1 Cellular Phones and Personal Communications Services

On April 1, 1995, the Associated Press reported that after nearly a century of monitoring telegraph distress calls, including the *Titanic*'s after her collision with an iceberg in 1912, the U.S. Coast Guard turned off its Morse code equipment.

The Coast Guard didn't make this decision lightly. After all, even the early U.S. manned space vehicles were equipped with Morse code systems in case other communications equipment aboard the spacecraft failed. But with technology advancing so rapidly, supporting Morse code hardware and training people to use it no longer made sense. The simple and slow dots and dashes have been replaced by satellites and a myriad of terrestrial communications choices.

The Morse code announcement sent a strong signal that the communications industry is changing, and not just the technology.

Long-distance phone companies are pushing into local phone services. Local phone companies are edging into long-distance and cable television markets. Cable TV companies are adding phone service and are connecting customers' home computers through cable modems and coaxial cable lines.

Broadcasters can hardly wait to install their new digital television system so they can begin to offer new revenue-generating data services. Utility companies are stringing fiber-optic cable in anticipation of offering new communication services. State and regional highway authorities are ready to start running wires along their roads to offer telecommunications services.

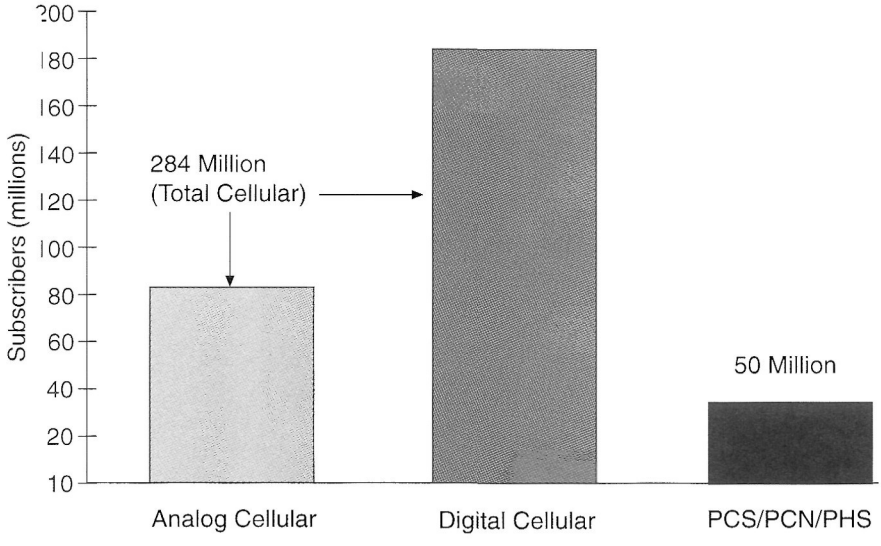
Meanwhile, wireless companies including cellular carriers are developing and enhancing their products and services, in some cases almost faster

than the market can absorb them. Wireless service has become the fastest growing segment of the world telecommunications market and the most dynamic.

Cellular service is growing at the rate of more than 50 percent annually worldwide. By the year 2001, if market projections are correct, there will be more than 280 million cellular subscribers in more than 120 countries. That's more than four times today's global subscriber level of about 65 million.

The U.S., with about half of the cellular subscribers in the world, added as many customers in 1995 as it did in cellular's first nine years of existence. With more than 90 operating networks, Europe is becoming one of the most dynamic cellular markets in the world. Currently only 2 out of 100 Europeans use a cellular phone, but one industry consulting group, MTA-EMCI, is projecting 78 million cellular subscribers across Europe by the year 2000.

The Global System for Mobile Communications (GSM), the European digital standard for cellular and personal communications networks (PCN), as personal communications services (PCS) are called in Europe, is ex-



Distribution of world cellular service and PCS subscriber base by technology, 2001.
Note: PCS/PCN/PHS includes U.S., Canada, U.K., Germany, France, Japan, Singapore, Malaysia, Thailand, and Puerto Rico.

pected to account for 74 percent of the subscriber base, followed by analog cellular and DCS-1800, a GSM derivative system operating in the 1.8 GHz band. The U.K., France, Germany, and Italy will likely be the dominant markets, accounting for more than 60 percent of the total cellular subscriber base by 2000.

PCNs based on the DCS-1800 standard and currently licensed in the U.K., Germany, and France are expected to be introduced in the Nordic countries, Italy, and Spain by the end of 1998.

MTA-EMCI expects Eastern European countries to triple their share of aggregate European cellular subscribers, increasing from 2 percent market penetration in 1994 to 6 percent in 2000, reaching almost 5 million subscribers. Most of the demand for cellular service in Eastern Europe will be in Hungary, Poland, and Russia.

The numbers on the infrastructure side are no less staggering. Worldwide, 50 new cellular networks came on line in 1995, a pattern of growth

The World's Largest Cellular Operators

Company	*Millions of Subscribers*
AT&T (U.S.)	4.03
SBC Mobile Systems (U.S.)	2.98
GTE (U.S.)	2.34
Telecom Italia	2.24
BellSouth (U.S.)	2.16
Vodafone (U.K.)	1.82
Cellnet (U.K.)	1.73
Bell Atlantic (U.S.)	1.68
DeTeMobile (Germany)	1.60
DGT (China)	1.57
AirTouch (U.S.)	1.56
NTT DoCoMo (Japan)	1.32
Ameritech Cellular (U.S.)	1.30
Telia Mobitel (Sweden)	1.18
Sprint (U.S.)	1.04
US WEST (U.S.)	.97
Korean Mobile Telephone Co.	.96
NYNEX Mobile (U.S.)	.91
Mannesmann Mobilefunk (Germany)	.85
Cantel (Canada)	.79

Source: Data from International Telecommunications Union (ITU).

"Well, I know how to be at one with nature, and *still* have my phone with me."

From the *Wall Street Journal*, April 26, 1995; © 1995 by Sidney Harris.

that will be easily matched in 1996 and 1997. In addition, billions of dollars will be spent to expand and upgrade existing systems.

Cellular carriers in the U.S. alone estimate they will need 15,000 new cell sites over the next 10 years to complete their coverage, upgrade their systems, and meet the growing demand for cellular service. Another 10,000 sites will be needed for new PCS providers, and thousands more are planned for new Enhanced Specialized Mobile Radio (ESMR) networks to expand and enhance commercial dispatch radio services.

There's more than enough business and competition to go around.

SOME BACKGROUND

In Europe, most of the excitement has developed from the digital Global System for Mobile Communications (GSM), which the European Tele-

communications Standards Institute (ETSI) has adopted as the European digital standard for cellular and personal communications networks. Initially known as Groupe Speciale Mobile, GSM evolved out of the rapid growth of conventional analog cellular networks in Europe and the need for a system with much greater capacity than analog could offer. In 1982, the Conference of European Post and Telecommunications (CEPT) formed a special working group to develop GSM. By 1987, 18 European nations had committed to the technology by signing the GSM Memorandum of Understanding. In 1989, the effort to develop a GSM standard was shifted to the European Telecommunications Standards Institute (ETSI) and plans were put in place to begin GSM service in 1991.

Things didn't quite work out as planned; the entire effort was slowed by almost a year when GSM equipment wasn't widely available and technical problems began to emerge; some were software related, but the major obstacle was the incompatible equipment from different manufacturers. Roaming became an issue when GSM operators tried to work out agreements on how to charge subscribers who use their GSM phones outside their home territories. Most of these problems have been solved and GSM appears to be on its way to becoming the world's most widely used digital cellular standard—at least for a while.

GSM has emerged in two phases. Initially, GSM handled basic voice service and some emergency calling features. The second phase, which began in 1994, added call waiting, caller information services, and improvements in subscriber identity module (SIM) cards, which contain a microchip with information on the caller. By inserting a SIM card in a GSM phone, the caller can gain access to the GSM network and be billed for the call, even if it isn't his or her phone. SIM cards can also store abbreviated phone numbers for speed dialing.

From the users' point of view, the obvious difference between GSM and the cellular systems now emerging in the U.S. is that virtually all cellular phones in Europe operate only digitally—in the GSM mode. In the U.S., cellular carriers are offering dual-mode (analog/digital) phones and U.S. subscribers will be switched—transparently—between the two modes, depending on their location (in other words, what service is available in the calling area).

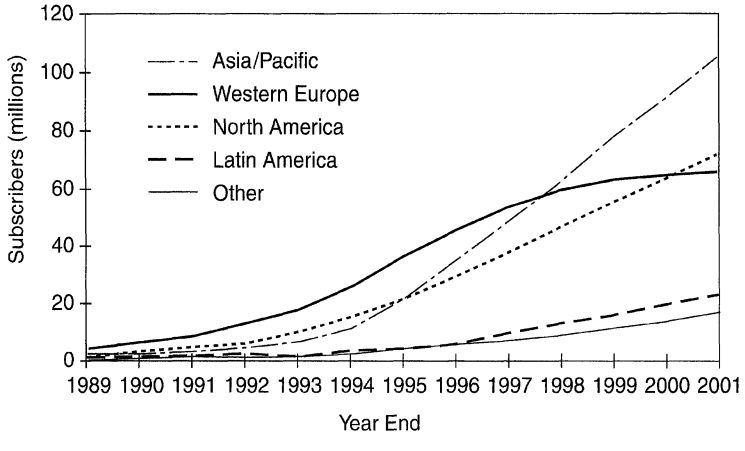
Another important development is the emergence of Digital European Cordless Telecommunications, or DECT. Originally intended for wireless private branch exchange (WPBX) service, DECT will eventually find a place in the residential and telepoint markets as well. DECT supports both

voice and data with encryption, and seamless handoff between cells, using spectrum already allocated throughout Europe in the 1,880–1,900 MHz band.

DECT has the support of ETSI, the European Commission (EC), and five major European telecommunications companies. Alcatel, Ericsson, Nokia, Philips, and Siemens have all announced plans to show DECT products.

Another new service emerging as Europe's PCN is Digital Communication Service, a GSM derivative operating at 1,800 MHz (DCS-1800). In fact, with some inherent capacity problems, GSM carriers will likely be forced to market multiband digital handsets to ensure that their subscribers can make or receive calls from virtually anywhere at anytime.

The U.K. represents the largest wireless market in Europe. It may also be the most confused market. The British government licensed four companies to provide CT-2 (cordless telephones–second generation) telepoint service shortly after the publication of the landmark *Phones on the Move* by the Department of Trade and Industry, but it couldn't handle the high operations costs, the competition, and, least of all, the lack of interest. All four soon disappeared. Today, the only company offering telepoint service in the U.K. is Hutchison Personal Communications Ltd., which wasn't even one of the original licensees.



World cellular subscribers by region, 1989–2001.

Hutchison invested a reported $100 million to build more than 8,000 base stations in train stations and along major highways in the U.K. But the service, known as Rabbit, never really caught on. (The joke in the U.K. is that there are more telepoint base stations than subscribers and, in fact, only a few thousand people subscribed to the service.) Hutchison has tried cutting its losses by selling CT-2 phones directly rather than through retail outlets.

Shortly after it licensed the telepoint operators, the British government issued PCN licenses to three companies—Mercury Personal Communications, Unitel, and Microtel—which said they planned to offer nationwide service. Mercury was initially a joint venture between Mercury, a subsidiary of Cable & Wireless, and US WEST. Unitel decided to abandon its PCN plans shortly after receiving its license and merged with Microtel, which is now owned by Hutchison. (Microtel had been owned by Pacific Telesis and Millicom, both U.S. companies, and Matra, a French company, but they all dropped out of the venture.) The Microtel–Unitel partnership still owns a telepoint license, but it's not clear what they're going to do with it.

According to *British PCN Policy Pitfalls: Implications and Lessons for the U.S.*, a report commissioned by the Cellular Telecommunications Industry Association (CTIA) and written by Alan Pearce, president of Information Age Economics Inc., one of the problems in getting a wireless personal communications network off the ground in the U.K. was the high cost of building three separate PCN infrastructures—about $1 billion each. Another was the way in which the British government doled out spectrum for the PCNs. As Pearce pointed out in his study, the three PCN licenses were a huge spectrum giveaway. The government, he noted, assigned 150 MHz of spectrum at 1.8 GHz (1,800 MHz) and said that the licensees were each entitled to 50 MHz once their networks had been built. That caused an immediate outcry of unfair competition, since cellular carriers in the U.K. only have 30 MHz of spectrum.

Government licensing rules also call for universal PCN service, but licensees said they planned to launch limited service focusing only on major metropolitan areas. In other words, said Pearce, universal PCN would have to wait until PCN proves itself in the marketplace. The dilemma here, according to the Pearce report, was that the PCNs can't have the full 50 MHz of spectrum until they offer universal service, and they can't afford to build a universal infrastructure until they prove that PCN service is in demand in the marketplace. Meanwhile, the PCN licensees were already op-

erating on 10 MHz of spectrum, temporarily quieting the two cellular carriers, Vodaphone and Cellnet.

The loudest response to the Pearce report came from US WEST, a founding member of CTIA and a partner with Cable & Wireless Plc in the U.K. PCN service called Mercury One-2-One, which was scheduled to begin service in the fall of 1993. US WEST publicly disassociated itself from the association-sponsored study. In a letter to FCC Interim Chairman James Quello, US WEST said CTIA was using the Pearce document to support its campaign in Congress to limit the potential of PCS. "The CTIA's recommendation that the public would best be served if the U.S. were to authorize five PCN licensees [per market] is not based upon the U.K. experience and represents no more than an attempt by the cellular industry to avoid viable competition," US WEST said in its letter to Quello.

US WEST also said it believes that the record of the U.K.'s PCN experience bears out the wisdom of certain policies, including awarding no more than three PCS licenses and allowing these licensees "latitude in meeting customer needs," using large regions for licensing PCS, and providing each licensee with access to a substantial block of spectrum to reduce the cost of providing service and to stimulate a mass market.

In response, CTIA called the US WEST assertions that it was using the report to gain influence in Congress "spurious," noting in its own letter to the Federal Communications Commission (FCC) that "CTIA and its members have been active, vocal advocates in the commission's PCS proceeding, urging a broad definition of PCS and open entry for as many competitors as possible."

The telecommunications industry is keeping a close eye on the Mercury One-2-One service, which, so far, is confined to London. Despite call charges that are up to 20 percent lower than cellular service in the U.K., service restrictions and reports of minor technical problems may make it difficult to wean cellular users over to the newer service.

With little acceptance of PCNs, the two major cellular carriers in the U.K.—Cellnet, a subsidiary of British Telecom, and the Vodafone Group, which is owned by Racal Electronics—have restructured their tarrifs to be more competitive with PCN services. Vodafone launched a regional GSM service in December 1991, but it met with little initial success. The service was essentially relaunched in early 1993, targeted at business users. Since then, Vodaphone, the larger of the two U.K. cellular operators, has signed roaming agreements with SIP, the Italian telecommunications concern, and

SFR, one of the French cellular system operators. Vodafone has also introduced a "short message" text transmission service using GSM protocols.

Originally, the German government took a monopolistic approach to cellular communications, licensing the Deutsche Bundespost Telekom (DBT), Germany's national public phone network, as the only analog cellular service operator. More recently, however, the German government launched a major modernization program called Telekom 2000 to upgrade the communications network in eastern Germany and link it with the rest of the country. To do that, Germany issued two GSM licenses: one to the DBT and the other to Mannesmann Mobilfunk GmbH, a privately held consortium whose members include several European and U.S. telecom organizations (PacTel International has a 26 percent interest). The difference is that Mobilfunk's license requires that the network be based exclusively on the GSM standard. BDT's license covers both analog and digital cellular service.

Mobilfunk began its D2 Privat service in June 1992; the DBT system, called D1 Privat, began operation in July 1992, and both services have grown steadily. Typical of fast-growing cellular services, prices of vehicle-installed GSM phones dropped from about $1,563 in June 1992 to $812 in February 1993. Transportable models cost slightly more, and the first handheld portables, which arrived in late 1992, were priced at about $1,406, considerably more than in today's competitive market.

In February 1993, Germany issued a third license to the German consortium E-PLUS for a new national service based on the DCS-1800 standard. E-PLUS began rolling out its service in Berlin and Leipzig, the largest cities in eastern Germany, in 1994. Consortium members are led by Thyssen AG and Veba AG, each with a 28 percent stake in the organization. Other investors include BellSouth Enterprises of the U.S.; Vodafone Group Plc of the U.K.; and a number of small- and medium-sized companies from eastern Germany and the Caisse des Depot et Consignations Group of France, which operates the Cofira telecom network in France with BellSouth, Bau GmbH, Industriemontagen Leipzig GmbH, Minol Mineralolhandel AG, and Part'Com S.A.

France's France Telecom operates the Radiocomm 2000 analog cellular system throughout the country, and began its GSM service, called Itineris, in 1992 in Paris and Lyon. The country's second analog carrier is Societe Francaise de Radiotelephonie (SFR), a private firm.

France's version of the cordless telephone, called Bi-Bop, is another telepoint service based on CT-2 technology. Launched in April 1993, the phone allows calls to any number provided it is no more than about 200 meters from a base station. At last count, Bi-Bop only had about 2,000 subscribers, and most of them were participants in the initial trial of the system.

Ameritech International, a subsidiary of Chicago-based Ameritech, helped build and operate a GSM-based cellular network in Norway, one of Europe's leading per capita users of mobile phones because so many Norwegians own second homes, few of which have fixed telephone service. Ameritech International and Singapore Telecom have won government approval to acquire 49.9 percent interest in Netcom GSM, a Norwegian firm. The three companies have been working together to build and operate the cellular network in Norway.

Analog cellular service was introduced in Japan in 1979, almost four years ahead of the U.S. Nippon Telegraph & Telephone Co. (NTT), Japan's government-owned public corporation, had the cellular market to itself until 1985 when Japan enacted the Telecommunications Business Law, which essentially abolished the legal monopolies held by NTT, the Telegraph Public Corp., and Kokusai Denshin Denwa (KDD), and privatized the NTT Public Corp.

In 1986, the Ministry of Posts and Telecommunications (MPT), which regulates the cellular industry in Japan, licensed two new service providers, Nippon Ido Tsushin and Daini Denden, Inc., to compete in the cellular market with NTT. However, neither company received a national license similar to NTT's. Ido—whose backers include Toyota, Nippon Electric Corp. (NEC), the Japan Highway Authority, and Tokyo Electric Power—is licensed to operate only in the Tokyo–Nagoya area. DDI Corp., which is made up of eight affiliated Japanese cellular companies, can operate only in the remaining, mostly residential suburban, regions of the country.

In fact, it wasn't until April 1994 that Japanese citizens could actually buy a cellular phone; prior to that time they could only lease a phone. The results of deregulation and new competition in the cellular market in Japan have been dramatic: More subscribers signed up for cellular service in the first 14 months following deregulation in April 1994 than subscribed in the first 14 years of cellular service in Japan.

Japan's digital mobile communication system is called Japan Digital Cellular (JDC). It is a TDMA-based system in the 800 MHz and 1.5 GHz

bands, and therefore similar to the American time division multiple access (TDMA) network, but with one major exception: It will not be dual mode (analog and digital). The digital market in Japan will be much more competitive than analog. Customers will be able to choose among four providers of digital cellular service. NTT and the new entrants will be licensed to offer digital cellular service nationally, although they are expected to begin operations on a regional basis. Ido and DDI also will be licensed to offer digital service, but only in their current regions.

NTT selected Motorola, AT&T, and Ericsson along with six Japanese manufacturers to develop its digital cellular network, and Fujitsu, Matsushita, Mitsubishi Electric, and Motorola are supplying NTT with digital phones. Motorola, NEC, and Ericsson will also supply DDI. Ido has selected AT&T, NEC, Fujitsu, and Nokia Mobile Phones as its key equipment suppliers. Ericsson and Toshiba of Japan have formed a joint venture to develop Ericsson's digital cellular equipment business in Japan, an agreement that called for Ericsson to supply Toshiba with digital cellular networks in Tokyo, Osaka, Kobe, and other Japanese cities.

Another emerging service in Japan is the two-way (send and receive) PCS type of Personal Handy Phone (PHP), which looks very much like most cordless phones. Operating in the 1.9 GHz band, PHP field trials began in the fall of 1993 and commercial service started in June 1995. PHP, now called the Personal HandyPhone System (PHS), is being offered through private networks and is not subject to the same foreign ownership restrictions applied to common carriers. As a result, the PHS market may be open to more competition than the cellular market. But with a range of only 100–200 meters, more base stations will be required than for the typical cellular system. Ultimately, DDI envisions PHSs operating building to building with base stations in homes, office buildings, and stores.

Japan has high hopes for PHS. The Ministry of Posts and Telecommunications (MPT) is predicting that the low cost of PHS could push sales to 40 million units by 2010. DDI is also trying to introduce PHS to Korea, Hong Kong, Singapore, Taiwan, and Thailand. DDI officials have met with several American companies, including the regional Bell companies, cable television companies, and MCI Communications, in an effort to promote PHS as an international standard.

Hong Kong is the largest per capita market for cellular phones in the world and the most competitive, and CT-2 is far more successful in Hong Kong than any other area. The government introduced cellular service in

1983 by granting Hutchison Telephone Limited, Pacific Link Communications Limited, and Hong Kong Telecom CSL Limited licenses to operate cellular networks. But three carriers were not enough to satisfy Hong Kong's "telephone fever." Capacity limitations created a slump in cellular handset sales in 1992, forcing the Hong Kong Telecommunications Authority to license a fourth cellular system. It also ordered the three existing cellular operators to switch their systems from analog to digital by mid-1995. To protect their existing customer base and allow continued roaming into the People's Republic of China (PRC), they most likely will switch to dual (analog/digital) systems. Building the fourth digital network and switching the other three to digital will cost an estimated $150 million for telecommunications equipment, not including handset sales. The Hong Kong Telecommunications Authority anticipates the need for a fifth cellular network operator in 1995.

The equipment for the Korean network will be supplied by four Electronics and Telecommunications Research Institute (ETRI)–designated Korean manufacturers: Goldstar Information & Communications, Ltd.; Hyundai Electronics Industries Co.; Maxon Electronics Co.; and Samsung Electronics Co. Under license from QUALCOMM, the developer of code division multiple access (CDMA) technology, Maxon will produce subscriber equipment only, while the other three companies will develop both subscriber and infrastructure equipment. In addition to providing equipment for the Korean market, these manufacturers will become alternate sources of CDMA equipment for networks in the U.S. and other countries implementing CDMA.

Eastern Europe and the former Soviet republics, once restricted from buying Western high-technology products, have become major customers of virtually every major telecommunications equipment manufacturer. Rather than spend years trying to bring their telecommunications systems up to the standards of the rest of the world by installing new telephone lines, most of these economically depressed areas have turned to wireless systems. In the reunited eastern and western states of Germany, for example, the Bundespost is implementing wireless local loop services to provide immediate, short-term telecommunications services. One of the key features of this system is that international calls are possible without having to go through the fixed network.

Not all eastern European and new Commonwealth of Independent States (CIS) countries are equally developed in terms of phone service.

The CIS has the third largest telephone system in the world, with 27 million access lines, but has a very low teledensity of nine phones per 100 inhabitants. What was Czechoslovakia probably has the best telephone system in the region, despite a relatively low penetration of 25 phones per 100 people. Hungary's phone system is not nearly as good, but it is making rapid progress, partly as a result of trade between the East and West growing and becoming less complicated politically.

Cellular service is also now available in every region in Mexico. Nationwide roaming became available in 1992, and Mexico has signed international roaming agreements with the U.S. With a population estimated at close to 86 million, Mexico has plenty of room for cellular growth.

In Canada, cellular systems operate on the same frequencies as the U.S., but they are licensed differently. Block A, the 800 MHz service, is provided by a single nationwide carrier—Mobility Canada—while Block B, the 900 MHz service, is provided by provincial carriers. Canada's 1992 population was 27.2 million and the CTIA estimates that roughly 85 percent have access to cellular service. According to Canada's Department of Communications, approximately 1.02 million people subscribe to cellular service.

In December 1992, Canada awarded four consortia licenses for PCS while Mobility Canada won a national license to provide a Personal Cordless Telephone (PCT) service using CT-2 Plus. An enhanced version of CT-2 developed by Northern Telecom Ltd. of Canada, CT-2 Plus features an optional dedicated common signaling channel, cellular-like handoff, enhanced transmission speeds of 19.2 k/bits per second, subchanneling to allow capacity increases as the technology improves, improved security, and integrated voice, data, and imaging. Mobility Canada's PCT public zone service, launched in major Canadian city centers in 1994, covers stadiums, hotels, shopping malls, airports, factories, offices, and public buildings. PCT private zones would cover the area in and around a customer's home or office. The service should be available to approximately 18 million Canadians by 1998.

Owners and/or shareholders of Mobility Canada include AGT Cellular Limited, BCE Mobile Communications Inc., BC Tel, Edmonton Telephone Corp., Island Telephone Co., Manitoba Telephone System, Maritime Telegraph & Telephone Co., New Brunswick Telephone Co., Newfoundland Telephone Co., Quebec Telephone Co., Saskatchewan Telecommunications, and Thunder Bay Telephone.

The four licensed PCS companies operating in the 944–948.5 MHz band are Canada Popfone Corp., Mobility Personacom Canada Ltd., Rogers Cantel Mobile Inc., and Telezone Inc.

WHAT'S NEW?

There are now more than 130 competing phone systems in the U.K. and they have to contend with some new and very large competitors, such as AT&T, MCI, and Sprint.

Finland has 52 independent telephone companies, many of them owned by their subscribers. Telecom Finland, the national phone service provider, is expanding its GSM mobile network with a new DCS-1800 system, and is installing Ericsson's MiniLinks, which are radio links operating in the microwave radio band for voice, data, and multimedia applications. Coverage of the MiniLinks is 50–60 km. Telecom Finland is also considering developing a wireless local loop service to compete with the local phone companies.

Belgium awarded its second cellular license in September 1995 to Mobistar, a consortium led by France Telecom. The group plans to invest $500 million in order to provide coverage to 97 percent of the country by early 1997.

Brazil passed a constitutional amendment to allow private operation of telecommunications services in late 1995. Cellular service was one of the first sectors liberalized through the licensing of systems to private companies that will compete with the regional government operators. The country will be divided into six or seven cellular regions.

In Chile, CTC Celular plans to spend $25 million in 1996 and 1997 to digitalize its cellular network.

Singapore issued a new cellular license to MobileOne, which will build both a CDMA and a GSM network. But the company cannot start operations until Singapore Telecom's monopoly runs out on April 1, 1997. Equipment contracts went to Motorola for CDMA, and Nokia for GSM.

Israel is expected to issue a third cellular license in 1997.

Taiwan passed new telecom legislation that will allow for competition in cellular service. It also opened the cellular and paging sectors to private participation with up to 20 percent foreign ownership.

In Russia, regional license winners continue to build their networks.

ASIA MAJOR

With more than half of the world's population, the Asia/Pacific region has the greatest potential for wireless personal communications growth in the

world. MTA-EMCI projects the region will have 78 million cellular subscribers by the year 2000. Much of the market has been slowed by restrictive government regulations and incompatible systems, but that is all changing.

The 1995 MultiMedia Telecommunications Association's (MTA) *Review & Forecast* says the mature Asian/Pacific mobile communications markets (such as Japan, Australia, and Singapore) are growing faster than the U.S.—an average rate of 60 percent per year. The level of international telephone traffic confirms the increased importance of telecom trading links within the region. According to MTA, intraregion calling now accounts for nearly 55 percent of all the traffic originating in Asia and the Pacific—a percentage equivalent to that of the European Community. China's international calling traffic has been growing at more than 50 percent a year, pushing its global telecom revenues to $2.6 billion annually. A growing share of that traffic is wireless. To meet the demand for new mobile and fixed wireless installations, China (which has about two phone lines for every 100 people) is signing contracts for the construction of new networks valued in the hundreds of millions of dollars.

Cellular technology is also quickly spreading into the developing economies of Southeast Asia where virtually every country faces a severe shortage of telephone lines. Thailand, Indonesia, Malaysia, Bangladesh, Cambodia, India, Laos, and Vietnam are all strong wireless markets.

Japan is still a small wireless market by western standards, but Japan's MPT projects the number of radio terminals—mostly cellular and PCS-type services—will reach 104 million by 2010 and could go as high as 130 million.

Japan's MPT has already issued 1.9 GHz PHS licenses to 21 carriers, several of which began service in mid-1995. PHS operates as a cordless phone with no airtime charges in the home or office and as a cellular phone when used outside. The downside is that PHS will not work from a moving vehicle; the systems's architecture simply will not allow it to hand off calls quickly enough for mobile use. Nevertheless, projections for PHS indicate the market could easily reach 20 million subscribers by 2005 and 38 million by 2010. To compete, Japan's cellular operators have been cutting their registration fees, handset prices, and monthly charges to offset some of the gains made by PHS.

Wireless service continues to do well in other Asia/Pacific areas. Korea Mobile Telecom Corp. has doubled its analog Advanced Mobile Phone Service (AMPS) cellular subscribers each year since 1984. South Korea

has selected CDMA as its national digital cellular standard, and several Korean electronics manufacturers plan to produce CDMA-based equipment for domestic use and to sell to other CDMA carriers around the world.

Singapore Telecommunications is adding new cellular subscribers at a rapid pace, but it will have new competition from four international organizations beginning in April 1997: MobileOne, Singapore Press Holdings, Hong Kong Telecommunications, and Cable & Wireless of Britain. Singapore Telecom's own projections call for a better than 25 percent market penetration rate for cellular phones by the year 2000.

Taiwan's Directorate General of Telecommunications (DGT), under pressure from consumers and legislators to meet the growing demand for cellular services, has expanded its AMPS network capacity to 590,000 subscribers, which is already oversubscribed. The waiting list for cellular phones at that time topped 120,000 and was growing at a rate of 10,000 a month.

India's addressable market for cellular subscribers is expected to grow from zero in mid-1995 to more than one million by the end of the decade. At one point, 33 consortia involving more than 60 companies were bidding for cellular licenses in India. That's not surprising since India's 920 million people have the fewest telephone lines of any major country in the world—about two lines per 100 inhabitants. New phone subscribers must wait two to three years for a phone line. However, the explosion of cellular systems in the country seems to be changing all that.

The Indian government has issued at least 39 licenses to fill out the country's wireless infrastructure. The eight cellular operators (Max/Hutchison, BPL/France Telecom, Bharti/Generale Mobile/SFR, Sterling/Cellular Communications, Modi/Telstra, Crompton Greaves/BellSouth/Millicom/DSS Communications, Usha Martin/Telekom Malaysia, and RPG/Vodafone) have launched cellular service in India's four biggest cities—Bombay, Delhi, Calcutta, and Madras.

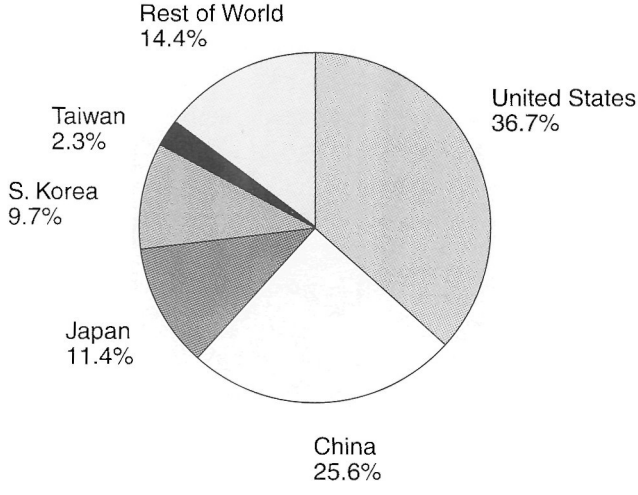
Overall, EMCI expects digital subscribers in the Asia/Pacific region to surpass analog users by the end of 1997. By 2000, EMCI expects subscribers on GSM, Japan's Personal Digital Cellular (PDC), CDMA, and other digital systems to account for more than 70 percent of the total subscriber base in the region. "The driving forces behind this phenomenon," EMCI says in a study, "are the introduction of GSM in China and India, the

two most populous countries in the world, and rapid subscriber growth of PDC systems in Japan and CDMA systems in South Korea."

EMCI expects China to replace Australia as the second largest cellular market by 2000, with almost 30 percent of the total subscribers in the region. (However, Australia will likely have the highest penetration rate by 2000 at 31.5 percent.) EMCI has also estimated that by the end of the decade, India will become the fifth largest market in the region with more than 6 million subscribers, all on GSM systems. Meanwhile, Japan is expected to account for about one-third of the region's cellular subscriber base, with much of that coming from PDC growth.

A BEEPING GOOD MARKET

Paging continues to grow at a record rate. Thirty-eight percent more subscribers signed up for the service in 1995 than the previous year. The last time that happened was in 1981. The 7.5 million subscriber increase in 1995 boosted the installed base in the U.S. to 27.3 million paging users, exceeding the previous year's gain by 3 million units. Worldwide, about 75 million people use pagers and the number is increasing steadily.



Distribution of paging subscribers by country, 1995.
Source: MTA-EMCI.

The pager market has also been marked by consolidation. At the end of 1994, 59 percent of the market was held by only 10 paging companies, according to the Yankee Group. A year and several service provider consolidations later, that number jumped to 72 percent. As a result, some companies have drastically changed their ranking in the market.

Research also indicates a kind of perverse pent-up demand for paging in that more people want nationwide paging coverage than actually subscribe to it. Most subscribers still use pagers on a local or regional basis.

Falling prices for equipment and service have been a key factor in paging's increasing popularity among business and consumer users. According to EMCI, revenue per pager continues to decline, although at a slower pace than in previous years. The industry's 1994 average revenue for digital display rental pagers was $13.10 per month, down from $14.20 in 1993. The reduction continues the trend of falling prices for paging services; in 1989, digital display rental revenues per pagers were $18.20 per month.

Digital display models continued their dominance as the most popular type of pager, accounting for about 87 percent of pagers in service in 1994. Tone/voice pagers accounted for 3 percent of the market in 1994, and tone-only units accounted for 2 percent. Alphanumeric pagers remained stable at 7 percent, but new models should help increase their market share.

Paul Kagen Associates estimates that paging revenues will more than triple to $11 billion and pagers in service will almost quadruple to nearly 100 million by the year 2006, a projection the telecommunications consulting firm bases on two facts: 90 percent of communications are one-way and 70 percent of e-mail and voice mail need no response. Some of the new, more highly featured pagers are already on the verge of creating a whole new category of wireless personal communications products.

Two-way paging has been slow to grow and could stay that way unless the service is improved and it is priced more competitively with other messaging services. Mtel launched SkyTel 2-Way, the first nationwide two-way paging and messaging service, and expects to offer two-way service in more than 300 U.S. cities.

Mtel sold 15,400 of its SkyTel 2-Way units by the end of 1995, outpacing initial sales of one-way nationwide pagers in 1987. The downside is that two-way paging is expensive—almost in the same league as cellular service. SkyTel 2-Way starts at $24.95 plus $15 for the lease of the pager. The price includes 100 messages plus the ability to receive and send na-

tionwide messages for an additional 95¢ per message. Monthly nationwide SkyTel 2-Way service starts at $74.95 plus $15 to lease the pager. Subscribers can also buy, rather than lease, the two-way pager for a hefty $399. Of course, competition will push down the price of two-way paging. More significant is the fact that 75 percent of Mtel's two-way paging subscribers are new customers.

SkyTel has joined with Wireless Access to create and build a second-generation two-way messaging device that can, among other new features, initiate messages directly from the pager. SkyTel 2-Way subscribers can also send and receive messages with an HP 100LX or 200LX palmtop PC, or with an HP OmniGo 100 handheld organizer. In addition to SkyTel 2-Way, Mtel's other services include SkyPager, SkyWord, SkyTalk, SkyFax, SkyNews, SkyQuote, and SkyMail. Mtel has also acquired 10 nationwide Narrowband PCS licenses.

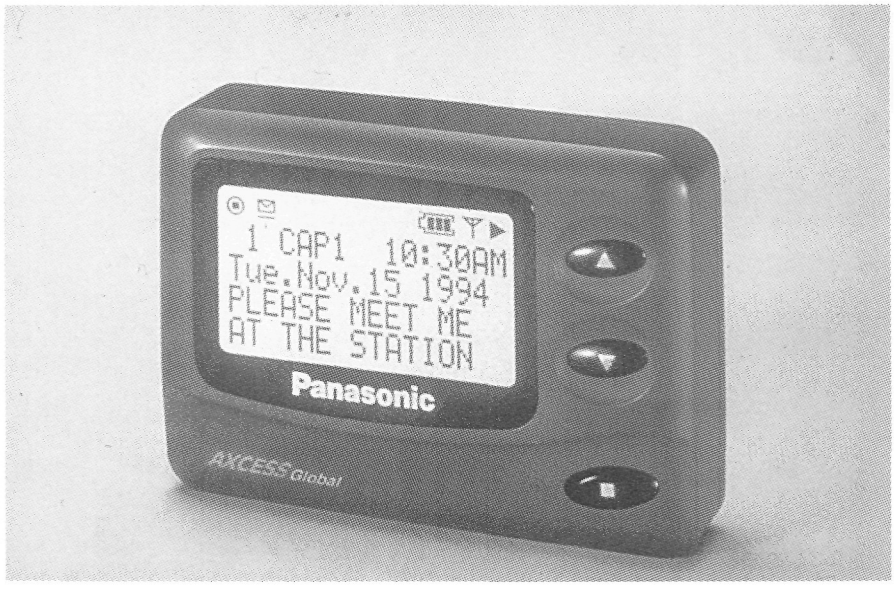
PAGING THE INTERNET

If recent market research holds up, information—in the form of e-mail and Internet services—will become more important to pager users than personal messaging. Motorola has teamed up with ESPN Enterprises, the all-sports cable TV network, to offer ESPNET To Go, a pager service that tunes into a network of satellites to pick up sports news, analysis, and commentary. Most of the sports data will be downloaded from SportsTicker, a sports news service jointly owned by ESPN and Dow Jones & Co.

Motorola also offers SportsTrax with PageNet. There are two SportsTrax models: One is dedicated to baseball and the other to basketball, and they provide updated information every day of the year.

Panasonic didn't enter the paging market until mid-1996, not so much because it liked the way paging was growing (which it did), but because of the high number of e-mail uses and the extraordinary growth of the Internet. Panasonic's extensive market research confirmed what its executives had long suspected—that pager users were willing to pay for information as well as person-to-person messaging.

Panasonic's three new alphanumeric models allow subscribers to access a broad array of basic services, including sports scores and headlines, weather forecasts, stock quotes, daily financial index and mutual fund updates, and local and national news. Subscribers can also contract for mailbox service to get extended PC-generated text messages. Total mailbox



Panasonic pager.

capacity of the new Panasonic pagers allows users to scroll messages of up to 2,000 characters. The Panasonic pagers use the FM subcarrier radio broadcast data system (RBDS) to send and receive information, the system used by broadcasters as a data transmission channel on their existing FM services.

SEIKO Telecommunication Systems is also using a FM subcarrier network under the Receptor trademark to provide personal messaging, news, sports, weather, and traffic information using a numeric display wristwatch receiver. The system features time division multiplexing wherein time is subdivided into a system of master frames, subframes, and time slots. Each slot contains a packet of information. In multiple-station systems, each station's transmissions are synchronized to universal time code (UTC), ensuring synchronization between stations. Each receiver is assigned a subset of slots as times for monitoring transmissions. Multiple receivers may share time slots due to the random nature of expected communications. Each slot is numbered and each packet contains the slot number that permits rapid location of assigned time slots.

Alphanumeric pagers may also soon be used to transmit a patient's electrocardiogram to a doctor, and to send telemetry-type messages to com-

puter printers and other devices. PageNet and Lexmark International are installing self-diagnostic wireless devices into their high-end computer printers; when technical problems are detected, a call is automatically sent to a technician's pager.

Upgraded paging systems and high-speed protocols, such as Motorola's FLEX, will allow paging carriers to increase their incremental revenues by entering previously unavailable niche markets. Enhanced 911 service is another potential application: Using two-way pager technology, onboard position location systems can be linked to airbags in cars and trucks to send out an emergency message in case of an accident.

Hewlett-Packard Co. and Apple Computer are collaborating with paging companies to make their computers work with the new two-way paging networks. Casio Computer Co. and Sharp Corp. have teamed with AirTouch Communication's paging operation to develop a pocket organizer that lets a user wirelessly retrieve or send updated information to a desktop or portable computer.

The availability of digital voice paging, which can receive voice messages, will be an important addition to consumers' product choices. Callers can dial an 800 number and leave a voice message, which is then transmitted to the pager. Voice pagers can store and play back up to four minutes of messages, but the network can store additional messages for a fee. New pager voice mail offerings have been introduced by PageNet (VoiceNow, developed with Motorola, will use a narrowband PCS network on frequencies licensed to PageNet), BellSouth Mobilcomm (ReadyTalk, developed with ReadyCom, uses the existing cellular nationwide phone network), and PageMart. Although somewhat larger than the other models, the ReadyTalk model lets the user talk into the pager to record a message, which is then forwarded to the number of the person who called. The voice pagers also operate on different communications networks.

The FCC's auction of nationwide and regional narrowband PCS licenses and the auction of smaller, metropolitan and basic trading area licenses will expand the paging market since most of the new Narrowband PCS licensees are expected to launch two-way paging networks. In June 1996, the commission granted 18 exclusive nationwide licenses to eight private paging carriers in the 929 MHz band. This is in addition to the 10 carriers that were granted exclusive nationwide licenses in May 1994.

The FCC unintentionally put at least a slight dent in the expansion of the paging market in early 1996 when it issued a three-month freeze on new

paging licenses. In an effort to develop a new set of rules to auction geographically based paging licenses while preventing fraudulent application speculation, the commission stopped accepting applications from all paging carriers except those licensed to build nationwide networks. Under pressure from trade groups, Congress jumped into the fray, expressing concern that damage could be done to a healthy industry. On April 23, 1966, the FCC ruled that incumbent regional and local paging companies could expand by erecting new antenna sites within 40 miles of another operational site that was in operation on February 8, when the FCC issued its initial freeze order.

The 28 nationwide licenses are the result of new FCC rules announced in 1993 that allowed exclusive licensing on 35 private paging carrier channels. The ruling was followed by a flood of applications for these frequency bands. However, the game changed again in August 1996 when private carriers became common carriers under the Omnibus Budget Reconciliation Act of 1993. Most private carriers have been expanding for several years, from smaller market operations to virtual common carrier status. The law places the carriers on level regulatory ground.

In Canada, where market penetration for paging is only 3 percent, or about one million people, there are only two big players—Mobility Canada with an estimated 42.3 percent market share, and Rogers Cantel with 17.6 percent market share. Telezone has another 3.5 percent and the rest of the market (36.6 percent) is covered, according to The Yankee Group's research, by 250 providers who operate their paging service as secondary businesses. Two-way paging is scheduled to start in Canada in 1997.

Pagers are hugely popular in India, where a Motorola pager production facility in Bangalore, India, began running at full capacity when it opened in mid-1995, and in Pakistan, even though there are few telephones in that country to respond to a message. Initial orders when pagers were introduced into India were in the hundreds of thousands. South Korea's Samsung Electronics is working with Larsen & Toubro Ltd., a Bombay-based builder of industrial machinery, to produce pagers, competing directly with U.S. companies that have so far dominated the Indian pager market. The two companies plan to spend $44 million through 2001 to expand India's pager market.

Current market statistics would indicate that Short Messaging Service (SMS) could challenge paging. SMS is already a component of the GSM package, and is bound to be offered in some form in other cellular and PCS

systems. An estimated 36 percent of cellular subscribers already use pagers, which could provide a major attraction for new digital phone users. In fact, most handset manufacturers plan to offer SMS capability in their new digital phones.

However, many analysts don't see SMS as a big threat to paging services. Their rationale is that basic paging continues to grow because it serves a specific requirement at a very low cost. In fact, the introduction of PCS with its own messaging features will very likely help increase the awareness of wireless service options and serve as a major boost to the entire market for advanced messaging, including basic paging services.

IN-BUILDING COMMUNICATIONS

If there is one wireless communications product that can claim a shot at ubiquity it is the cordless phone. Currently, there are several hundred million cordless telephones in use around the world, with 18 million sold each year in the U.S. In fact, about half the homes in the U.S. are now equipped with cordless phones.

Most of these products operate in the 46–49 MHz frequency band and exhibit several drawbacks, such as limited range and voice quality, and questionable privacy. The problem is that the number of callers using the cordless phones at any given time often exceeds channel capacity in many densely populated areas. Low transmission power can greatly limit the range of a cordless phone. Also, it is not unusual for someone living in an apartment house, for example, to be able to listen in to a conversation of someone living in the same building—perhaps one floor away.

Consumers can avoid these problems, however, by acquiring a cordless phone that operates in the 900 MHz range. These phones are available in the U.S. and Europe. They exhibit very little, if any, static or any other kind of interference and their operating range is up to several hundred yards. But they cost at least twice and sometimes three times as much as the 46–49 MHz models.

However, the market for 900 MHz cordless phones is growing, which should help reduce the price over time. It's also a strong replacement market; an estimated 12 percent of the available market switched to 900 MHz phones in 1995, which translates to 4 million units. Sales trends favor 900 MHz phones, with forecasts predicting that by the year 2000, 900 MHz phones will claim half of the cordless phone market.

In dollar terms, there's an even larger in-building market in wireless local-area and wide-area communications. Portable phones or personal information terminals can now operate with no airtime charge inside a home or in or around a business or other campuslike facility, and then transparently become a standard cellular or PCS device when the subscriber moves outside.

The typical in-building system ties into an existing wireline telephone system. This could be a private branch exchange (PBX), Centrex, or key system. Since they are connected to the building's wireline system, they operate just like a desk phone. However, some in-building systems operating in licensed frequencies will tie seamlessly into public wireless networks.

Bell Atlantic NYNEX Mobile employees in Connecticut were the first customers in the U.S. to use INReach, a new wireless in-building communications system developed by Motorola. INReach connects digitally with multiple PBX manufacturers' equipment. The system uses the SpectraLink Pocket Communications System at noncellular frequencies and requires no incremental airtime charges or monthly fees. Calls are charged to the regular landline system.

Initially, in-building wireless customers will purchase and use these systems to improve productivity and communications. The sell is that you will always be accessible by phone. It's a legitimate pitch: A study by Opinion Research Corp. estimates that people spend an average of 302 hours each year listening to voice mail and responding to pages, costing businesses more than $3 billion in lost time.

The market's growth has been slowed by a dearth of products, but that should change with the introduction of several new systems by AT&T Network Systems, Ericsson, and Nortel, as well as a number of innovative products from smaller equipment vendors.

A survey by Alexander Resources has found that at some point, as the price and performance of these systems reaches that of a wired telephone network, the purchase of an in-building communications system will be made more on cost. Alexander Resources expects the in-building wireless systems market to reach $1.3 billion by the end of the decade. InfoTech Consulting estimates that manufacturers shipped more than 88,000 handsets in 1995 for in-building wireless systems, and projects that number could jump to 1.6 million handsets in the year 2000.

Systems using the 900 MHz industrial-scientific-medical (ISM) band have accounted for most of the market, but InfoTech expects this market

segment to plateau as vendors migrate to the new unlicensed PCS frequencies. Market research by MTA-EMCI indicates that many manufacturers will take advantage of FCC rulings, which dedicate 20 MHz of unlicensed spectrum for the development of wireless office telephone systems and wireless local-area networks (WLANs).

Both cellular and PCS carriers are expected to aggressively pursue in-building wireless service subscribers. In fact, several cellular and PCS handset manufacturers have established original equipment manufacturer (OEM) relationships with PBX manufacturers.

Interviews of U.S. telecommunications managers have revealed that awareness of wireless office telephone systems (WOTS) increased from 23 percent of telecom managers in 1991 to 31 percent in 1994. Awareness was strongest among manufacturing, financial services, and health-care managers. EMCI also found that 17 percent of the respondents had a "definite" or a "probable" need for wireless PBX/Centrex or key systems.

By 1999, EMCI expects WOTS usage in the U.S. to grow from a few thousand lines to 2.4 million lines. The widespread availability of dual-mode handsets, which can also access cellular or PCS networks, could generate even higher growth rates. As in-building use begins to take hold, carriers will have to develop new pricing schemes for indoor-outdoor service, and then refine those schemes as competition increases and new, enhanced services are introduced.

In Europe, MTA-EMCI expects that the development of DECT and the introduction of dual-mode handsets will be the primary drivers of market growth for in-building services. EMCI projects the installed base of wireless office telephone users in France, Germany, and the U.K. to grow from several thousand today to more than 2 million lines by 1999. Despite the use of what seems like ancient CT-2 (cordless telephones–second generation) technologies today in PCN and other networks, EMCI expects the majority of the European growth to occur in DECT-based office telephones.

The initial acceptance of WLANs has been slow. Data rates, distances covered by different technologies, and distribution systems also differ. And there are no formal or de facto standards for WLANs. At least not yet.

The Institute of Electrical and Electronics Engineers (IEEE), the largest technical society in the world with more than 300,000 members, has established a subcommittee—designated IEEE 802.11—to produce a 1–10 megabit/sec wireless LAN specification covering everything from wire

augmentation and ad hoc networking to factory automation. The IEEE group has been meeting regularly for more than six years, but progress has been slow. Part of the problem is that IEEE 802.11 meetings are attended by representatives of up to 100 companies of all sizes from different countries and different cultures, representing a mix of computer, communications, and components suppliers, with each company and industry sector promoting its own agenda.

Wireless private automatic branch exchanges (WPABXs) are used primarily for voice communications, although some companies have been using them successfully as a low-data-rate WLAN system. WPABXs are being pitched as a way to reduce wiring costs and virtually eliminate unanswered calls by freeing workers to roam around the office or plant with a cordless phone that is linked to the company's WPABX. This may be viewed as more of a curse than a blessing, but studies have shown that some 60 percent of business calls do not reach the intended party on the first try.

Although an all-wireless PBX system is not expected for several years, wireless adjunct systems are now available. The wireless communications system adjuncts that have already been announced tie in to a PBX via analog connections, although future plans call for specialized circuits (called T1 links) that transmit digital signals over wired telephone networks between the adjunct and main PBX.

Wireless PBX adjuncts usually consist of a control server and strategically placed transmitters/receivers, or base units, including antennas. Pocket telephones with a range of about 100 meters communicate with the base station, which is usually hidden away in a closet. As the user roams the facility, calls are handed off among the base stations, just as they are in a cellular network.

The wireless PBX market is off to a slow start for many of the same reasons that WLANs are experiencing slow market acceptance—management information system and telecom managers are trying to figure out how to implement wireless technologies into their office and factory systems. They're concerned about spectrum allocation, standards, and usage fees. Clearly, PBX users would be reluctant to pay for airtime when using their own system. And they haven't yet seen enough WLAN or wireless PBX installations to give the technology the credibility to commit to a full-blown, in-house wireless network.

Outside the U.S., several companies are building 2.4 GHz spread spectrum systems because of the potential international market opportunities in Europe and Japan at that frequency.

WIRELESS LOCAL LOOP

Wireless local loop (WLL) has been described as the "last mile" of phone service. Essentially, WLL, or fixed wireless, is the wireless version of the physical connection between a telephone and the telephone company's central switching center.

With worldwide telephone penetration rates at 11 percent and at less than 5 percent in many developing countries, the international WLL market may represent the greatest opportunity for growth in the wireless infrastructure equipment market. Globally, the infrastructure market is growing at 40 percent a year. By the year 2000, ArrayComm, one of the key players in WLL, believes that WLL will account for more than half of this market.

WLL can be used in point-to-point or point-to-multipoint radio phone links in analog or digital fixed cellular systems or limited-range cordless phone networks. WLL also fits into automated teller machine (ATM), point-of-sale (POS) terminal, point-of-banking terminal and kiosk, and online gaming and lottery terminal applications.

WLL is one of the hottest areas in wireless communications because it encompasses several technologies and expands telephone service in underserved developing and underdeveloped countries where wired infrastructures are too expensive to install. WLL can also be installed much faster than wireline systems.

There are 5.5 billion people in the world and only a fraction of them—about 500 million—have phones. Telephone line penetration in the less developed regions of the world averages about 10 percent, and most of that is in the larger urban but telecommunications-poor areas.

In developed countries with high levels of telephone line penetration, WLL is expected to serve two primary purposes: to implement competition in the local loop and offer new fixed wireless services in an emerging range of vertical and horizontal telecommunications services.

Worldwide, MTA-EMCI projects 60 million WLL subscribers in developed and developing markets by the year 2000, almost evenly split be-

tween the two market sectors. However, from 2000 to 2005, the market research firm expects developing markets to significantly outpace developed markets. By 2005, developed markets are projected to have 54 million WLL subscribers, while developing markets will have nearly three times that amount—148 million—as they work to bring their telecommunications networks up to speed with the rest of the world.

The biggest opportunities for WLL are China, India, Indonesia, Brazil, and Russia. These countries alone could account for nearly three-quarters of the total global market demand by 2005. Bangladesh, for example, is installing a WLL network that could grow to 250,000 subscribers. The first of several planned WLL systems in Paraguay is a single-cell, five-channel Advanced Mobile Phone System (AMPS) that will serve about 100 rural subscribers in Paraguay's agricultural region. WLL systems have also been installed in Mexico, Taiwan, and the U.K., where Ionica began WLL telephone service in May 1996 for residential customers. Ionica subscribers will connect to the local exchange using a 12-inch-diameter flat antenna that operates in the 3.425 GHz and 3.490 GHz bands, using technology developed with Nortel of Canada.

WLL will work in the U.S. for some of the same reasons it works elsewhere: It is cheaper and faster to install than wire. To some extent, WLL in the U.S. has fallen into niche applications. In New Orleans, for example, a local cellular operator has installed a WLL system that links the paddlewheelers that ply the Mississippi River with New Orleans banks. Using WLL, gamblers on the riverboat casinos can access an ATM at any time.

But there's a much broader WLL market across the country. Approximately 7 percent of the nation's population is without telephone service, either because some people don't have access to copper or fiber-optic cable, or it's just too expensive to reach some remote areas.

Competition among WLL equipment providers will be tough. At least 30 companies are now touting various WLL solutions.

NOW, THE SMRs

So far, the cellular industry seems to have everything going for it, even with the introduction of PCS. What the cellular carriers did not plan on until fairly recently was having to compete with Specialized Mobile Radio (SMR) operators. Like cellular service, SMR is a two-way service, used mainly for dispatching taxis and delivery vehicles, and for public safety.

SMR uses mobile phones and base stations that communicate through the public telephone network.

Although most SMRs have been struggling to make the transition to digital networks—either they can't find the financing to expand their networks or seem to be stuck in mostly vertical applications—most market projections give them the benefit of the doubt. MTA-EMCI expects SMR/ESMR (Enhanced SMR) operators to increase their share of the mobile data market from 13 percent in 1995 to 21 percent by the year 2000. While most of this growth is expected to come from digital SMR subscribers, MTA-EMCI believes the analog SMR operators will also increase their penetration of the mobile data market, adding significantly to SMR revenues.

Churn could be a big problem for SMRs, however. Churn rates are not as high as the rates being reported for paging or cellular service, where getting people to keep their pagers and cellular phones (and to use them) has always been an industry problem, but churn is growing for SMRs—reaching an estimated 21 percent in 1995.

The American Mobile Telecommunications Association (AMTA) blames a soft economy. Most SMR users are small businesses, such as taxi operators and small construction companies, many of which have gone out of business or cut back on their communications when business gets tough. Some SMR operators also are losing customers to cellular carriers, mainly because they like the mobility offered by cellular service. SMR operators may also lose customers to new digital mobile networks. Still, EMCI is predicting that the industry will add about 4 million subscribers by the end of the decade, close to half of which will be using digital systems.

Even as its revenues have more than doubled (mostly reflecting acquisitions), Nextel Communications, the biggest of the SMRs, has suffered large losses in recent years as it builds its nationwide wireless network.

In February 1991, the FCC gave Fleet Call, Inc. (now Nextel), permission to convert its conventional 800 MHz SMR systems in six major markets to digital, cellular-like networks with at least 15 times their original capacity, handling both voice and data. Understandably, the cellular industry, led by CTIA, McCaw Cellular (now AT&T Wireless Services), and the regional Bell cellular operators, strongly opposed the FCC's decision, fearing that a new service so closely resembling theirs may force them to cut prices.

The FCC took a different view, noting that competition is good and that, at any rate, Nextel wouldn't be competitive with cellular for years, especially on a national scale. Indeed, SMRs will have to build a totally new in-

frastructure to handle the new service, including new subscriber handsets, which should make it more expensive than cellular service. Nextel says its phones will be priced competitively with digital cellular handsets, although the handsets may be a little bulkier than cellular models.

Nextel's new system, called Enhanced SMR (ESMR), was launched in the greater Los Angeles metro area in August 1993. It's a huge "footprint," stretching from Santa Barbara to San Diego. Three cellular metropolitan service areas (MSAs) cover the same area. Nextel also agreed to buy a large segment of mobile radio licenses from Motorola for $1.8 billion in stock, and announced in November 1993 that Nippon Telegraph and Telephone of Japan would invest $75 million in the company and would design a system that would enable Nextel to link all its local systems into a single network within three years. The Motorola licenses, along with those it already owns, would expand Nextel's network across 21 states, with the potential to serve 180 million people, making it considerably larger than the McCaw system. However, Nextel still has a long way to go to reach its operational goals, while cellular has easily exceeded its market expectations with more than 30 million subscribers in the U.S.

ENTER PCS

The entire competitive picture changes for wireless personal communications with the introduction of personal communications services (PCS). Billions of dollars are being spent to develop PCS in the U.S.

Accounts of preparations for competition in the Dallas market between AT&T Wireless, Sprint Spectrum, and PCS PrimeCo, for example, refer to a "war zone" mentality with sales teams taking on names like "82nd Airborne."

An analysis by the Deloitte & Touche Consulting Group gives PCS almost half (48 percent) of the current allocation of land mobile radio frequency spectrum by type of service. Cellular service only has 20 percent. Smaller allocations are held by public safety (9 percent), SMR (8 percent), and "Other" (15 percent).

Consumers in some areas may now choose between different technologies, different pricing plans, and distinct coverage areas. The challenge for both cellular and PCS carriers will be to differentiate themselves.

A rundown of MTA-EMCI's end-of-year 1995 PCS market analysis calls for critical milestones in the implementation of commercial PCS in

the U.S. to include the first direct competition with cellular and WLL applications. EMCI believes that PCS revenues will be generated by both traditional mobile and new WLL services. The dominant service offering is assumed to be a mobile radio service directly competitive with cellular service, including portable and mobile voice, mobile data, mobile messaging, and hybrid voice and data services.

After accounting for the competitive environment, consumer preference, market rollout, and geographic rollout, EMCI projects a PCS subscriber base of 20 million in the year 2000 and 27 million in 2005. Net subscriber growth will peak between 1998 and 2000, when between 5 million and 7 million net subscribers will be added each year. Revenues for mobile services are projected to exceed $12 billion by 2001.

EMCI assumes that some carriers will offer differentiated PCS focused on providing basic telephone services in and around the home. There will be a significant overlap between mobile and local loop subscribers. Even where mobile and local loop services are used by the same subscriber, EMCI assumes that local loop services represent an additional revenue stream to the carrier.

In fact, the number of local loop subscribers could be significant, reaching 7 million by the year 2002. The PCS industry should generate approximately $1.7 billion in annual revenues from WLL services by 2003. Looking at both mobile and WLL income, PCS carriers are likely to generate about $10 billion in annual revenues by 2000.

Projections for PCS handset revenues call for the market to peak at almost $3 billion in 1999. EMCI projects the PCS handset market to exceed 500,000 units in 1996, climbing to 12 million handsets annually in 1999 and 2000.

PCS carriers are expected to dramatically change the competitive characteristics of the wireless market. Today, cellular carriers essentially dominate the mobile telephone market while ESMR represents a relatively insignificant number of subscribers. By the year 2000, however, PCS carriers could capture about 27 percent of the mobile communications market. By 2005, the mobile market will still likely be dominated by cellular service, with almost two-thirds of the market. At that point, PCS is expected to have a 28 percent share of a much bigger market, with ESMR pulling down 7 percent of the market.

In fact, the emergence of PCS is already showing signs of boosting cellular sales by helping to promote the entire concept of portable, anywhere, anytime, communications. That doesn't mean that cellular carriers won't

have to make some changes in the way they promote their products and services. Cellular One in the Washington/Baltimore area was forced to make some adjustments when APC/Sprint Spectrum became the first PCS carrier in operation in the U.S. in the same area. Cellular One immediately introduced several new services to compete with PCS, including a TDMA digital service, paging, enhanced directory assistance, and a long-distance service. Cellular One also beefed up its customer retention effort and introduced preferred customer and upgrade programs. Clearly, lower-priced, smaller, and lighter phones with more features are in the future.

Why "Cellular" Communications?

In nontechnical terms, cellular service works by dividing a city or region into small geographic areas called cells, each served by its own set of low-power radio transmitters and receivers. Once a cellular call or data message reaches a transmitter/receiver tower, it is plugged into the regular land-line phone system. Each cell has multiple channels to provide service to many callers at one time. As a caller moves across town, the signal to or from the cellular telephone is automatically passed from one cell to the next, without interruption.

AT&T Bell Laboratories developed the concept in 1947, but the first tests weren't conducted until 1962 to explore commercial applications. It then took another eight years before the Federal Communications Commission (FCC) set aside new radio frequencies for land mobile communications. That same year (1970), AT&T proposed to build the first high-capacity cellular telephone system. It was called Advanced Mobile Phone Service, or AMPS.

The FCC decided to license cellular systems in the 306 largest metro areas first (called metropolitan service areas, or MSAs), then to the less populated 428 rural service areas (RSAs). With its rules in place, the FCC began accepting applications for the 60 largest cities during 1982. In early 1983, when 567 applications were filed just for the 30 markets ranked 6lst to 90th in size, the FCC knew it had a problem: Its traditional system of issuing licenses following comparative hearings would take forever. In May 1984, the commission amended its rules to allow lotteries to be used to select among competing applicants in all but the top 30 markets. On October 13, 1983, the first cellular system began operating in Chicago.