rule Making*, & 149, page 60; and *First Report and Order*, FCC No. 93-329, July 1993,& 58, page 25; & 77, page 32; and footnote 63, page 32.

42. *PCS Docket*, *Third Report and Order*, & 10 and footnote 15, page 7; & 12, page 8; and & 80, page 31.

43. *Ibid.*, & 37-38, page 17; & 49-50, pages 20-21; & 80, page 31.

44. *Ibid*, & 51-55, pages 21-23; & 80, pages 31-32.

45. *Ibid.*, & 60, page 25; & 74, page 28; & 80, page 31.

46. *PCS Docket,Memorandum Opinion and Order on Remand*, FCC Order No. 94-209, August 9, 1994, & 20 and footnote 54, page 14.

47. *Ibid.*, & 21-22, page 14. *Uruguay Round Agreements Act*, Pub. L. No. 103-465, 108 Stat. 5050 (1994).

48. OTA, pages 203-204 and Box 8-1, page 204.

49. The FCC has already received a petition to preempt local zoning rules applied to PCS towers and antennas. Arguments for preemption point to the difficulties experienced in negotiating cable TV franchises and rights-of-way. Arguments against preemption point to disruptions and costs incurred by construction and riding rough shod over community aesthetics. Simply put, do you want to wait forever for services while your town negotiates a deal? Or, do you want a cell site ruining the view from your window? Cellular Telecommunications Industry Association (CTIA), *Petition for Rulemaking*, *Ammendment of the Commission's Rules to Preempt State and Local Regulation of Tower Siting for Commercial Mobile Radio Service Providers*, *Petition by the Cellular Telecommunications Industry Association*, RM-8577, December 22, 1994.

50. *PCS Docket*, *Memorandum Opinion and Order*, & 155-156, page 63.

51. *PCS Docket*, *Fourth Report and Order*, & 30, pages 13 and 14.