Global Competitiveness of U.S. Advanced-Technology Industries: Cellular Communications

Investigation No. 332-329

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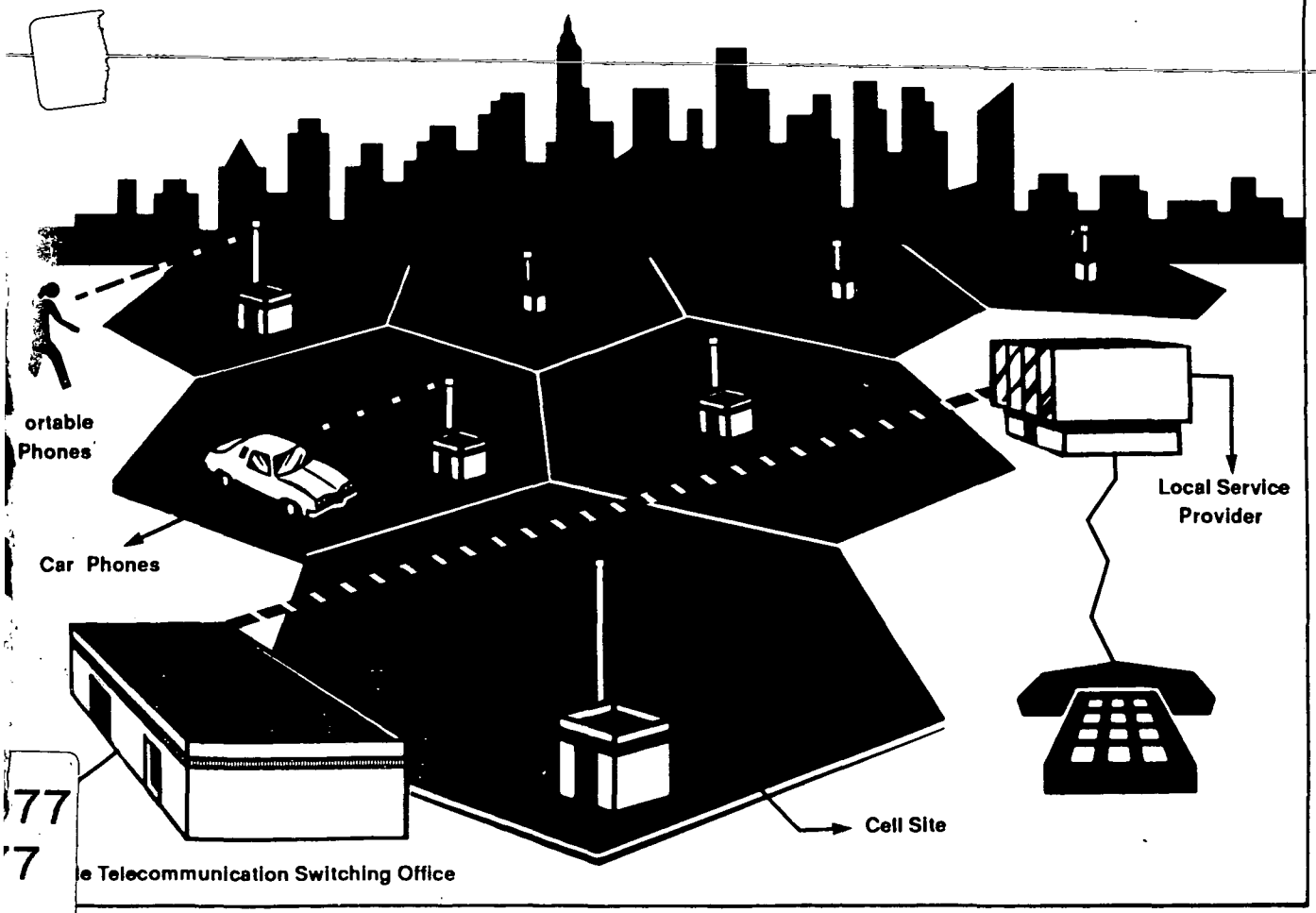

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Global Competitiveness of U.S. Advanced-Technology Industries: Cellular Communications

blication 2646

June 1993

PREFACE

Following receipt on June 11, 1992, of a request from the Senate Committee on Finance (appendix A), the U.S. International Trade Commission instituted the three requested investigations, Cellular Communications (investigation 332-329), Aircraft (332-332), and Computers (332-339) under section 332(g) of the Tariff Act of 1930 (19 U.S.C. 1332(g)). The purpose of these investigations is to examine the global competitiveness of the U.S. cellular communication, aircraft, and computer industries, respectively. These investigations follow three competitive assessments provided to the Finance Committee during September-October 1991. This report is the first of the current three and examines the cellular communications industry.

Copies of the notice of the investigation were posted in the Office of the Secretary, U.S. International Trade Commission, Washington, DC 20436, and the notice was published in the *Federal Register* (57 F.R. 33971) on August 19, 1992 (appendix B). The Commission held a public hearing in connection with the investigation on January 27, 1993. All persons were allowed to appear by counsel or in person, to present information and to be heard. In addition, interested parties were invited to submit written statements concerning the investigation.

The information and analysis provided in this report are for the purpose of this report only. Nothing in this report should be considered to reflect possible future findings by the Commission in any investigations conducted under statutory authority covering the same or similar subject matter.

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EXECUTIVE SUMMARY

This is the first of three competitive assessments of selected U.S. advanced technology industries requested by the Senate Committee on Finance on June 11, 1992. The other two concern the large civilian aircraft and computer hardware industries. These three studies are part of an ongoing series of competitive assessments begun in 1990.

The Commission has been requested to examine all factors found to be relevant to the global competitiveness of the U.S. cellular communications industry. The request letter specifies that the factors to be examined by the Commission may include, but are not limited to, government policies, regulatory and trade impediments, and research and development financing and expenditures.

The study examines three discrete sectors of the cellular communications industry: cellular service providers, cellular network equipment manufacturers, and cellular phone manufacturers. The analysis focuses principally on cellular communications industries in the United States, Europe (the European Community and Scandinavian countries), and Japan, which jointly account for virtually all internationally active cellular communications firms.

Industry Conditions

The global market for cellular services is valued at $10-15 billion. The global market for cellular network equipment and cellular phones is valued at $1-2 billion. U.S. manufacturers and service providers are among the predominant players in both service and equipment markets. The advent of personal communications, a derivative of cellular communications, is projected to create a $30 to $40 billion market for services and equipment in the United States by the year 2000.

- Currently, the U.S. cellular communications industry generates revenues of $8 billion annually and employs 31,000 workers.
- Revenues and employment among U.S. cellular service providers are growing at rates in excess of 35 percent per year.
- Revenues and employment among U.S. cellular equipment manufacturers are growing at rates in excess of 15 percent per year.

Competitive Position of U.S. Firms

Approximately ten years after the initiation of cellular communication services in the United States, U.S. service providers and equipment manufacturers are among the most competitive firms in the global cellular communications industry.

With respect to cellular communication service providers, this report finds that:

- Like many other firms in the U.S. service sector, which has generated consistent trade surpluses during the past decade, U.S. cellular service providers have established strong competitive positions in overseas markets.
- The key factors that appear to result in success when competing for foreign cellular service licenses are experience in the home market and the technical, marketing, and cost management skills derived from experience.

- Many countries are moving from monopoly provision of cellular services to a duopoly market where private firms, whether foreign or domestic, can provide services in competition with the national telecommunication authority. Approximately half of the licenses which countries have awarded to firms from outside the home country have been awarded to U.S. firms, principally the Bell regional holding companies (RHCs).
- Service providers based in the United Kingdom and Sweden are the chief competitors for U.S.-based firms when these additional licenses are awarded.
- Firms in the United States, the United Kingdom, and Sweden generally have benefitted from competitive environments in their home markets, endowing them with valuable experience and motivating them to develop expertise in fields such as engineering, software programming, systems integration, and marketing.
- The advent of personal communication services presents U.S. firms with the opportunity to further enhance their position in foreign markets, but U.S. and foreign regulatory agencies must first grapple with a host of new challenges relating to spectrum allocation and licensing procedures.

With respect to cellular network equipment manufacturers, this report finds that:

- Network equipment manufacturers compete by bidding for contract awards from cellular service providers. The key factors that appear to result in receiving systems contracts are: research and development; experience in radio and wireline switch manufacturing; and the ability and willingness to manufacture equipment to the world's predominant technical standards. Strategic corporate alliances may be formed to compensate for deficiencies in these areas.
- Through 1990, roughly half of the world's cellular subscribers received services over systems supplied by two companies, Motorola and AT&T. These firms' success is due in large part to their predominance in the U.S. market, which accounts for about 50 percent of global subscribers.
- In foreign markets, Ericsson appears to have a competitive advantage, in large part due to its ability and willingness to build systems conforming to a broad array of technical standards and its experience in manufacturing and marketing wireline switches.
- European systems suppliers appear to be reaping short-term benefits from the European Community's early adoption of a single digital standard, although the long-term impact on U.S. and European firms' relative competitiveness is presently unclear.
- Future sales opportunities will likely depend on firms' ability and willingness to supply systems conforming to at least 3 new digital standards, and the ability to manage costs since price competition appears likely to intensify as a result of changing procurement practices.

With respect to cellular phone manufacturers, this report finds that:

- Cellular phone manufacturers compete by selling phones at the retail and wholesale level.
- Motorola, with a global market share of 23 percent, is the largest cellular phone manufacturer in the world, followed by Nokia (Finland), and Matsushita, Mitsubishi, and NEC (Japan).
- Motorola appears to owe its preferred competitive position to experience in radio manufacturing; competency in integrated circuit design and manufacturing; and to the implementation of advanced manufacturing techniques.
- The cellular phone market increasingly resembles consumer electronics markets where firms compete principally in terms of price, elevating the importance of cost management and marketing skills.

- Motorola's principal competitors will likely continue to be Japanese firms, which have prospered in other consumer electronics markets.

Government Regulation

The most significant regulatory policies affecting competitiveness in the cellular communications industry regard licensing, spectrum allocation, and standards.

With respect to licensing, this report finds that:

- Countries such as the United States, the United Kingdom, and Sweden, which have fostered competition among cellular service providers by licensing more than one cellular carrier, have generally benefitted as a result, enjoying larger cellular subscribership and lower service prices.
- Many countries with monopolies in cellular service plan to introduce competition in their cellular markets by licensing multiple providers using the newest generation of technology, digital cellular services.
- Countries also expect to introduce or further intensify cellular competition by licensing additional providers for personal communication services. Licensing of personal communication service providers is proceeding more slowly in the United States than in the United Kingdom and Germany. In addition, U.S. licensees may have to bear the costs of relocating incumbent spectrum users. These conditions may result in further delays and higher costs, which are not likely to be imposed on personal communication service providers in Europe or the Far East.

With respect to spectrum allocation, this report finds that:

- There is no consensus among representatives of the U.S. cellular communications industry regarding the long-term impact of spectrum scarcity in this country.
- The United States and the European Community are largely relying on market forces to motivate the development and deployment of spectrally efficient digital technologies to allow providers to increase subscribership without receiving additional spectrum. Japan, on the other hand, has reserved larger amounts of spectrum to ensure sufficient capacity for existing technologies. In part, Japan is able to allocate greater amounts of spectrum to cellular communications because it does not have to allocate spectrum for military use.

With respect to standards, this report finds that:

- Standards-setting processes in the United States, the European Community, and Japan have remained relatively open, although U.S. industry representatives note concern regarding declining U.S. influence in the European Telecommunication Standards Institute.
- The development of a common analog standard enhanced the competitive position of U.S. firms early on, and the lack thereof in Europe clearly stymied the growth of the European industry during the past decade.
- Within 5 years, larger cities within all major cellular markets will be using networks that employ digital transmission technology, the newest generation of cellular communications technology.
- The European Community's adoption of a common digital standard, GSM (Global System for Mobile Communications), is reportedly helping European firms to market network equipment, and the inability of U.S. firms to adopt a common digital standard is reportedly impairing U.S. firms' equipment sales at home and abroad.
- The U.S. industry is divided with respect to the adoption of a common digital standard; two are under consideration at present. There have been calls for the U.S. Government to work with domestic firms to forge a consensus in support of one of

these standards. Supporting this stance is the concern that U.S. equipment manufacturers have already lost momentum and sales opportunities to firms from Europe because the EC dictated the adoption of GSM. This situation may only have an effect in the short run, since greater deliberation and research among U.S. firms may ultimately result in the development of digital systems that are superior to GSM systems, conferring competitive advantage on U.S. firms over the long run.

Abbreviations

AMPS	Advanced Mobile Phone Service
CDMA	Code Division Multiple Access
ETDMA	Extended Time Division Multiple Access
GHz	Gigahertz
GSM	Global System for Mobile Communications
IMTS	Improved Mobile Telephone Service
JDC	Japanese Digital Cellular
LATA	Local Access and Transport Area
MFJ	Modification of Final Judgment
MHz	Megahertz
MSA	Metropolitan Statistical Area
MTSO	Mobile Telephone Switching Office
NAMPS	Narrowband Advanced Mobile Phone Service
NMT	Nordic Mobile Telephone
RHC	(Bell) Regional Holding Company
RSA	Rural Service Area
TA	Telecommunication Authority
TACS	Total Access Communication Systems
TDMA	Time Division Multiple Access

CHAPTER 1
Introduction

Purpose of Study

This study is a part of an ongoing series of reports assessing the competitiveness of U.S. advanced-technology industries.[1] The series of reports, requested by the Senate Committee on Finance, attempts to provide policy-makers and other interested groups with a thorough and methodical analysis of the determinants and status of global competitiveness in certain high-technology industries. This study focuses on the global cellular communications industry, an industry that both incorporates some of the most advanced technology available and contributes to the technological advance of other industries.[2] In particular, this study assesses the international competitiveness of U.S. cellular service providers and equipment manufacturers vis-a-vis their international competitors. Areas such as government policy, industry evolution, and technological change are also examined to provide the proper context for this assessment.

Approach

This report features both qualitative and quantitative analysis. It relies principally on qualitative analysis to assess the competitive position of U.S. firms, and to evaluate the implications of trends that were identified in over 70 interviews conducted by Commission staff.[3] Quantitative analysis, integrated into chapter 5 of the report, supports or qualifies conclusions regarding the relationship between competitiveness and firms' skills or attributes.

Information for this analysis has been collected from a wide variety of sources. As stated, contacts with key domestic and foreign manufacturers, service providers, regulators, and prominent industry analysts have provided much of this information. In-person or telephone interviews were conducted in the United States, Europe, and the Far East with principal cellular equipment manufacturers, service providers, and government officials. In addition, the Commission held a hearing pertaining to cellular communications on January 27, 1993.[4] Testimony presented by interested parties attending the hearing has been incorporated into this report. Research conducted by organizations within universities and national and international standard-setting bodies is presented where applicable.

Scope of Study

This study focuses principally on developments since 1990 because it is only in the last 3 years that cellular communication has become a significant segment of the telecommunications industry. For the purpose of this study, the cellular communications industry encompasses service providers, network equipment manufacturers, and phone manufacturers (see figure 1-1). While this diversity broadens the scope of the report, the study is limited in the sense that other wireless communications, such as mobile satellite communications, paging, and cordless telephony, are not discussed (see figure 1-2). These modes of communication are excluded because they differ significantly from cellular communications in terms of infrastructure, customer base, and near-term growth potential. Emerging communication technologies, such as personal communications,[5] are discussed as they relate to cellular communications.

Cellular service providers are of two types: traditional wireline service providers and "pure-play" service providers (see figure 1-3). Traditional providers are those cellular service firms that also offer telecommunication services over wireline networks. In the United States, examples of traditional service providers include the cellular subsidiaries of the seven Bell regional holding companies (RHCs) and the cellular subsidiaries of independent wireline service

[1] The series is described in the United States International Trade Commission (USITC), *Identification of U.S. Advanced-Technology Manufacturing Industries for Monitoring and Possible Comprehensive Study (investigation No. 332-294)*, USITC publication 2319, Sept. 1990, pp. 15-16.

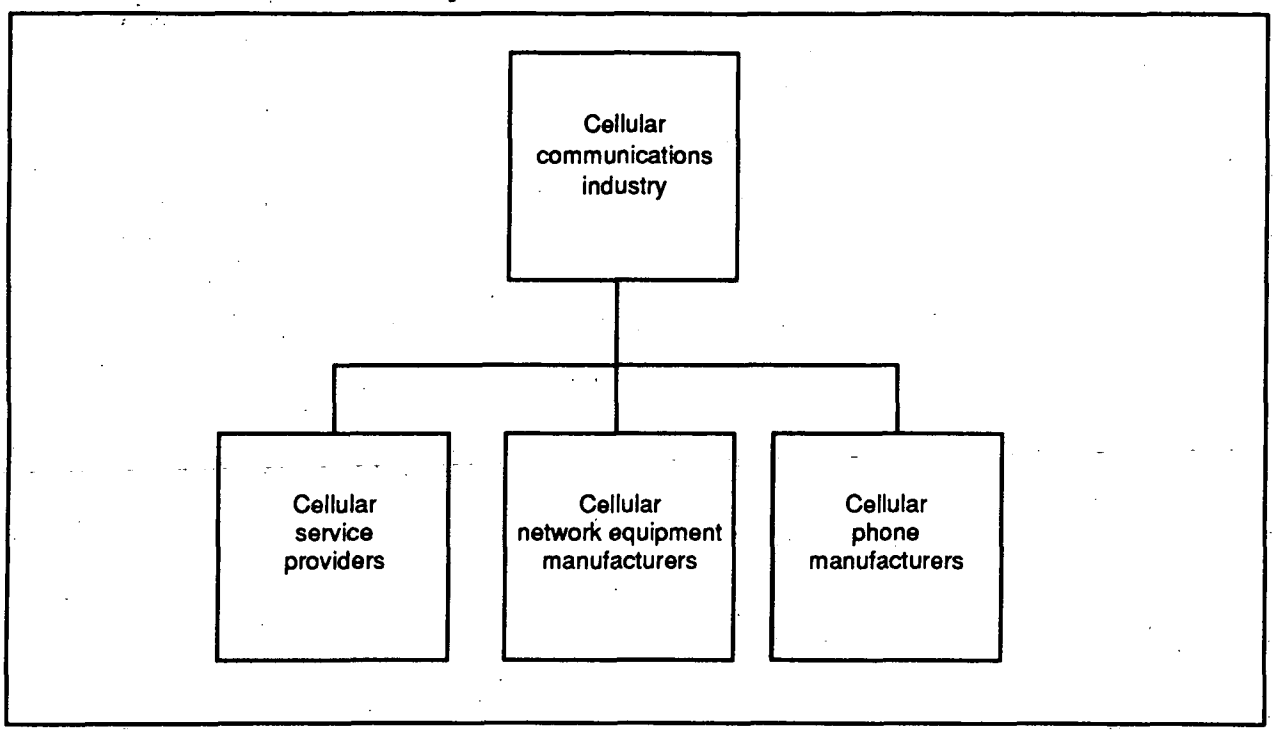
[2] On June 11, 1992, the Senate Committee on Finance requested that the USITC prepare studies on the cellular communication, large civilian aircraft, and computer hardware industries as part of the series of competitive assessment studies, begun in 1990. See appendices A and B for more detail.

[3] See appendix C for the list of firms, associations, and government agencies interviewed by Commission staff during the course of this investigation.

[4] See appendix D for a list of witnesses participating in the public hearing on cellular communications.

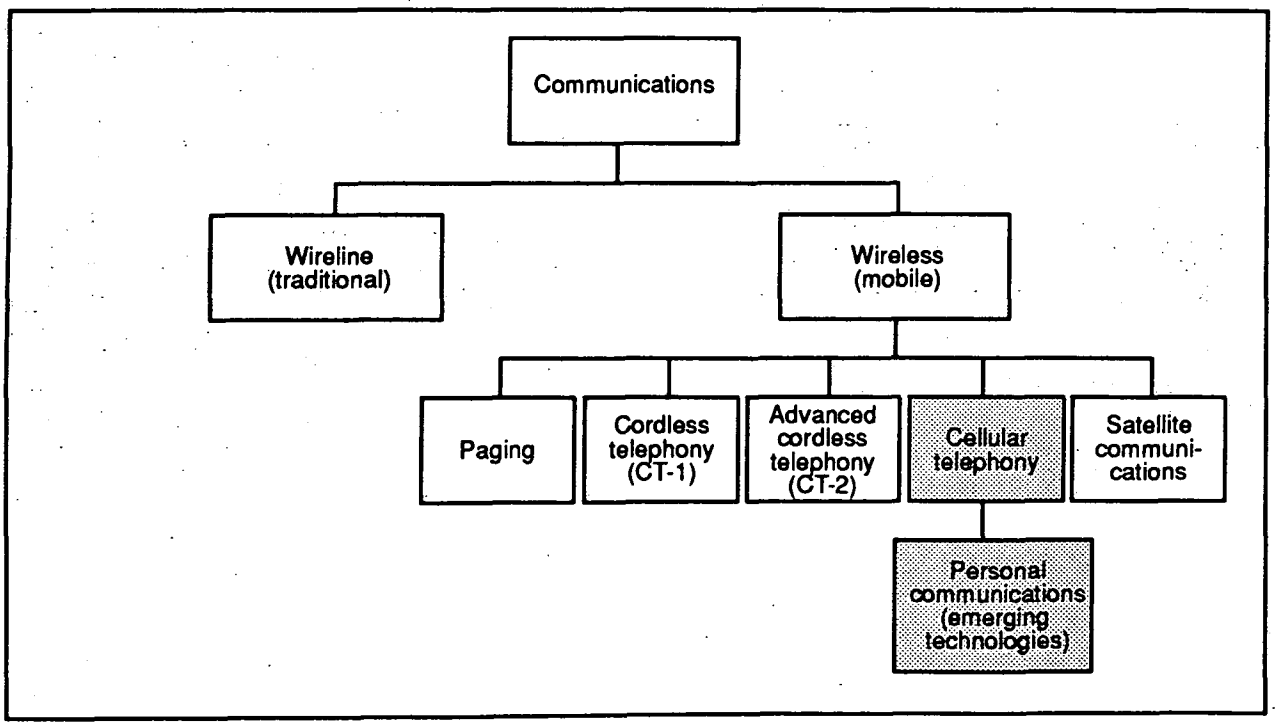
[5] See appendix E for a glossary of selected technical terms used in this report.

Figure 1-1
Cellular communications industry sectors



Source: USITC staff.

Figure 1-2
Communications industry



Source: USITC staff.

providers such as General Telephone and Electronics Corp. (GTE). "Pure-play" cellular service operators are those firms that exclusively operate mobile communication networks. Figure 1-3 lists the predominant service providers by category.

Cellular equipment manufacturers are divided into two categories, cellular network equipment manufacturers and cellular phone manufacturers. Cellular network equipment manufacturers produce switches and radio base station equipment. Within each cellular service area, switches coordinate all cell sites, control call processing, and interface with telephone company central offices. Radio base station equipment in each cell site receives and transmits calls between cellular phones and switches. Currently, as shown in figure 1-4, the predominant switch manufacturers also produce radio base station equipment.

Cellular phones comprise three categories: carphones, transportable phones, and portable phones (see figure 1-4). Carphones were the first cellular handsets, designed for permanent in-vehicle installation. The transportable phone is built into a briefcase or bag, offering greater mobility than the carphone. It contains a battery so that it can be used either inside or outside the vehicle. The most recent type of cellular phone is the portable unit, which typically is small enough to be carried in a jacket pocket.

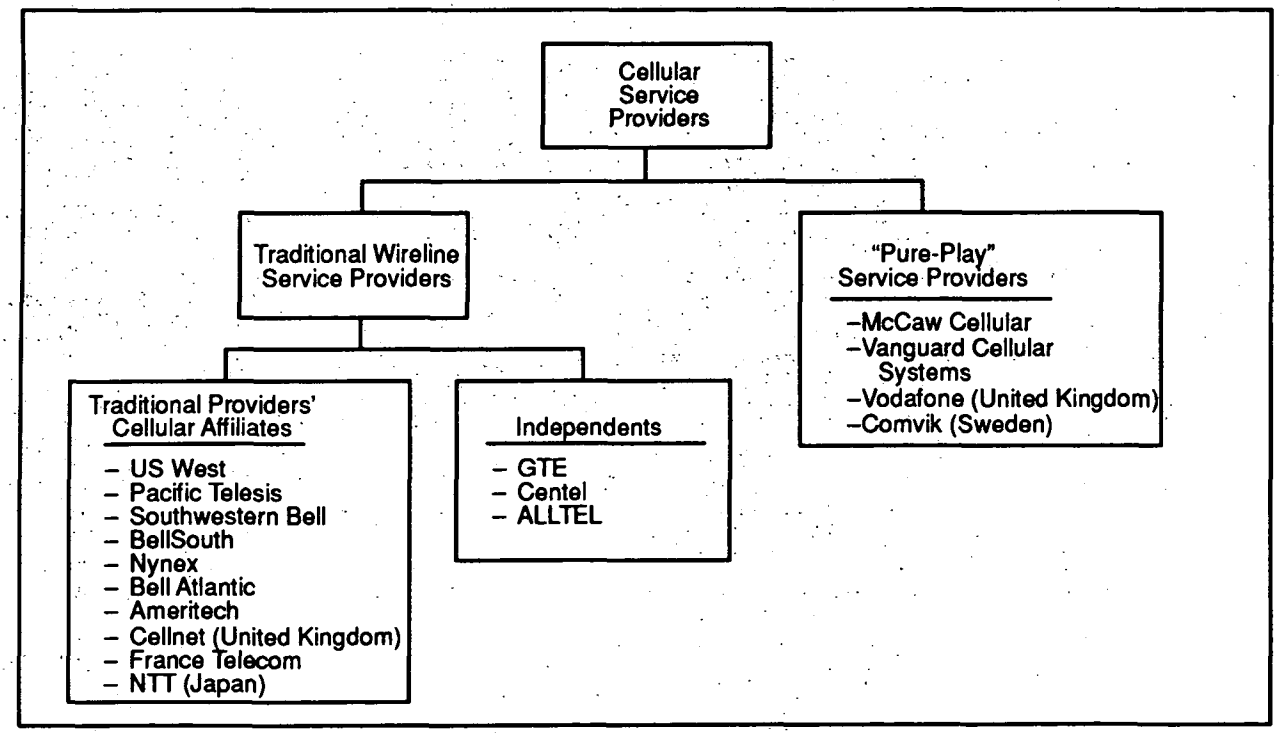
The principal countries and regions analyzed in this report are the United States, Japan, and Europe. These are three major cellular equipment producing regions, the home of the most experienced cellular service providers, and the most significant markets for cellular equipment and services. Emerging cellular markets, such as those in Eastern Europe, Asia, and Latin America, are also examined when applicable. These regions are analyzed mainly as markets, rather than as producers.

Organization of Study

Chapter 2 lays the groundwork for chapters 3 through 6 by discussing the technology underpinning the industry and by examining the direction of technological change and its effect on the marketplace. The chapter also provides a baseline analysis of the industry, lending perspective on the size, growth, and competitive position of U.S. firms.

Chapter 3 discusses the nature of competition in the cellular communications industry. First, it introduces the analytic framework used to examine competitiveness in the cellular communications industry. For each sector of the industry, the framework identifies the indicator of competitiveness, the terms of inter-firm competition, and the factors

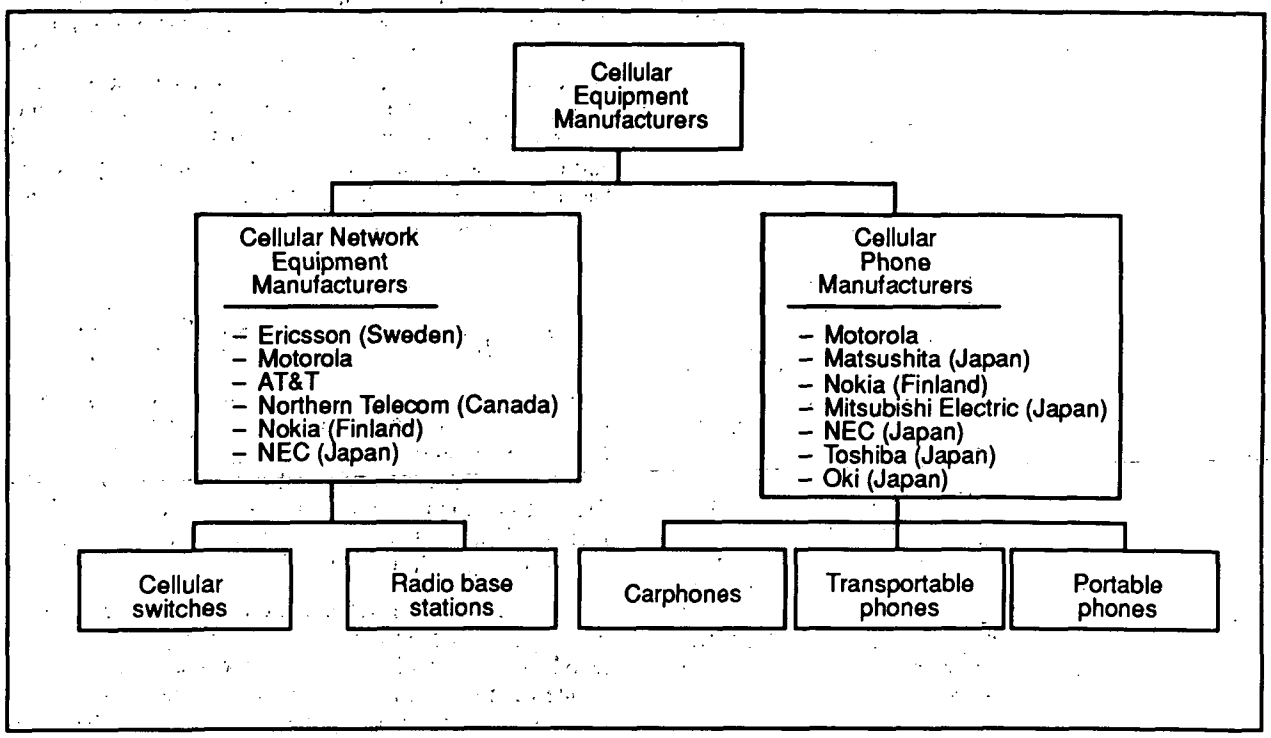
Figure 1-3
Cellular service providers[1]



[1] Firms listed above originated in the United States unless noted otherwise.

Source: USITC staff.

Figure 1-4
Cellular equipment manufacturers[1]



[1] Firms listed above originated in the United States unless noted otherwise.

Source: USITC staff.

that most significantly influence firms' abilities to compete. Afterward, the chapter presents three separate and distinct discussions, each corresponding to one industry sector, that provide fuller detail on the indicator of competitiveness and the terms of international competition. International competitiveness among cellular service providers is indicated by licenses awarded in foreign countries; competitiveness among cellular network equipment manufacturers, by system contracts awarded in foreign countries; and competitiveness among cellular phone manufacturers, by global market share.

Chapter 4 examines the external factor that exerts the greatest influence over the cellular communications industry, namely, government policy. The chapter focuses principally on government policies pertaining to licensing, spectrum allocation, and standards in the United States and in key foreign markets. Other significant discussions in the chapter regard the Modified Final Judgement (in the United States) and procurement policies.

Chapter 5 examines firm skills and attributes, previously identified in the analytic framework, that exert the most influence over inter-firm competition. In three independent discussions, the competitiveness of cellular service providers, cellular network equipment manufacturers, and cellular phone manufacturers is analyzed both qualitatively and quantitatively. The qualitative analysis of each industry sector begins by listing foreign license awards for service providers, foreign system contracts for network equipment manufacturers, and global market share for cellular phone manufacturers. Then, factors that appear to have conferred competitive advantage on U.S. and foreign firms are examined. Quantitative analysis, focussing on the statistical relationship between indicators of competitiveness and certain firm attributes, is integrated into each discussion. The three separate discussions conclude by briefly summarizing findings and identifying trends that may significantly influence the future competitive environment in each industry sector.

Chapter 6 summarizes the report's principal findings regarding the competitive position of the U.S. cellular communications industry and the influence of key government policies. The present competitive position of U.S. firms, and likely future developments, are summarized separately for each industry sector.

CHAPTER 2
The Cellular Communications Industry

Evolution of Cellular Communications

During the 1920s public safety agencies such as police and fire departments began using the first mobile radio systems. In the twenty years that followed, the use of mobile radios slowly spread to the private sector, although limitations on capacity and the high cost of service at the time restricted the use of mobile telephone systems to taxis, trucking companies, and other businesses that had mobile operations.

In 1946, AT&T introduced a new mobile radio technology known as mobile telephone service (MTS) that enabled users to send and receive messages. MTS could also be interconnected with the public-switched telephone network providing users with universal calling. During the 1950s, MTS usage steadily grew, but capacity shortages restricted its availability in major metropolitan areas because of the limited number of channels available for simultaneous use. In 1969, AT&T introduced a redesigned system called improved mobile telephone service (IMTS). IMTS eliminated the need for placing calls through a special mobile operator, but capacity shortages remained.

Cellular Telephony

Responding to the Federal Communications Commission's (FCC) request in 1970 for proposals to establish new mobile systems, AT&T submitted a plan to provide services based on a concept known as cellular telephony, conceived by Bell Laboratories in 1947. Whereas mobile telephony used one powerful transmitter to send messages throughout large regions, cellular telephony uses many low-power, interconnected transmitters to send messages within smaller geographic areas known as cells.

Cellular systems re-use radio frequencies, permitting more subscribers to place or receive calls without additional allocations of radio spectrum. When radio frequencies are re-used, subscribers in different, non-contiguous cells may simultaneously use the same frequency channel without signal interference. A frequency supporting a certain conversation in one cell may support another conversation in a different cell. As subscribers move from cell to cell, the cellular system automatically reroutes calls using a hand-off technique that, in the best of situations, is inaudible to subscribers. The degree to which frequencies can be reused depends on the number of cells, terrain, antenna height, and level of power transmission at each cell.

As shown in figure 2-1, cellular systems consist of three parts: cellular phones, radio base station equipment, and one or more mobile telecommunication switching offices (MTSOs). The subscriber uses the cellular phone to place or receive telephone calls over the system; while radio base station equipment at each cell site acts as an interface between the phone and the MTSO. The MTSO is the brain of the system, coordinating traffic among cell sites and switching calls to connect mobile subscribers with other mobile subscribers and with the public-switched, wireline telephone network.

Cellular service is provided by firms that have received licenses allowing them to offer cellular communications in specific geographic areas. Licensing practices vary across countries, but an increasing number of governments currently provide two or more licenses for each area, one of which is usually granted to the traditional wireline service provider. License holders are chosen in a number of ways, including comparative hearings, lotteries, and auctions.

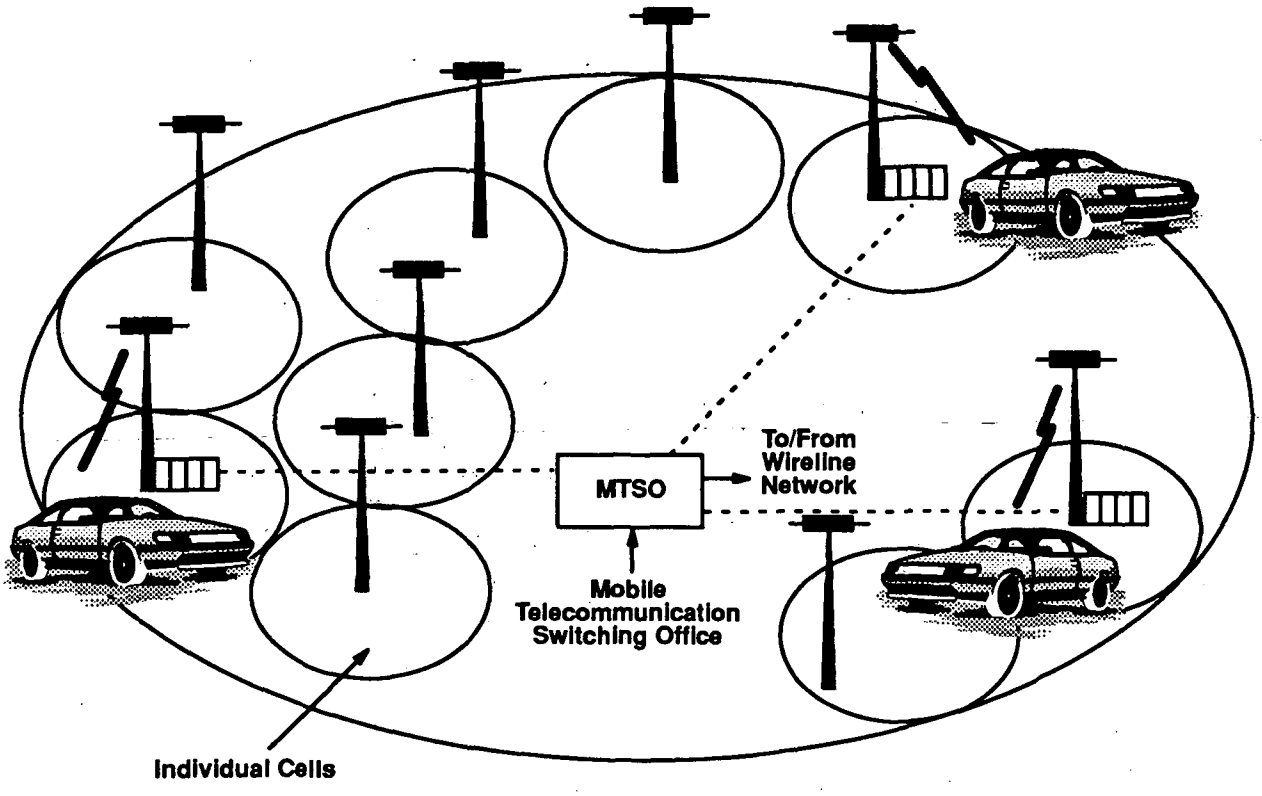
Service providers purchase cellular systems comprised of switches and cell site equipment to create cellular networks. Switches and radio base stations are usually purchased from the same systems contractor, although the adoption of open systems architecture may soon change this practice.[1] Cellular service providers sell services to customers on a contract basis. Depending on the country, customers may obtain phones from the cellular operator, resellers, or retail outlets.

Cellular Phones

Three types of cellular phones — carphones, transportable phones, and portable phones — are currently in use. These phones differ with respect to transportability and transmission distance. The first cellular handset was designed for permanent in-vehicle

[1] Open systems architecture facilitates the interconnection of equipment manufactured by different firms through the standardization of interface protocols.

Figure 2-1
Cellular communication systems



Source: Hatfield and Associates.

installation, and was known as a mobile handset or carphone. The transportable phone is built into a briefcase and contains a battery so that it can be used either inside or outside a vehicle. As the transportable unit and battery shrank in size, it could be carried in a smaller, soft-sided case, leading to the term "bag phone." The most recent form of cellular phone is the portable unit, which can fold into a package the size of a pocket calculator, and can easily be carried in a jacket pocket.

The key difference in the product groups' transmission capabilities is the broadcasting range. Carphones and transportable phones have greater broadcast ranges than portable phones.[2] This transmission difference initially determined the place where the different types of cellular phones could be used. Carphones and transportable phones could be used in both urban and rural settings because of their longer broadcasting ranges, whereas portable phones could be used only in urban settings where cells were smaller and cell sites were more tightly concentrated. This difference is decreasing gradually as portable phone users increase their phones' transmission power to 3.0 watts by adding car adapters to their phones. With such an adapter, the broadcasting range of a portable phone is roughly equivalent to the broadcasting range of a carphone and a transportable phone.

Radio Base Station Equipment

Located in each cell of a cellular system are low power transmitters, receivers, antennas, processing equipment, power amplifiers, and back-up power equipment. Channel bank equipment, typically located at the cell site, carries on digitally coded communication with the MTSO over wireline or microwave links, and transforms outgoing messages into analog signals for radio transmission.[3] Cell site controllers monitor and manage the routing of all calls taking place within the cell. Cell site antennas typically have ranges of 1 to 15 miles, depending on cell size. As cells, particularly those in urban areas, become more congested, system operators typically subdivide initial cells to improve service.

[2] Car phones, which utilize larger batteries, transmit at 3.0 watts, while portable phones, with smaller batteries, transmit at only 0.6 watts.

[3] The need for channel bank equipment will decrease as digital cellular systems are deployed.

Cellular Switches

In its construction and reliance on software-driven processing of calls, a cellular switch is similar to a switch employed at a central office (CO) of the traditional wireline network. However, the demands placed on the cellular switch differ from the demands placed on a CO switch. In addition to the automated billing, routing, and enhanced functions that a CO switch must perform, a cellular switch must also interact with channel bank equipment to locate the mobile phone unit and determine if it is operable. To locate the unit, the cellular switch uses paging techniques and search algorithms. It must also direct the change of frequencies when a caller moves from one coverage area to another. These additional functions consume much of the processing power of a cellular switch, thus reducing the number of callers that it can serve efficiently. One industry source estimated that a cellular switch can handle about 15 percent of the number of calls that a CO switch can handle.[4]

Early Markets

Despite its advantages, cellular communications developed slowly. The primary goal of most national governments was to obtain universal service through the wireline network. In addition, because most wireline telecommunication service providers were monopolies, they had little incentive to invest in competing technology.

In the United States, the FCC allocated radio frequencies for mobile telephony use in 1970, and, with the development of large-scale integrated circuit technology in the early 1970s, cellular communications became technically feasible and spectrally efficient. After developing an experimental cellular mobile system in Chicago in cooperation with Motorola in 1983, AT&T introduced the first commercial U.S. cellular service, called Advanced Mobile Phone Service (AMPS), in Chicago, and followed with a second system in the Baltimore-Washington area. AMPS systems currently serve about 60 percent of the world's cellular subscribers, most of these being in the U.S. market.[5]

A number of countries initiated cellular service before the United States. In the late 1970s, Japan's Nippon Telephone and Telegraph (NTT) and Sweden's L.M. Ericsson began testing cellular technology and started designing equipment that would facilitate commercial service provision in their respective home markets. In 1979, NTT launched the first cellular system in the world when it began offering service in the Tokyo area. By 1982, Ericsson had constructed the first European cellular systems for use by Scandinavian service providers (table 2-1).

Throughout Europe, Japan, and the United States, cellular communication systems were introduced to complement service offered by traditional wireline systems. However, in countries with less developed communication infrastructures, such as many in the Asian-Pacific, Latin American-Caribbean, East European, Middle Eastern, and African nations, cellular communication systems were sometimes introduced as substitutes to traditional wireline systems. It is generally less expensive to establish a cellular communications system than a wireline system due to lower infrastructure and labor costs. In countries where cellular systems were introduced as substitutes, cellular usage is typically less sensitive to price because no alternative exists. As illustrated in table 2-1, most of these countries deployed analog cellular systems between 1985 and 1992. Most of these systems were designed and built by U.S., Japanese, or European equipment manufacturers.

The Evolution of Cellular Technology and the Global Market

First-generation cellular telephony uses analog technology. Analog signals are radio waves that vary in frequency and amplitude. During the late 1980s and early 1990s, analog cellular systems experienced capacity shortages in certain metropolitan areas, reducing transmission quality. Cell-splitting restored service quality in most areas, although concerns remain regarding eventual capacity limits.

To address this problem, and to offer a broader array of services, cellular system manufacturers are developing a new generation of equipment using digital technology. Digital signals consist of a stream of discontinuous pulses that correspond to the digital bits used in computers. In analog transmission, the time gaps between spoken words result in an inefficient use of radio spectrum. In contrast, digital signals from one phone conversation are divided into packets that are transmitted simultaneously with packets from other conversations. Digital packets fill the gaps in conversations with packets from other calls on the same frequency. At the receiving end of the transmission, the system reassembles these packets into the original message. In addition to increasing transmission speed, digital technology protects transmission integrity because digital pulses are more easily regenerated by computers; high transmission integrity allows cellular service providers to offer an expanding array of new data services.

Until cellular system manufacturers deploy digital technology on a large-scale basis, companies such as Ericsson (Sweden), American Telephone and Telegraph (AT&T, United States), Motorola, Inc. (United States), and Northern Telecom Ltd. (Canada),

[4] Cellular industry representatives, interviews by USITC staff, Washington, DC, summer 1992.

[5] Shawn P. Steward, "The World Report '92," *Cellular Business*, May 1992, pp. 20-28.

Table 2-1
Timeline of countries initiating analog cellular service, 1979-92

1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991/92
Japan	(1)	Norway Saudi Arabia Sweden	Denmark Finland Indonesia Spain	United States	Austria Hong Kong	Canada France Ireland Italy Luxembourg Malaysia Netherlands Oman Tunisia United Kingdom	Australia Bahrain Germany Iceland Israel Kuwait South Africa Thailand Turkey Virgin Islands	Belgium Cayman Islands China Dominican Republic Egypt Morocco New Zealand Philippines Switzerland	Bahamas Cyprus Macao Singapore Venezuela Zaire	Algeria Argentina Brunei Chile Costa Rica Curacao Gabon Mauritius Mexico Portugal Sri Lanka Taiwan United Arab Emirates	Brazil Guatemala Hungary Malta Peru	Bolivia Colombia Czecho-slovakia Estonia Greece India Jamaica Kenya Latvia Lithuania Nigeria Pakistan Paraguay Poland Romania Russia Uruguay

[1] No analog cellular systems were initiated this year.

Source: Shawn P. Steward, "The World Report '92," *Cellular Business*, May 1992, and U.S. Department of Commerce, *A Competitive Assessment of the U.S. Cellular Radio-Telephone Industry*, June 1988.

will manufacture systems that use both analog and digital transmission. Some of these systems will be able to convert digital signals into analog signals by using modems that decipher coded digital signals and reconstruct analog waves. Conversely, analog signals can be converted to digital using a method of pulse code modulation that reduces the analog wave to a series of digital codes by sampling the amplitude of the wave at split-second intervals.

Competing Standards

As U.S. systems operators have moved toward constructing digital networks, two competing digital technologies for cellular communications have emerged: time division multiple access (TDMA) and code division multiple access (CDMA). TDMA[6] technology, originally adapted for cellular communications by Ericsson, splits a frequency channel into different time slots, resulting in as much as a six-fold increase in capacity over analog transmission modes. As a result, up to six calls can travel over the same cellular channel formerly used for one call. Hughes Network Systems, a subsidiary of Hughes Aircraft Co. (United States), has developed an extended TDMA (ETDMA) that reportedly increases capacity by up to 17.5 times that of existing analog systems.[7]

Qualcomm Incorporated, a U.S.-based military contractor, proposed a CDMA standard, which uses a spread-spectrum technology that separates call packets and scatters them over a wide range of frequencies. A chip inside the cellular telephone separates and reassembles these packets. This encoding method reportedly boosts analog capacity from 10 to 20 times.

Equipment based on CDMA technology is not yet ready to be deployed commercially, while equipment conforming to the TDMA-based standard is currently viable in the marketplace. The United States' Cellular Telecommunications Industry Association (CTIA) and all large cellular equipment manufacturers endorse the standard derived from TDMA technology. Although CTIA endorses TDMA, it has not ruled out competing alternative technologies. Such technologies as CDMA and narrowband AMPS (NAMPS) are also being explored by the industry.

In the United States, certain cellular service providers are beginning to deploy digital systems based on the TDMA standard. Ericsson will replace analog cellular systems manufactured by AT&T for new digital systems in Seattle, Washington and Portland, Oregon. Southwestern Bell has also issued tenders for digital cellular equipment based on TDMA and is expected to deploy such equipment soon. Motorola, AT&T, and Siemens AG (Germany) are all expected to compete for this contract.

In Japan, the Ministry of Posts and Telecommunications (MPT) also decided to follow the United States and adopt TDMA technology according to specifications similar to those developed in the United States. Two consortia, Digital Phone Group and Tu Ka Cellular Phone Company, have been licensed to provide nationwide digital carphone service using the Japanese digital cellular (JDC) standard.

Together, the United States, Japan, and Canada will represent over 65 percent of the digital cellular market.[8] Industry analysts believe that the development of compatible systems will benefit equipment manufacturers from these three countries and enable them to realize great economies of scale.

A derivative of TDMA technology, but incompatible with the U.S. and Japanese standards, has been implemented in the European global system for mobile communications (GSM) digital network. Government regulators, together with telecommunication authorities (TAs) and equipment manufacturers, developed the GSM standard to replace six incompatible analog standards used by the European Community (EC) and other West European countries.[9] The rationale behind GSM was to create a single market for handsets and network equipment similar to the analog AMPS system in the United States. The GSM systems will be operated by the national TAs and licensed private service providers in each country. The first GSM systems began operating in Finland, Germany, and the United Kingdom in 1992. Ericsson has signed an agreement with the Swiss TA to provide $85 million worth of digital cellular equipment for a GSM network, beginning in 1993 and finishing in 1995. Ericsson and Ascom (Switzerland) provided analog cellular equipment for the Swiss TA's NMT 900 network in 1987. That system had about 170,000 subscribers as of the end of 1991.[10]

Because of an aggressive marketing program undertaken by European firms and governments, countries outside Europe are taking an active interest in the GSM cellular standard. In Asia and the Pacific, the following countries are developing GSM systems: Hong Kong, Singapore, Thailand, India, Australia, and New Zealand. In the Middle East, over a dozen countries are expected to establish GSM networks (see appendix F). European and other cellular equipment manufacturers are increasingly turning their attention to developing these markets.

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[6] Although TDMA is, strictly speaking, a digital cellular transmission technology, the term is commonly used to describe the U.S. digital standard derived from this technology, also known as U.S. digital (USD).

[7] "Dual Mode," *Journal of the Electronics Industry (JEI)*, Aug. 1992.

[8] EGIS, *Digital Cellular Subscriber Equipment in Japan*, Dec. 1990, p. 28.

[9] The EC member states are: Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom.

[10] "Ericsson Helping Switzerland Break Into Digital Cellular," *Radio Communications Report (RCR)*, Dec. 16, 1991, p. 11.

Personal Communications

Though digital technology is only now being deployed in most developed cellular markets, a new technology is already being tested in the United States, Europe, and Japan. This generation of cellular communications will be based on smaller pocket-sized handsets, individual phone numbers (enabling increased mobility), and advanced intelligent network services (INS). By the year 2000, advances in wireless communications technology should enable cellular service providers to compete with the local wireline network.[11]

Personal Communication Network (PCN) systems will consist of a large number of low-power microcell transmitters that increase system capacity by allowing greater frequency re-use. Because PCN systems will use less power, the handsets will be able to run on smaller batteries, which ultimately will reduce the size, weight, and cost of handsets.

Personal Communication Service (PCS) refers to a hybrid service that can be provided over PCNs and the public-switched telephone network. The main concept behind PCS is to provide communication services to individuals rather than to fixed locations. Users will be assigned a telephone number, much like a social security number, enabling an individual to be reached at any location. Eventually, this service will be expanded to include international coverage, as well as cordless and paging services. Internationally, the system will be known as the Universal Mobile Telecommunications System (UMTS).

Industry analysts indicate that the global success of personal communications will depend on the adoption of common standards, early deployment of services on a large-scale basis, allocation of sufficient spectrum, and an affordable price for handsets and services.[12] Industry analysts forecast that the worldwide market for personal communications will account for annual revenues of $50 billion to $60 billion by the year 2000, and the number of subscribers could reach 150 million.[13] The United States is expected to account for most of the world market and should generate annual revenues of $20 billion to $25 billion.[14]

Currently, the U.S. Congress is discussing spectrum allocation for personal communications. The spectrum proposed for personal communications, 1.8 to 2.2 Gigahertz (GHz), is now reserved for fixed microwave users. The deputy administrator of the National Telecommunications and Information Administration has conveyed to Congress the U.S. industry's concern that "if the United States [does] not have service plans, including frequency allocations within the [next] two years, the United States will be playing catch-up with the European and Japanese manufacturers."[15]

[11] Alan Burkitt and Lucia Constanzo, "British and American Companies Invest Heavily in PCS," *Telocator*, Apr. 1992, pp. 18-20.

[12] William C. Y. Lee, "Cellular: An Easy Path to PCS," *Telecom Asia*, Apr. 1992, pp. 11-20.

[13] Ann Taff, "FCC at Juncture in History of PCN Nets," *Network World*, Dec. 16, 1991, p. 24.

[14] Kurt A. Wimmer, "Global Development of Communication Services," *Communications Lawyer*, summer 1992, p. 7.

The U.S. Cellular Communications Industry

When compared to mature U.S. industries, such as the automotive or textile industries, the cellular communications industry is small. While the automotive industry generated revenues of $128 billion and employed 221,000 workers in 1991, the cellular communications industry generated revenues of $8 billion and employed 31,000 workers.

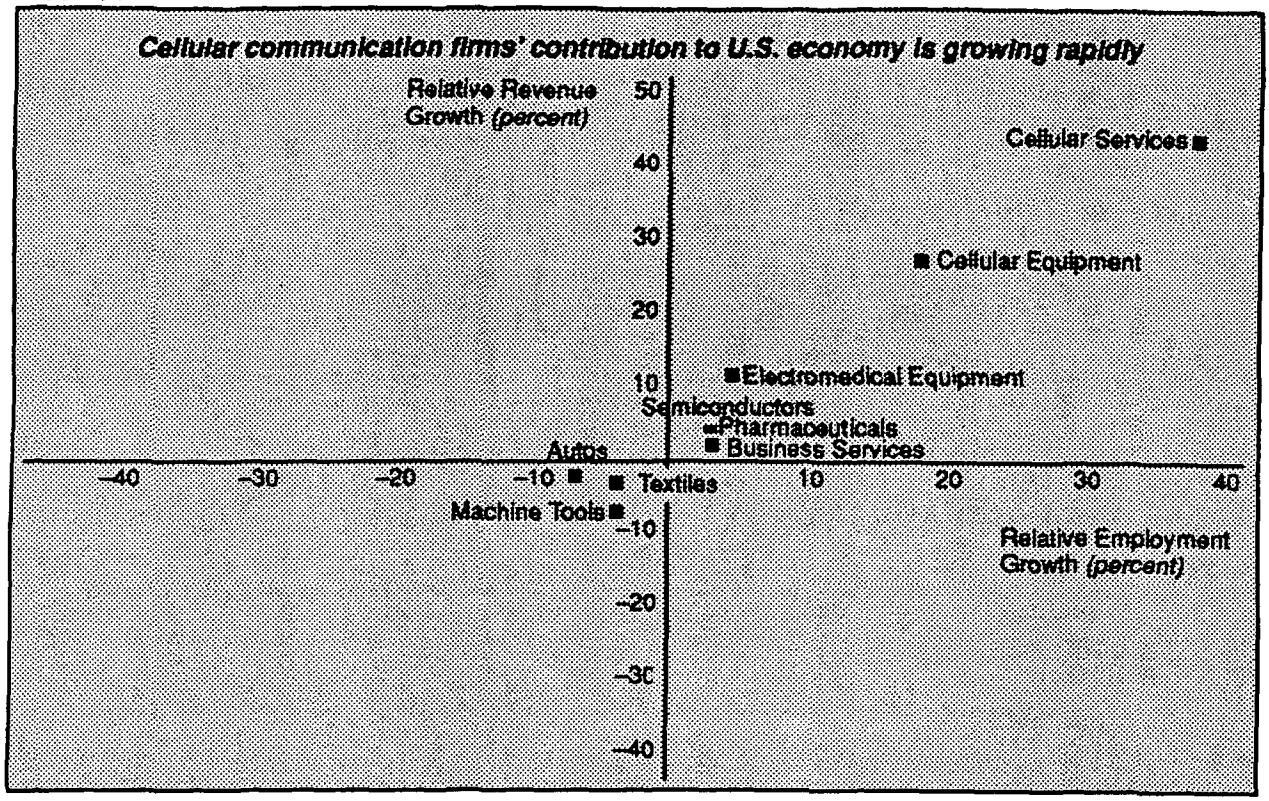
In contrast to such mature industries, however, the U.S. cellular communications industry has experienced rapid growth in recent years. Figure 2-2 shows that during 1987-91, U.S. cellular service providers' average annual revenue growth exceeded average annual GDP growth by 44 percent, and that average annual employment growth among such firms exceeded average annual private sector employment growth by 38 percent. U.S. manufacturers of cellular network equipment and cellular phones also compared favorably during this period; average annual revenue growth exceeded average annual GDP growth by 27 percentage points, while average annual employment growth among these firms exceeded average annual private sector employment growth by 17 percentage points. Perhaps more significantly, growth among U.S. cellular communications firms compared favorably not only to overall economic growth, but also to growth experienced by other rapidly expanding industries, including the electromedical equipment, pharmaceutical, and business services industries. As illustrated in figure 2-3, the 10-year penetration rate of cellular phones exceeds that of projection televisions and telephone answering machines.[16] The 10-year penetration rate of cellular phones is comparable to that of video cassette recorders (VCRs).

The generally favorable competitive position of U.S. cellular communications firms is reflected in figures 2-4, 2-5, and 2-6. Owing largely to the acknowledged expertise of U.S. Bell regional holding companies, U.S. service providers clearly have been the dominant recipients of foreign cellular service license awards, with firms from Sweden and the United Kingdom finishing in distant second and third places, respectively. As shown in figure 2-4, U.S. service providers currently account for 49 percent of all cellular service licenses awarded to foreign firms, whereas Swedish firms and British firms account for 15 and 12 percent, respectively. Figure 2-5 illustrates that in 1990, the aggregate global market share of U.S.

[15] "House and Senate may take separate roads to ET plan," *RCR*, July 27, 1992, p. 9.

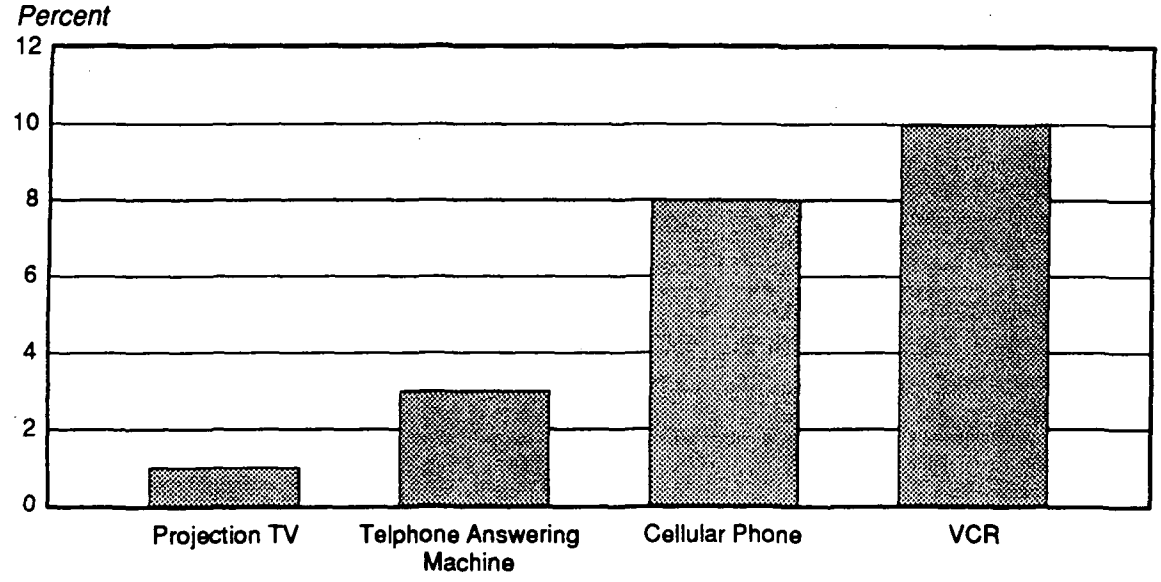
[16] The 10-year penetration rate is the percentage of households with the service or commodity 10 years after its commercial introduction.

Figure 2-2
Recent growth of certain key industries in relation to GDP and private sector employment, 1987-91



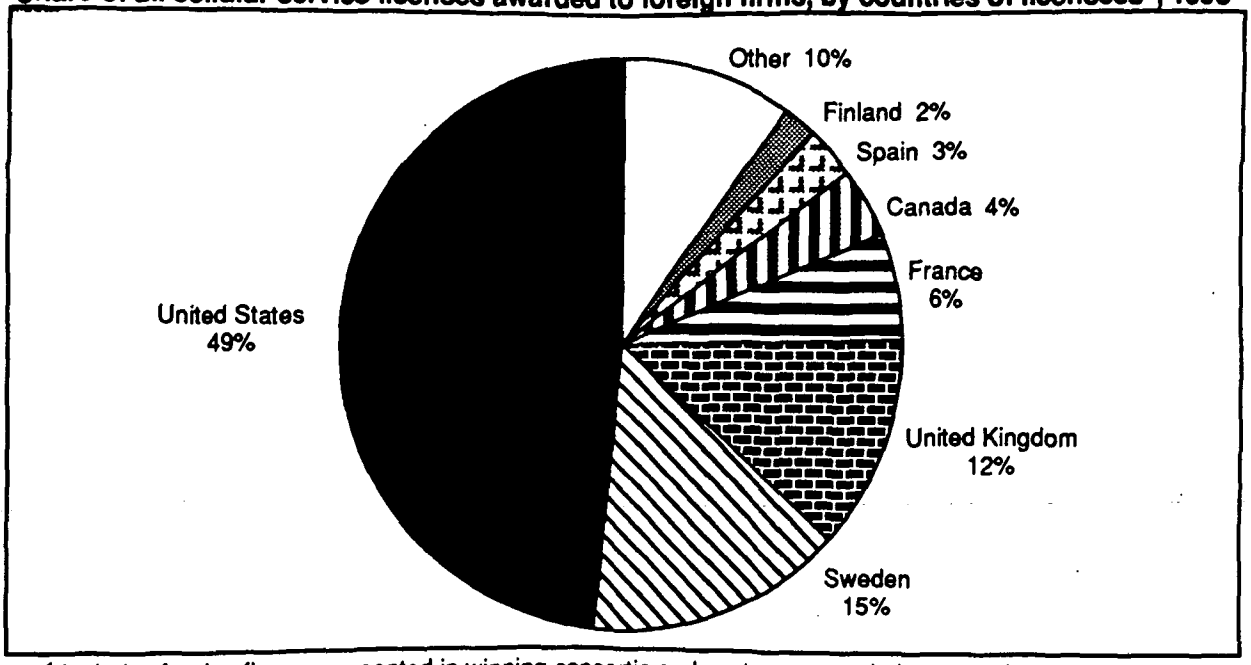
Source: USITC staff and U.S. Department of Commerce, *U.S. Industrial Outlook 1992* and *A Competitive Assessment of the U.S. Cellular Radiotelephone Industry: Partial Statistical Update*, Mar. 1992.

Figure 2-3
U.S. household penetration rates of select consumer electronic products 10 years after their commercial introduction



Source: Electronic Industries Association (EIA) and Cellular Telecommunications Industry Association (CTIA).

Figure 2-4
Share of all cellular service licenses awarded to foreign firms, by countries of licensees[1], 1993

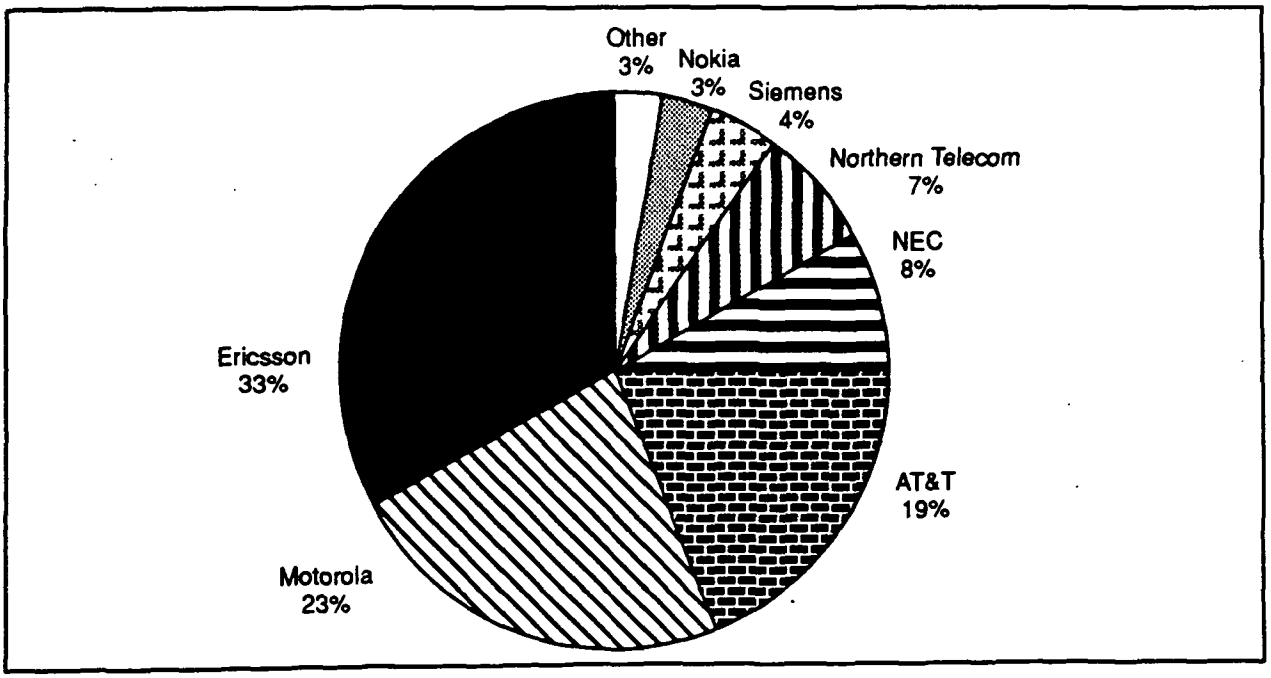


[1] Includes foreign firms represented in winning consortia and contracts awarded to more than one foreign firm.

Note.—Because of rounding, market shares do not add up to 100 percent.

Source: Pyramid Research and various issues of *Telephony, Radio Communications Report, Global Finance, Communications Week International, Mobile Phone News, FCC Report, Communications Daily,* and *Cellular Business.*

Figure 2-5
Global market share of leading cellular network equipment manufacturers, by number of subscribers, 1990



Note.—U.S. firms' market shares prorated, based on contracts awarded in the 20 largest Metropolitan Statistical Areas (MSAs).

Source: Estimated by USITC staff.

cellular network equipment manufacturers, mainly Motorola and AT&T, exceeded 40 percent. Ericsson accounted for the largest individual market share, whereas NEC Corporation (Japan), Northern Telecom, Siemens AG (Germany) and Nokia Corporation (Finland) each accounted for significantly smaller shares. As illustrated in figure 2-6, Motorola dominates the global cellular phone market, with a 23 percent market share. Japanese firms account for all other top shares, excepting that held by Nokia.

Regulatory Implications

Although technological innovations have recently diminished governments' ability and desire to regulate the industry, the telecommunication service industry remains highly regulated. Government regulation initially stemmed from the perception that telecommunication is a public good, offering economic and social benefits to the public beyond those delivered directly to individual consumers. In addition, governments regulated service providers because they believed that telecommunication service was a natural monopoly. Government regulation has been designed to maximize direct and indirect benefits, usually by requiring or promoting universal coverage, high service quality, and affordable prices.

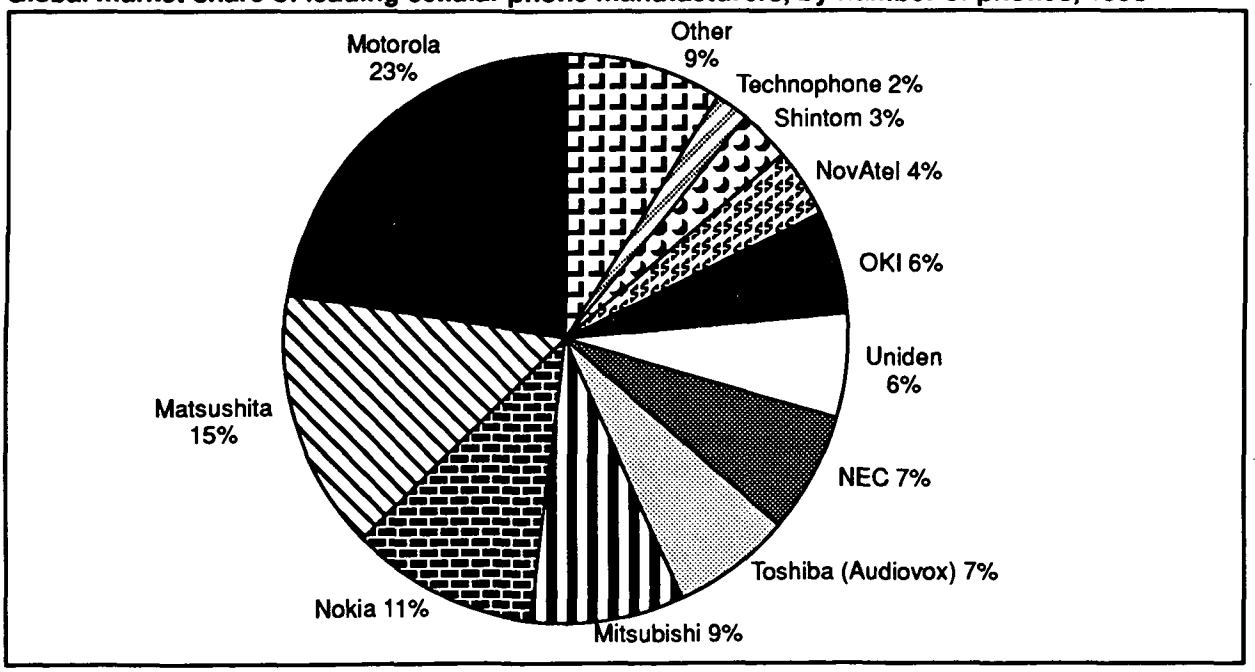
However, the availability of new communication technologies, such as microwave transmission and cellular communication, has led many governments, including that of the United States, to modify regulatory frameworks. In the United States, for example, developments in microwave transmission technology led to the introduction of competition in the long-distance telecommunication market. Competitive service provision is deemed preferable to monopoly service provision to the extent that it is expected to increase service quality and reduce prices.

Other technologies created regulatory dilemmas by blurring the distinction between computer-based information services, historically provided on a competitive basis, and network-based telecommunication services, traditionally provided by monopolies. In the European Community, regulators resolved this dilemma by reserving basic voice telephony for traditional monopoly service providers, and all other services for competing firms.[17] By 1990, telecommunication service markets in the United States, Japan, and in most European countries featured at least limited competition.

The development of cellular communication technology has led governments to another reassessment of telecommunication regulation, resulting in competitive provision of services once reserved for monopolies. In the United States and Japan, competition has been introduced in the local service market as two or more cellular service licenses have been granted for each service area. In the same manner, competition has been introduced in some of the European markets for voice telephony.

[17] European Commission, *Commission Directive on the Competition in the Markets for Telecommunications Services*, 90/388/EEC, *Official Journal of the European Communities (OJ)*, No L 192, (July 24, 1990), p. 10.

Figure 2-6
Global market share of leading cellular phone manufacturers, by number of phones, 1990



Note.—Because of rounding, market shares do not add up to 100 percent.

Source: Estimated by USITC staff.

In addition to continuing the trend toward more competition in many telecommunication markets, cellular communications development has raised other regulatory issues. Some regulations, such as those pertaining to network interconnection and standards-setting, were brought to the fore when competition was introduced to wireline networks. However, certain others, such as spectrum allocation, are more specific to cellular communications. Treatment of these and other regulatory issues has created an exceptionally fluid regulatory environment, calling for a fuller discussion of key regulatory issues. Such a discussion is provided in chapter 4.

CHAPTER 3
Competition in the Cellular Communications Industry

Introduction

This chapter briefly discusses the nature of competition in the cellular communications industry. It first presents the analytic framework employed by the ITC to assess competitiveness. Thereafter, the chapter examines the nature of competition in each industry sector. These discussions draw on both a comprehensive literature search and extensive industry interviews conducted in the United States, Europe, and the Far East.

The Competitive Assessment Framework

The overall ITC framework for assessing competitiveness in the cellular communications industry is presented in figure 3-1. The ITC

Figure 3-1
Competitive assessment framework for cellular communications industry

Firms...	*compete for...*	*In terms of...*	*Influenced by...*
Cellular service providers	Foreign cellular service licenses	❑ Cost management skills ❑ Technical skills ❑ Marketing skills ❑ Financial resources	❑ Home market experience ❑ Government policy
Cellular network equipment manufacturers	Foreign systems contracts	❑ Technical capabilities ❑ Service ❑ Price	❑ Radio research, development, and manufacturing experience ❑ Wireline switch manufacturing and marketing experience ❑ Strategic alliances
Cellular phone manufacturers	Global market share	❑ Price ❑ Design features ❑ Talk time ❑ Size and weight	❑ Radio manufacturing experience ❑ Integrated circuit core competency ❑ Advanced manufacturing techniques

Source: USITC staff.

framework does not seek to measure overall competitiveness in the cellular communications industry. The framework rather provides for separate and distinct discussions of competition among cellular service providers, cellular network equipment manufacturers, and cellular phone manufacturers. Separate discussions of each of these sectors are warranted since industry interviews and industry literature have indicated that the nature of international competition in the cellular communications industry varies widely by sector.

For each industry sector, the ITC framework identifies the most suitable indicator of global competitiveness, the terms of international competition, and the principal factors that influence firms' ability to compete. This chapter principally focusses on indicators of competitiveness and the terms of international competition, as identified in over 70 interviews with cellular communications firms, industry associations, research organizations, and government and quasi-government agencies. Chapter 4 focuses in great detail on government policies and their influence on firms' competitiveness. Chapter 5 focuses on actions taken by firms themselves. The discussion in chapter 5 has both qualitative and quantitative aspects; econometric analysis has been performed to assess the statistical significance of certain factors highlighted in the qualitative discussion.

Competition Among Cellular Service Providers

The Assessment of Competitiveness

When assessing the global competitiveness of cellular service providers, Commission staff has focussed on the foreign cellular service licenses awarded to each firm. It does not appear that licenses awarded to firms in their home countries are an accurate indicator of competitiveness because many governments, as a matter of policy, have awarded at least one cellular service license to traditional wireline service providers. These licenses have not been awarded to domestic service providers as a result of competitive ability.

The Terms of Competition

This discussion examines the terms in which cellular service providers compete for foreign cellular service licenses and the effects of home market structure on firms' competitive posture. Interviews with 25 cellular service providers in the United States, Europe, and the Far East suggest that these firms compete for foreign license awards principally in terms of technical, marketing, and cost management expertise. These skills are developed by firms in response to competitive pressures in the home market, which is greatly influenced by government regulation. Government determinations regarding the number of cellular service providers, spectrum allocation, and licensing procedures have a significant impact on the domestic competitive environment and the specific skills developed by firms. These skills enhance service providers' ability to compete in the international market.[1]

Cost management skills

Cost management skills are developed in response to price competition in the home market. Cellular service providers that have experienced the most intense price competition in the home market appear to be the best prepared to compete in terms of cost management skills.[2] For cellular service providers, principal costs include infrastructure equipment expenditures, operating expenses, cell-site maintenance costs, and marketing costs. In recent years, cellular service providers reportedly have focused on reducing marketing costs, the single-largest variable cost, to enhance their domestic competitive positions.[3] To a lesser extent, cellular service providers also have relied on technological innovation and managerial expertise to reduce costs.

To identify those firms that have superior cost management skills, one must identify firms that have competed most intensely in terms of price in the home market. Although the lack of comprehensive data renders a full examination of the intensity of price competition impossible, there are indications that intense price competition occurs between cellular service providers in the United States and the United Kingdom.[4] A study issued by the U.S. General Accounting Office (GAO) finds that the prices[5] charged by cellular service providers in the 30 largest U.S. cellular markets tend to be fairly uniform, with price differentials of less than 10 percent in two-thirds

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[1] The terms of competition to win foreign license awards differ from the terms of competition among license holders. Subject to government regulation, cellular service license holders typically compete in terms of price, geographic coverage, mobility, call features, and call quality. Firms competing for foreign license awards most commonly compete in terms of cost management, technical, and marketing skills.

[2] U.S. industry representatives, interviews with USITC staff, Washington, DC and New York, NY, spring-summer 1992. For a broader discussion of this theme, see Michael Porter, *The Competitive Advantage of Nations* (New York: The Free Press, 1990).

[3] Industry analyst, interview with USITC staff, New York, NY, May 6, 1992.

[4] European industry representatives, interviews with USITC staff, London and Stockholm, Sept. 22-29, 1992; and *Mobile Communications*, July 18, 1991.

[5] The prices analyzed by the GAO were carriers' best prices for the purchase of 150 minutes of airtime by a single consumer in which 80 percent of the calls were made during peak hours, and the average length of a call was 2.5 minutes. GAO, *Telecommunications: Concerns About Competition in the Cellular Telephone Industry*, July 1992, p. 23.

of these markets.[6] In the 30 largest U.S. cellular service markets, the price of cellular service fell by 27 percent in real terms during 1987-91.[7] The existence of broadly similar and falling prices, coupled with the knowledge that costs in large markets may not be falling,[8] indicates that U.S. cellular service providers are competing in terms of price (figure 3-2).

In contrast, price competition appears to be less intense in certain other countries. In Japan, Nippon Telephone and Telegraph Corporation (NTT) effectively had a monopoly in cellular service provision until December 1988, when Daini Denden Inc. (DDI) and Nippon Idou Tsushin Corporation (IDO) began to offer service. Upon entering the market, DDI and IDO undercut NTT's basic fee of ¥18,000 by offering subscribers basic fees of ¥13,000. NTT followed by reducing its basic fee, but only to ¥15,000. Since then, DDI and IDO have reduced fees to ¥11,000, and NTT has reduced fees to ¥13,000. Although recent interviews with Japanese industry representatives have indicated that NTT will further reduce prices in the near future, it may be some time before NTT is driven to match or undercut the prices charged by its competitors.[9]

Because firms in the United States have had to compete in terms of price, they are believed to have developed superior cost management skills. Superior cost management techniques enhance firms' international competitiveness by helping firms find foreign partners, many of whom have little or no experience in managing the costs associated with communication networks. Furthermore, consortia that are able to draw on the cost management skills of U.S. firms are more likely to win foreign cellular service licenses since licensing agencies typically require that firms submit business plans that identify how cellular service prices will be reduced over time.

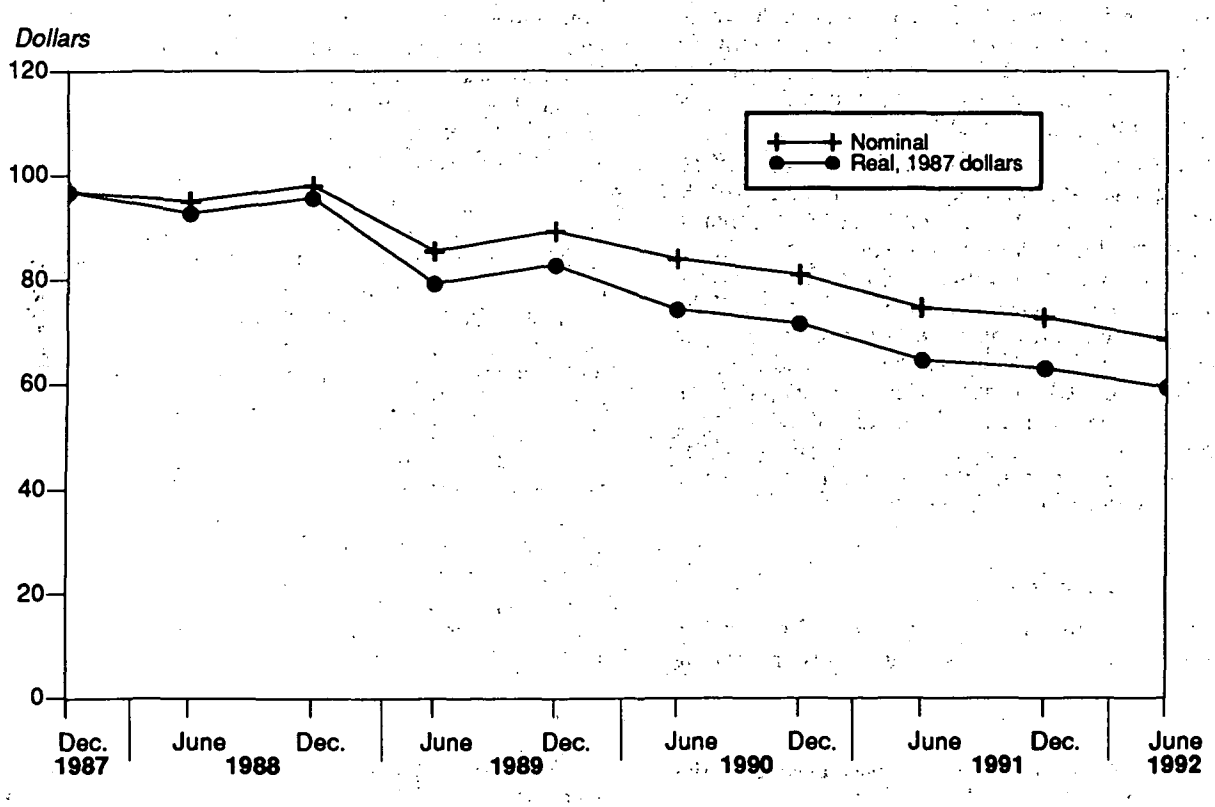
[6] In the smaller U.S. cellular markets, the prices charged by competing firms often varied by more than 10 percent, apparently due to differences in the prices of special packages tailored to the needs of different types of cellular users. GAO, *Concerns About Competition in the Cellular Telephone Industry*, pp. 22-25.

[7] Ibid., p. 19.

[8] Short-run average costs may not be falling because many cellular service providers that are adding customers have been required to employ an expensive technique known as cell-splitting. Depending on the number of customers added, cell-splitting may actually increase average costs during the short run. U.S. cellular service industry representatives, interview with USITC staff, Washington, DC, spring-summer, 1992; and GAO, *Concerns About Competition in the Cellular Telephone Industry*, p. 24.

[9] Japanese industry representatives, interviews with USITC staff, Tokyo, Sept. 28-Oct. 2, 1992.

Figure 3-2
U.S. cellular subscribers' average monthly bill,[1] Dec. 1987-June 1992



[1] Average monthly bill is a function of both usage and price of service.

Source: Cellular Telecommunications Industry Association.

Technical skills

Firms that have been encouraged by government policies or market forces to compete in terms of caller mobility, call quality, and call features in the home market are believed to develop superior technical skills, such as network configuration and software-writing skills. Firms with superior technical skills find it easier to penetrate foreign markets since these skills are highly coveted by foreign governments and by potential joint venture partners.

Network configuration expertise

Firms that compete in terms of caller mobility and call quality in the home market develop superior network configuration skills. Firms' ability to facilitate subscribers' use of their cellular phones outside their local service area has influenced competition in a number of markets. In Japan, for example, the Ministry of Posts and Telecommunications granted NTT a nationwide license whereas its competitors, IDO and DDI, received licenses to compete with NTT either in the Tokyo area or outside Tokyo, respectively. Mobility is important in the Japanese cellular market, where a significant percentage of the population works but does not reside in the Tokyo area.[10] As a result of Japan's licensing arrangement, NTT was accorded a short-term competitive advantage in Japan since the firm was able to provide its subscribers with greater mobility. Insofar as the policy provided incentives for IDO and DDI to engineer interfaces between their systems, however, the global competitiveness of these firms may be enhanced. In October 1991, IDO and DDI signed an agreement to provide roaming service to both systems' subscribers throughout Japan.[11]

In a similar way, the Hong Kong Post Office, which regulates telecommunications in that country, has encouraged Hong Kong firms to develop technical skills that facilitate subscriber mobility and enhance call quality. Given that many Hong Kong cellular subscribers have business interests in China, cellular service providers must offer cross-border roaming to compete in the Hong Kong market. In addition, the Hong Kong Post Office has placed great emphasis on cellular network quality. To retain their existing spectrum, cellular service providers in Hong Kong must adhere to strict schedules for the transition from analog to digital cellular networks.[12]

Software expertise

Firms that compete in terms of call features[13] in the home market develop superior software-writing skills. U.S. cellular subscribers' demand for advanced call features is stronger than that of subscribers in Europe and Japan, perhaps because of the wider availability of such services over the United States' traditional wireline network.[14] This demand has motivated U.S. cellular service providers, initially competing against one another in the home market, to develop superior software-writing skills, enhancing their ability to compete in the global market. In particular, U.S. firms' software-writing skills have facilitated penetration of the European market, where firms will begin to compete in terms of call features with the deployment of GSM systems.[15]

Marketing expertise

Effective marketing skills have also helped U.S. and British firms penetrate foreign cellular service markets. Monopoly service providers, and potential joint venture partners without relevant marketing experience, reportedly value the marketing expertise of U.S. and British firms. Cellular service providers in the United States and the United Kingdom have successfully sold cellular communications as a viable complement to existing wireline communications. In addition, U.S. and British cellular service providers have been the first firms to focus marketing efforts on residential, rather than business, users. Early marketing efforts were targeted at business users, who value mobile communications as a means of increasing productivity, but more recent marketing efforts have been aimed at residential users, who are more likely to value the convenience of cellular communications. Business users reportedly place emphasis on the availability of advanced call features, whereas residential users are more likely to make decisions on the basis of price alone.

As competition has been introduced to cellular service markets outside the United States and the United Kingdom, firms' marketing skills and the ability to control marketing costs have become more important, particularly in Continental Europe. Once GSM is fully operational, European cellular operators will compete with one another in terms of price, call features, mobility, and quality, with differences among firms' service likely disappearing over time. As a result, each European firm's ability to persuade potential subscribers to choose that particular firm rather than its competitors will be nearly as important as the ability to provide competitively priced, attractive cellular services. One industry representative asserted that competition among operators in Europe will depend less on call features themselves than on the way they are marketed.[16]

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[10] Ibid.

[11] Ibid.

[12] Hong Kong industry representatives, interviews with USITC staff, Hong Kong, Oct. 7-9, 1992.

[13] Popular call features are voice mail, call waiting, call forwarding, information services, and data transmission.

[14] U.S. industry representatives, interview with USITC staff, Washington, DC, Aug. 19, 1992.

[15] U.S. industry representatives and analysts, interviews with USITC staff, London and Germany, Sept. 22-Oct. 5, 1992.

[16] U.S industry representative, interview with USITC staff, Germany, Oct. 5, 1992.

Other factors

Industry representatives have identified financial resources, government support, and sensitivity to foreign cultures and business practices as important when competing in world markets. Financial resources appear to be the most important of these, especially in emerging cellular markets. The initial cost of constructing cellular networks is at least $1,000 per subscriber,[17] and certain countries have added to this cost by conducting auctions for cellular service licenses. The relative importance of financial resources, government support, and cultural sensitivity vary by region, but in nearly all cases such considerations are secondary to the experience and expertise that cellular service providers can offer to potential partners and foreign licensing authorities.

Competition Among Cellular Network Equipment Manufacturers

The Assessment of Competitiveness

Commission staff has measured the competitiveness of network equipment manufacturers by the number of foreign systems contracts that they have been awarded. Systems contracts awarded to firms in the home country are not always an accurate indicator of competitiveness since cellular service providers largely awarded initial cellular systems contracts to domestic firms, relying on domestic technologies and domestic technical standards. In addition, it has been the strategy of certain state-owned service providers to favor domestic firms as suppliers of cellular network equipment. Focussing on foreign systems contracts eliminates the biases introduced by these practices.

The Terms of Competition

Eleven cellular network equipment manufacturers[18] in the United States, Europe, and the Far East, accounting for over 90 percent of foreign analog and digital systems contracts, agree that these firms compete for systems contracts principally in terms of the technical capabilities of their equipment, after-sales service, and price (figure 3-1). The competitive position of firms is most significantly influenced by radio research, development, and manufacturing experience; wireline switch manufacturing and marketing experience; and strategic corporate alliances. In addition to reducing research costs and enhancing marketing efforts, strategic alliances have been used by network equipment manufacturers to compensate for deficiencies in radio or switch manufacturing experience.

Cellular service providers in the United States, Japan, and Europe generally employ a two-step process to evaluate cellular network equipment components or systems bids. Service providers first assess technical capability. During this stage, systems suppliers' equipment must satisfy certain minimum technical requirements specified by service providers, the most basic of which is conformity to selected analog or digital standards.[19] A U.S. industry representative explained that "minimum technical requirements must be met consistently if a vendor is to stay in the business [of selling cellular network systems]."[20] A Japanese cellular service provider presented a similar view regarding the primacy of technical capabilities:

> Network equipment vendors must offer network equipment components or systems that ... satisfy minimum technical standards that the Japanese carriers have set. In fact, cellular network equipment components must meet minimum technical standards before the carrier's buying agents will consider the price of cellular network equipment.[21]

If the network equipment is adequate for their needs, service providers compare after-sales service and proposed price.

Technical capabilities

The technical capabilities of switches and cell site equipment are assessed differently and, so, are discussed separately. Specific technical capabilities of each are listed in figure 3-3.

Switches

When purchasing switches, service providers focus on call capacity, processing efficiency, and software-based functions. Call capacity is the number of calls a switch can process simultaneously. Call data processing is a measure of how efficiently a switch can connect inbound and outbound calls to the wireline network and other cellular switches. Software-based functions support advanced call features, automated billing systems, and databases.

Experience in manufacturing and marketing wireline switches appears to enhance significantly the

[17] Coopers and Lybrand, *Technological Change and the Cellular Telecommunications Industry*, Nov. 1991, p. 33.

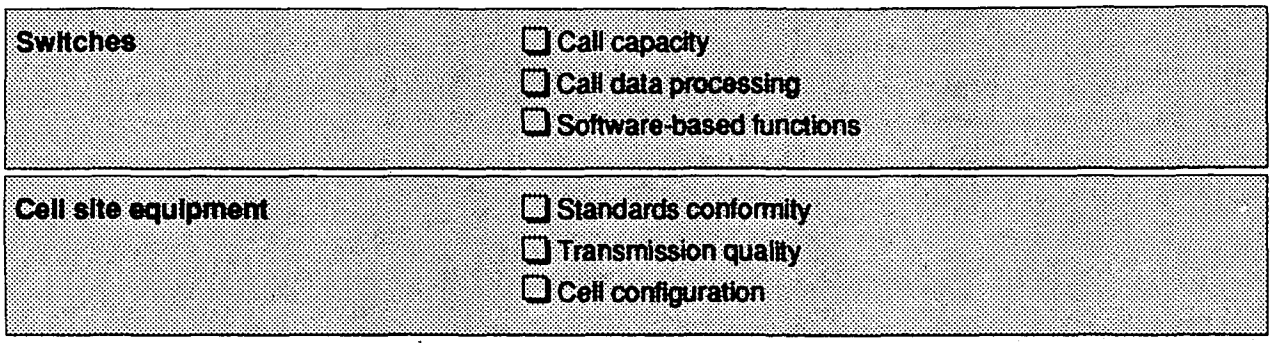
[18] See appendix C for a list of the firms interviewed by Commission staff.

[19] Commonly, vendors attempt to influence the development of a proposal through technical consultations with the carrier to create requirements that favor their equipment.

[20] U.S. industry representatives, telephone interview with USITC staff, Washington, DC, Sept. 9, 1992.

[21] Japanese industry representatives, interviews with USITC staff, Tokyo, Sept. 28-Oct. 2, 1992.

Figure 3-3
Technical criteria for cellular network equipment



Source: USITC staff.

competitiveness of cellular network equipment manufacturers. Such experience reportedly reduces the cost of research and development programs, which may run into billions of dollars per company. Previously developed expertise in designing and manufacturing wireline switches and software is reportedly transferrable to the design and manufacture of switches for cellular networks. Previous experience in marketing wireline switches also enhances firms' competitiveness to the extent that it has fostered favorable relationships with cellular service providers.

Switch Capacity

System configurations vary widely across operators, depending on terrain and demography. Centralized configurations, which require large capacity switches, are generally used in densely populated urban settings. Decentralized configurations, employing smaller switches, are used in rural settings. Large capacity switches serve from 70,000 to over 100,000 subscribers,[22] whereas small capacity switches serve between 10,000 and 30,000 subscribers.[23]

Switch capacity is important because it affects reliability. Switches process information less quickly and with more failure incidents when the number of processed calls and the amount of related information approach the switch's capacity. Therefore, it is important that a switch's capacity exceeds the number of simultaneous calls an operator expects; without this call capacity safety margin, the switch may suffer unacceptable rates of dropped calls and data losses.[24] To maintain customer satisfaction and lower maintenance costs, one U.S. cellular carrier reports that it routinely purchases switches with call capacities that exceed projected needs by at least 13 to 15 percent.[25]

Call Data Processing

Operators also look for switches that process data on local and roaming calls efficiently. Local call data is the electronic information a switch requires to direct signals to cellular phones and the wireline public network, and to maintain local billing information. Roaming call data is required to identify roamers, direct inter-switch communications, and provide inter-carrier billing.

Some industry participants report, for instance, that switches that possess Signalling System 7 switching capabilities are very efficient at processing call data.[26] Signalling System 7 is a digital switching protocol that transmits call data separately from the voice conversation data. This separation enables switches to exchange call data rapidly without slowing the transmission of voice conversation data.[27] Signalling System 7 also enables switches to connect with remote data bases,[28] transmits billing information to multiple cellular service providers, improves the speed and ease of processing roaming call data,[29] and provides for automatic inter-system hand-offs.

Software-Based Functions

When purchasing switches, cellular service providers also consider software-based functions that support advanced call features such as call waiting, call

[22] U.S. industry representatives, interview with USITC staff, Washington, DC, July 27, 1992; telephone interview, Sept. 9, 1992.

[23] U.S. industry representatives, interview with USITC staff, Washington, DC, July 27, 1992; telephone interview, Dec. 10, 1992.

[24] U.S. industry representatives, interviews with USITC staff, Washington, DC, Aug. 8, 1992.

[25] U.S. industry representatives, telephone interviews with USITC staff, Washington, DC, July 27 and Aug. 14, 1992.

[26] U.S. industry representatives, interviews with USITC staff, Washington, DC, Aug. 14 and 19, 1992.

[27] "AT&T Takes SS7 Right to Customers", *Telephony*, June 15, 1992, p. 68.

[28] Harry Newton, *Newton's Telecom Dictionary*, p. 426.

[29] Jan Wareby, "Intelligent Signalling: FAR & SS7," *Cellular Business*, July 1990, p. 60.

forwarding, and conference calling.[30] As mentioned previously, such functions are reportedly more important to U.S. firms than to foreign firms.[31] In the United States, cellular service providers commonly require advanced software-based features to meet their subscriber's expectations.[32] To date, Japanese and European service providers have generally downplayed the significance of software-based functions.

Foreign interest in software-based functions, however, is slowly growing. One Japanese service provider recently purchased a U.S.-manufactured cellular switch that provides software-based functions,[33] an action which may encourage other Japanese service providers to do the same. The European GSM standard includes specifications for software-based functions, indicating that European interest in software-based functions is increasing. Certain European producers are responding to this latent interest; Sema Group (France/United Kingdom), for example, is reportedly developing software-based functions such as electronic voice mail for GSM networks.[34]

In both wireline and cellular telephone systems, specialized functions are supported by software that is installed at the main switch and at related call processing points. Overall, a cellular switch's basic software design is very similar to a wireline central office switch, creating a natural competitive advantage for such manufacturers as AT&T and Ericsson that have long-standing wireline switch-manufacturing experience.

Cell Site Equipment

To be competitive, manufacturers of cell site equipment must first be able and willing to adapt cell site equipment to the standards specified by cellular service providers. This ability and willingness determines the number of contracts for which firms may bid. Experience in reconfiguring existing radio equipment for overseas markets reportedly enhances firms' ability to reconfigure cell site equipment for new technical standards.[35]

Beyond this, cell site equipment manufacturers compete principally in terms of transmission quality, which is partly a function of cell configuration. To increase network capacity, manufacturers of cell site equipment are increasingly called on to help service providers engineer "microcells" and still smaller "pico cells."[36] These smaller cell configurations increase network capacity by allowing more frequent reuse of radio channels; microcellular architecture is becoming increasingly important in congested, urban areas with high cellular subscribership.[37] Manufacturers' abilities to help cellular operators configure microcells and pico cells will help them compete as personal communication networks are developed since these configurations will enable personal communication subscribers to better transmit and receive phone calls using small, low powered portable phones.[38]

Research and development programs markedly influence the competitiveness of cell site manufacturers. Industry representatives indicate that key research programs currently focus on developing personal communications. These programs examine air protocols to reduce the amount of electricity consumed by transmissions between base stations and cellular phones, thus allowing phones to become smaller. Research programs also focus on software design, to provide more call features, and on equipment miniaturization, to facilitate the installation of more base stations.

After-sales service

Cellular service providers in the United States, Europe, and Japan have indicated that they assess manufacturers' after-sales service records based on the speed and quality of equipment repairs and software upgrades. Network equipment manufacturers that supply both cellular switches and cell site equipment reportedly have an advantage in these terms as they provide faster and more comprehensive service.

Cellular service providers also attempt to evaluate manufacturers' future commitment and ability to provide high quality service by assessing the size and direction of current research and development. Carriers indicate that they are looking for firms that are actively pursuing digital transmission technologies and open systems architecture.[39] Over time, the construction of open systems may reduce the service advantage presently enjoyed by producers of both cellular switches and radio base station equipment.

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[30] Such functions are commonly packaged as part of an advanced intelligent network, which can be developed as part of an SS7 switch or as an independent software application stored within a switch.

[31] U.S. industry representatives, interview with USITC staff, Libertyville, IL, Dec. 4, 1992; Japanese industry representatives, interviews with USITC staff, Tokyo, Sept. 28-Oct. 2, 1992.

[32] U.S. cellular subscribers generally expect their cellular operators to provide services that are similar to wireline network services. Thus, U.S. subscribers expect software-based functions.

[33] Japanese industry representatives, interviews with USITC staff, Tokyo, Sept. 28-Oct. 2, 1992.

[34] "Telephones Lose Strings," *Financial Times*, Sept. 8, 1992.

[35] U.S. industry representatives, interview with USITC staff, Libertyville, IL, Dec. 4, 1992.

[36] Microcells and pico cells cover smaller broadcast areas than normal cell sites.

[37] Hong Kong industry representatives, interviews with USITC staff, Hong Kong, Oct. 7-9, 1992.

[38] Elsevier Advanced Technology, *Profile of European Mobile Communications Industry - Market Prospects to 1996*, p. 47.

[39] U.S. industry representatives, interview with USITC staff, spring-summer 1992; Japanese industry representatives, Tokyo, Sept. 28-Oct. 2, 1992.

Price

Because cellular network equipment is routinely sold to cellular service providers through confidential bidding processes and because switches and cell site equipment are usually sold in packages, it is difficult to discern actual prices of cellular network equipment. Furthermore, some service providers purchase systems on a turnkey basis, including installation, management, and after-sales service, whereas others install the equipment themselves.[40] Financing terms, too, may significantly affect the ultimate price of cellular systems.[41]

With the advent of open systems architecture, it is likely that radio base station manufacturers, in particular, ultimately will find it necessary to compete on price. As a result, cost management skills will become more important. Strategic alliances, wherein firms undertake cooperative research programs and cross-license patented processes and products, will help manufacturers control research and development costs. Strategic alliances will become increasingly important as expanded research programs and investment in new manufacturing facilities place greater financial demands on cell site equipment manufacturers.

Competition Among Cellular Phone Manufacturers

The Assessment of Competitiveness

When assessing the competitiveness of cellular phone manufacturers, Commission staff has focussed on firms' global market share. In contrast to international competition among cellular service providers and network equipment manufacturers, it does not appear that government policies or practices significantly affect the competitive position of these firms.

The Terms of Competition

Interviews with eight predominant cellular phone manufacturers in the United States, Europe, and the Far East suggest that these firms principally compete for global market share in terms of price, design features,[42] talk time, size, and weight, although the last three concerns are important only for portable phones (figure 3-1).[43] The cellular phone market increasingly resembles other consumer electronic markets in the sense that the technology necessary to manufacture cellular phones has diffused widely, reducing differences in product quality[44] offered by the industry's predominant firms. Skills that appear to enhance firms' ability to compete in the global market include radio manufacturing experience, integrated circuit core competency, and advanced manufacturing techniques.

Price

Manufacturers of carphones and transportable phones currently compete almost solely in terms of price, primarily because the quality and design of these phones differ little. The emphasis on price competition has been recently reinforced by the increased use of cellular phones among non-business or residential users. Residential users' demand for cellular phones is much more elastic, or price-sensitive, than that of business users. In addition, carphones and transportable phones have the greatest use in the United States and the United Kingdom,[45] where consumers typically tend to emphasize price as a purchasing criterion.

Spurred by consumers' emphasis on price, and aided by increasing economies of scale, phone manufacturers have reduced carphone and transportable phone prices in the U.S. market dramatically since 1987. Carphone prices have tended to remain relatively high in continental Europe owing to lesser economies of scale in countries using phones designed for unique analog standards.

Until recently, portable phone users have tended to emphasize terms other than price when making purchases. Typically, portable phone users display more willingness to pay higher prices in return for greater mobility and smaller or lighter phones. Nonetheless, even portable phone prices have dropped significantly in recent years as the quality, design features, talk-time, and size and weight of phones manufactured by various firms have become more comparable. The average price of portable phones in the U.S. market fell from $2,200 in 1987 to $650 in 1991.[46] Portable phone prices remained high in continental European countries, principally due to far lower economies of scale.

Aiding manufacturers' efforts to reduce prices and control costs are automated manufacturing techniques

[40] Turnkey systems are designed, produced, installed, and tested by the manufacturer for the purchaser.

[41] Firms typically provide favorable financing terms only in developing countries. Such terms may include delayed payment, below market interest rates, and network manufacturers' agreement to purchase existing equipment at book value.

[42] Design features include alphanumeric memory, speed dialing, electronic locks, and equipment attachments.

[43] These firms account for over 70 percent of cellular phone sales in the United States, Europe, and Japan. See appendix C for a list of firms interviewed by Commission staff.

[44] Cellular phone manufacturers define product quality in terms of transmission clarity, durability, and reliability.

[45] Estimated sales figures are based on subscriber and sales estimates made by Herschel Shosteck Associates, Shearson Lehman Brothers, Nokia, and Japanese industry sources.

[46] Herschel Shosteck Associates, *The Retail Market of Cellular Telephones*, Dec. 1991, figs. 8.8 and 12.2.

that enhance the efficiency of production lines, save labor, and reduce waste. In particular, interviews with the industry's largest cellular phone manufacturers indicate that automated quality control programs have been particularly effective in reducing waste by identifying and resolving problems with phone components before they reach phone production lines.

Design features

U.S. cellular phone buyers tend to value advanced design features more than their foreign counterparts, although it is reported that design features influence the purchasing patterns of business users and residential users differently. According to industry representatives, such convenience features as speed-dialing, link-dialing, one-touch dialing, alphanumeric memory, and hands-free microphones significantly influence choices made by business users, who are likely to perceive cellular phones as productivity enhancers while away from the office.[47] Design features affect the preferences of residential users only to a modest degree. Residential users, who usually have carphones rather than portable phones, and who are likely to use their cellular phones less often than business users, are more concerned with price than with advanced design features.

The influence of design features on business users' cellular phone selection has decreased slightly over time because the features of different phone brands have become very similar.[48] Although many manufacturers have attempted to distinguish their product by adding new features, competitors have rapidly been able to duplicate features that have been successful in the marketplace.[49] In 1992, roughly 90 percent of carphones offered comparable features.[50]

The convergence of design features has also occurred with transportable and portable phones. For instance, when the NEC 9000 was introduced to the U.S. market in 1987, its immediate success was largely due to the availability of a transmission booster.[51] Transmission boosters adapt portable phones to in-car use, making them more versatile. Soon after the introduction of the NEC 9000, however, other manufacturers added transmission boosters as standard options.[52] By 1992, most portable phones included transmission boosters as an option.

The introduction and replication of new design features require a core competency in integrated circuit design. These circuits process all the data introduced to the phone by the radio base station on one end and by the user on the other. Core competency in integrated circuit design will continue to exert a strong influence on the competitive position of cellular phone manufacturers as these firms begin producing phones for digital standards. Phones interpreting digital signals will require much more memory than phones interfacing with analog networks. GSM phones, for instance, will require 15 times the memory capacity of current analog phones.

Size and weight

Portable phones also compete in terms of size and weight. Demand for smaller and lighter phones is driven by users' desire for increased portability.[53] In response to the demand for such phones, manufacturers have designed significantly smaller and lighter portable phones. Motorola's 1989 introduction of the MicroTac phone, which weighed 11.5 ounces, began manufacturers' rush toward smaller portable phones. By 1990, no portable phones in the U.S. market weighed more than 18 ounces and almost half of the phones weighed less than 14 ounces.[54] A similar trend occurred in the Japanese market during 1989-90.

Factors influencing firms' ability to compete in terms of phone size and weight are competencies in advanced manufacturing techniques and integrated circuit design. Surface mounting, wherein very small components are attached to circuit boards by robots, has enhanced firms' abilities to reduce phone size and weight. Firms' abilities to design smaller central processing units and other integrated circuits have also helped to reduce phone weight and size.

Talk time

Portable phones also compete in terms of talk time, which is the length of time a phone can operate before its battery loses its electrical charge.[55] Presently available portable phones offer between 45 and 140 minutes of talk time.[56]

Talk time and the size and weight of a portable phone are inversely related primarily because larger, heavier batteries are necessary to increase talk time. Talk time may be increased by the development of small batteries with greater electrical capacities. At present, nickel cadmium batteries predominate, but recent battery research centers on developing lighter, higher capacity nickel hydride batteries.[57]

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[47] U.S. industry representative, interview with USITC staff, Washington, DC, Apr. 20, 1992.

[48] U.S. industry representative, interview with USITC staff, Washington, DC, July 23, 1992.

[49] U.S. industry representative, telephone interview with USITC staff, Washington, DC, Apr. 10, 1992.

[50] U.S. industry representative, interview with USITC staff, Washington, DC, July 23, 1992.

[51] Herschel Shosteck Associates, *The Retail Market of Cellular Telephones*, Dec. 1991, p. 86.

[52] "Packaging the Perfect Portable," *Cellular Business*, Jan. 1989, pp. 55-58.

[53] Cellular phone portability means the level of ease at which a user can carry a phone to various locations.

[54] Herschel Shosteck Associates, *The Retail Market of Cellular Telephones*, Dec. 1991, fig. 7.1.

[55] Talk time is the maximum conversation length a phone can support before the phone's electric battery loses its charge. Standby time is the length of time that a phone can receive messages and calls before it loses its charge.

[56] "Plenty of Portables," *Cellular Business*, June 1991.

[57] U.S. industry representative, interview with USITC staff, Washington, DC, Apr. 20, 1992.

The factors that most influence firms' ability to compete in terms of talk time are integrated circuit design skills and advanced manufacturing techniques. Smaller integrated circuits, situated closer together, result in shorter electrical pathways. Reducing the distance electricity must travel decreases the amount of electricity that is lost due to resistance along the pathway; shorter electrical pathways result in more efficient use of the electricity available.

CHAPTER 4
Government Policy

Introduction

The most significant government policies affecting competitiveness in the cellular communication industry are licensing, spectrum allocation, and standards setting.[1] These policies influence the domestic environment in which cellular service providers and equipment manufacturers develop, and often shape firms' abilities to compete internationally (see chapter 3). Certain policies which are more limited in scope also affect the international cellular market. The most significant of these are the Modified Final Judgment (MFJ), which affects the activities of cellular service providers in the United States, and European procurement policies.

This chapter examines and compares government policies and their effects on the international competitiveness of cellular service providers and equipment manufacturers in the United States, Japan, and Europe. Where applicable, the examination is extended to cover emerging cellular markets. Strategies employed by U.S., Japanese, and European regulatory agencies in developing personal communications are also examined.

Licensing

The number of cellular communication licenses awarded by national regulatory agencies determines the level of competition within the cellular service sector. The number can vary depending on the amount of spectrum available for a particular service (see section entitled "Spectrum"); and the objectives of the licensing agency. A greater number of licensed cellular service providers tends to promote a higher degree of competitive pricing, product diversity, and technological advancement. This in turn, tends to increase the market penetration rate[2] of cellular communications among domestic consumers.

The United States and the United Kingdom encouraged a degree of competition within their respective domestic cellular markets upon introduction of the service, whereas such countries as France, Germany, and Japan have only recently introduced competition by offering more licenses for wireless communications. This approach, in part, has led to relatively higher market penetration rates in the United States and the United Kingdom. Penetration rates are illustrated for these countries in figure 4-1. The Scandinavian cellular industries have achieved high market penetration due to intra-regional cooperation, which has promoted economies of scale in equipment manufacturing, and difficult topography (e.g., frozen, mountainous terrain where it is difficult to install wireline telecommunication networks).

The following is a closer examination of licensing policies for select countries and their effects on the international competitiveness of domestic cellular service operators and equipment manufacturers. Table 4-1 depicts the respective national licensing agencies, competitive environments, service prices, and penetration rates of cellular communications in the United States, Japan, and Europe. Because of their extreme diversity, emerging cellular markets are not shown in this table.[3]

United States

Analog Cellular Systems

The Federal Communications Commission regulates non-government[4] use of radio spectrum in the United States.[5] In 1981, the FCC divided the domestic cellular market into 306 Metropolitan Statistical Areas (MSAs) and 428 Rural Service Areas (RSAs). Within each of these service areas a "B block" and an "A block" license were issued. The "B block" license was issued to an existing wireline operator and the "A block" license was issued to an unaffiliated wireless operator.

[1] Factors such as tax credits, depreciation schedules, foreign ownership, export promotion, multilateral controls, government-assisted research and development programs, and antitrust policies have been omitted from the analysis due to similarities in regulations employed by U.S., Japanese, and European Governments. These factors do not appear to confer significant competitive advantages on cellular operators and equipment manufacturers in the international marketplace.

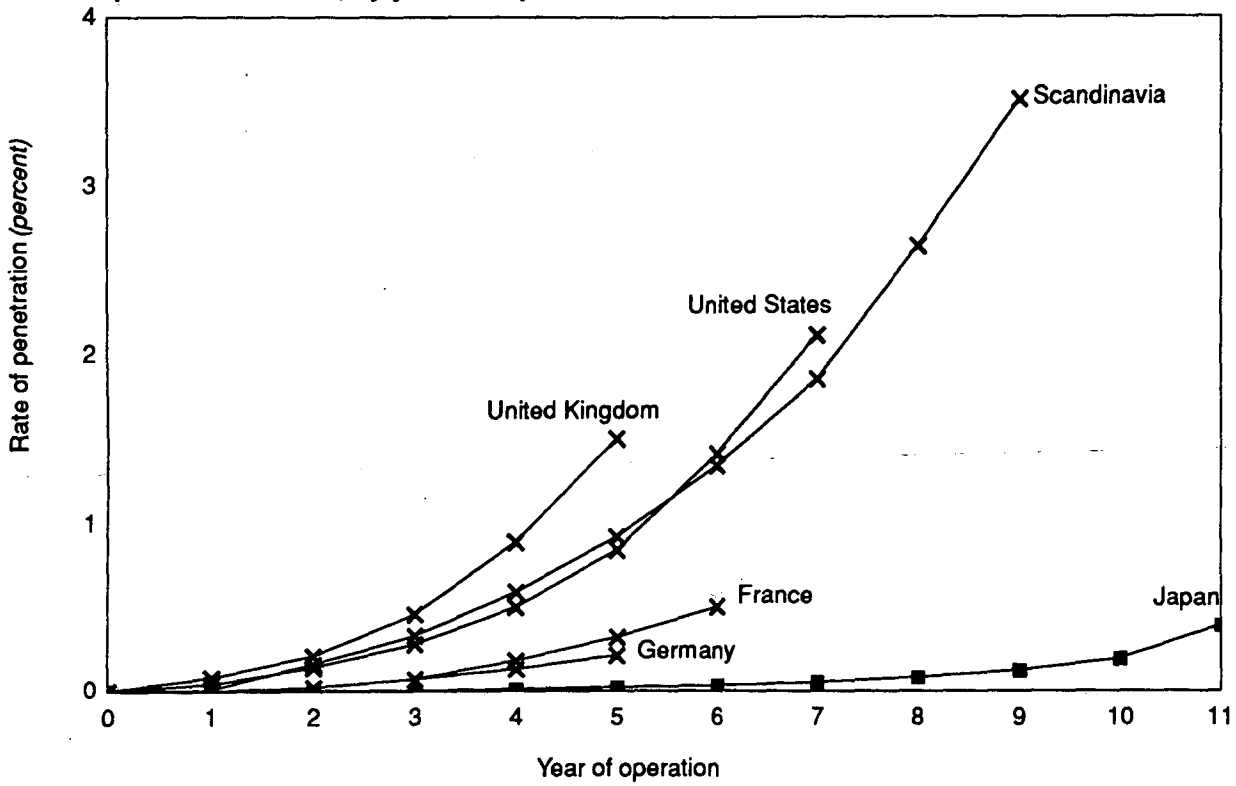
[2] The market penetration rate is derived by dividing the number of cellular subscribers by the total population.

[3] Developing countries will be omitted from tables unless uniform characteristics exist.

[4] The National Telecommunications and Information Administration (NTIA) is responsible for managing spectrum used by the U.S. Government. See section entitled "Spectrum."

[5] Foreign ownership of radio licenses is limited by Section 310.a of the Communications Act of 1934. This section limits foreign investment of cellular service providers to 25 percent of total ownership.

Figure 4-1
Cellular penetration rates, by years of operation



Note.—For each country, the origin of the figure corresponds to the year that cellular service was introduced. The last data point provided for each country is determined by data availability.

Source: Compiled by USITC staff.

It was not the intention of the FCC to limit the geographic coverage of cellular carriers to specific MSAs and RSAs.[6] Rather, the FCC viewed the distinct markets as "an application processing tool," which allowed both wireline-affiliated and "pure play" firms an opportunity to provide cellular service.[7] In this light, the FCC's licensing policy proved successful. However, the reliance on MSAs and RSAs, which conflict with LATAs (Local Access and Transport Areas) in more than 1,300 locations,[8] places the cellular service affiliates of the Bell regional holding companies (RHCs) at a significant competitive disadvantage as opposed to independent wireline (e.g., GTE) and "pure-play" (e.g., McCaw) cellular service providers.[9] This is because only the RHCs are required to hand-off all inter-LATA services to long distance companies and, therefore, are required to pay additional expenses not incurred by other cellular service providers.

The decision to promote limited competition within the domestic market for cellular communications reflects in part the U.S. Government's interest in promoting consumer benefits. Rather than licensing only one nationwide service provider, which, reportedly, would have been more cost efficient in the short run,[10] the FCC believed that a duopoly would balance the benefits of economies of scale with the benefits of competition, given the amount of spectrum available.[11] While not providing the most competitive market structure, the FCC thought that duopolies would provide certain competitive advantages, including fostering different technological approaches,

[6] Federal Communications Commission Reports, *Cellular Communications Systems*, F.C.C. 2d at 68; F.C.C. Reply at 2, (1989).

[7] Applications of James F. Rill, Trustee for Comet Inc. & Pacific Telesis Group, 60 Rad. Reg., P & F, 2d at 583, 593-594 (May 27, 1986); see also Applications of Advanced Mobile Phone Serv., Inc., Contel Mobilcom, Inc., & GTE Mobilnet of Los Angeles, Inc., 93 F.C.C. 2d at 683, 692, 693 (1983).

[8] Application for a Waiver to Permit Southwestern Bell Corporation to Provide Intersystem Hand-Off Between Adjacent Cellular Systems at 26-27, United States v. Western Electric Co., No. 82-0192 (DOJ July 21, 1988).

[9] Wireline operators are prevented from offering inter-LATA service by the MFJ. For further discussion on MFJ restrictions, and their effects, see section entitled "Modified Final Judgment."

[10] AT&T had estimated that unit costs under a duopoly would be 30 percent higher than those under one licensed operator per service area (86 F.C.C. 2d. at 479).

[11] Federal Communications Commission Reports, *Cellular Communications Systems*, 86 F.C.C. 2d. (1986).

Table 4-1
Licensing agencies, competitive environments, service costs, and penetration rates for cellular service in select countries and regions

	United States	Japan	Europe
Licensing bodies	Federal Communications Commission (FCC)	Ministry of Posts and Telecommunications (MPT)	National Ministries
Competitive environment (analog)	Regional duopolies (No firms are licensed nationally).	Regional duopolies (only NTT is licensed in each region).	National duopolies in France, United Kingdom, and Sweden. National monopolies in other EC countries.
Average annual cost of cellular service in 1991 (including phone)[1]	$1,500	$4,000	Ranges from $2,000 (United Kingdom) to $5,700 (Germany).
Penetration rate in 1990 (percent)[2]	2.1	0.4	Scandinavia 3.5 United Kingdom 1.5 France 0.5 Germany 0.2
Competitive environment (with addition of digital)	Regional duopolies (no firms are licensed nationally).	Four competitors in each region (three are licensed nationally).	One to three nationally licensed providers.

[1] Estimates based on data collected through USITC interviews with industry representatives, 1992.
[2] Estimated by USITC staff.

Source: Compiled by USITC staff.

diversifying service options, and providing some degree of price competition.[12] As illustrated in table 4-1, this policy appears to have been relatively successful, creating a domestic environment that promotes lower prices, as U.S. customers pay less for cellular service, on average, than customers in Japan and Europe.[13] With the exception of the United Kingdom and, to a lesser extent, Sweden, European analog cellular communication markets feature less competition than the U.S. market.

The FCC initially allocated analog cellular licenses using comparative hearings for the 90 largest MSAs. The comparative hearing process, which was intended to evaluate each license applicant's capability to provide high quality service, entailed a review of a firm's financial strength, experience, proposed marketing plan, and overall technical capability.[14] However, concerned that this lengthy process unnecessarily delayed cellular service to the public, while offering established "B block" operators a potentially unfair head start, the FCC adopted a system based on a lottery for MSAs 91-306 and RSAs 1-428.[15]

The FCC's decision to change to a lottery system does not appear to have injured the international competitiveness of domestic cellular service providers. Rather, it appears to have afforded smaller firms the opportunity to introduce cellular service, while simultaneously allowing larger firms the right to compete to augment their existing facilities.[16] Also, the lottery system proved significantly more time efficient than comparative hearings, thereby facilitating cellular deployment. However, it appears that the lottery system also induced rapid consolidation within

[12] Ibid., 79 F.C.C. 2d. at 991 (1979).
[13] U.S. industry representative, interview by USITC staff, San Francisco, CA, Sept. 22-25, 1992.
[14] U.S. industry representative, telephone interview by USITC staff, Palo Alto, CA, Oct. 6, 1992.
[15] U.S. Government official, interview by USITC staff, Washington, DC, Aug. 1992.
[16] Firms that won licenses in the lottery were permitted to sell their licenses to other service operators.

the cellular industry since many of the larger cellular companies purchased operating licenses for contiguous, or otherwise important, markets. Consolidation has disturbed some industry critics, who have expressed the concern that a more concentrated industry may keep cellular service prices too high, thereby reducing consumer welfare.[17]

Digital Cellular Systems

Currently, the domestic cellular industry is moving towards implementing the next generation of communications based on digital standards and equipment. This move will substantially augment the efficiency of operating wireless systems through increased capacity, as well as increase the assortment of services rendered. Existing cellular service providers will be allowed to migrate toward digital systems on a voluntary basis, and no additional cellular licenses will be offered.[18]

The move to digital cellular communications will be on the basis of "need," and is expected to occur more quickly in MSAs where market penetration is the greatest (e.g., New York, Chicago, and Los Angeles). This strategy permits cellular service providers to respond to changes in the marketplace and to determine the rate at which new equipment should be introduced. It also affords cellular service providers the ability to postpone modifications of networks until other, perhaps more advanced technologies are commercially feasible (see section entitled "Standards" for discussion of CDMA and TDMA technologies). By contrast, in Europe, service providers are required to implement a certain digital standard by a specific date (see section entitled "Standards").

At present, it appears that the U.S. strategy of implementing digital technology is adversely affecting the international competitiveness of U.S. cellular network equipment manufacturers as international competitors gain valuable marketing and manufacturing experience by deploying less advanced, but more readily available, digital systems. However, the U.S. strategy could enhance the position of both U.S. cellular service providers and equipment manufacturers in the long run as the domestic industry would be less likely to invest in less advanced, more expensive digital equipment that may unnecessarily limit network capacity and economies of scale (see section entitled "Standards").

[17] United States General Accounting Office, *Telecommunications: Concerns About Competition in the Cellular Telephone Service Industry*, (Washington GAO/RCED-92-220) July 1992.

[18] However, the introduction of personal communications is expected to augment the existing competitive environment (see section entitled "Personal Communications" for further discussion).

Japan

Analog Cellular Systems

The Ministry of Posts and Telecommunications regulates the cellular communication industry in Japan. From the introduction of domestic cellular service in 1979 until the divestiture of Japan's telecommunication system in 1985,[19] MPT relied exclusively on a wholly government-owned public corporation, Nippon Telephone and Telegraph, to provide domestic cellular service. During this period, cellular market penetration remained at 0.04 percent, a rate significantly lower than the rate achieved over an equivalent time span in the United States (see figure 4-1). This low rate of domestic market penetration prevented Japanese service providers and equipment manufacturers from gaining domestic experience. Inexperience, in turn, hindered Japanese service providers' and equipment manufacturers' efforts to become internationally competitive.

In 1986, MPT licensed two new service providers, Nippon Ido Tsushin[20] and Daini Denden, Inc.,[21] to compete in the cellular market with NTT. However, neither company received a nationwide license similar to NTT's. IDO was offered an operating license only in the Tokyo-Nagoya region, and DDI was offered an operating license only in the remaining portion of the country. IDO and DDI were therefore prevented from offering uninterrupted cellular service between the Tokyo-Nagoya region, which accounts for the majority of Japan's commerce, and the residential suburban areas, while NTT was licensed to operate in each sector. The licensing scheme employed by MPT, therefore, offered NTT an unparalleled competitive advantage in gaining the many customers requiring cellular service in both regions. Competition was only marginally promoted, and therefore, appears to have induced only nominal market penetration and service rates.

MPT allocates cellular service licenses in a significantly different manner than the FCC, promoting the interest of producers over that of consumers. Reportedly, the licensing process in Japan is relatively closed as well as less transparent than the licensing procedures administered in the United States and Europe. Companies interested in offering cellular

[19] In April 1985, with the enactment of the Telecommunications Business Law, Japan liberalized its telecommunications sector. The two main objectives of this law were to abolish the legal monopolies held by the Nippon Telephone and Telegraph Public Corporation and Kokusai Denshin Denwa (KDD) and to privatize the NTT Public Corporation.

[20] IDO includes, among others, Toyota, NEC, Japan Highway Authority, and Tokyo Electric Power.

[21] DDI consists of eight affiliated companies: Hokkaido Cellular Telephone Co., Ltd., Tohoku Cellular Telephone Co., Ltd., Hokuriku Cellular Telephone Co., Ltd., Kansai Cellular Telephone Co., Ltd., Chugoku Cellular Telephone Co., Ltd., Kyushu Cellular Telephone Co., Ltd., Shikoku Cellular Telephone Co., Ltd., and Okinawa Cellular Telephone Co., Ltd.

service in a particular region are required to contact the MPT and offer justification for receiving a license. Reportedly, MPT officials deliberate on the request for a period ranging from several days to several months. This procedure appears to favor established operators, which are apt to be more knowledgeable about market conditions and better connected with decision-makers within the MPT.[22]

Digital Cellular Systems

MPT has introduced a competitive structure in the upcoming digital market. Customers will have the opportunity to choose among four providers of digital cellular communications. NTT, along with two new market entrants, Tu Ka Cellular Phone Company, Inc. and the Digital Phone Group, will be licensed to offer digital cellular service nationally.[23] Further, IDO and DDI will be licensed to offer digital service, but only in their current respective regions.

It is expected that the increase in competition will result in greater penetration levels.[24] However, since tariff rates are controlled by MPT, price competition will likely remain modest because the MPT reportedly sets a floor and a ceiling for cellular tariffs, and service providers must offer prices within these boundaries.[25] Rather than competing on the basis of price, cellular service operators will probably begin to compete by offering various software-based call features, such as call-waiting.[26]

Europe[27]

Analog Cellular Systems

With the exception of the United Kingdom and Sweden, European countries relied exclusively on national telecom operators, known as Telecommunication Authorities, to introduce analog cellular communications. The TAs, which operated national wireline communication systems, charged high prices and offered comparatively limited coverage for cellular communications.[28] Historically, the TAs have contracted national equipment manufacturers to promote economic growth domestically.[29] This practice often resulted in procurement of less advanced and more expensive network equipment than was commercially available in the international marketplace.[30] Reliance on a single, state-controlled service provider failed to achieve cellular penetration rates comparable to countries that possessed more competitive domestic environments.

Digital Cellular Systems

In Germany, Finland, Norway, Denmark, and Portugal, the advent of digital cellular communications has been used to introduce competition into traditionally monopolistic communication markets.[31] In Sweden, which originally licensed two analog cellular service providers, the introduction of digital cellular communications has led to the licensing of a third service operator. Typically, the new cellular carriers have been licensed to offer digital services exclusively. The TAs, on the other hand, have received digital licenses in conjunction with established analog licenses. According to industry sources, this practice creates an uneven competitive environment in the short run because the TAs already have operational analog cellular networks and existing market bases. However, as digital technology replaces analog systems, the competitive environment is expected to become more equitable.[32]

A notable change in the cellular licensing philosophy of many European governments is their present willingness to open their telecommunication markets to experienced, financially secure, multinational companies. Generally, these governments have encouraged foreign firms to enter into consortia with domestic firms, which compete for licenses through relatively transparent bidding processes. This has afforded many European cellular communication firms opportunities to benefit from the technical, marketing, and cost management expertise, as well as the financial resources, of foreign firms (see chapter 5, section entitled "Cellular Service Providers").

To follow is a closer examination of the licensing policies of select European countries and regions and their effects on the international competitiveness of their respective cellular industries.

United Kingdom

In the United Kingdom, cellular communications began as a competitive industry. The nationwide service providers, Cellnet Limited and Vodafone plc were granted nation-wide licenses to build and operate competing analog cellular networks under the

[22] Japanese industry representatives, interviews by USITC staff, Tokyo, Sept. 26-Oct. 2, 1992.

[23] However, these digital networks will become operational on a regional basis.

[24] Japanese industry representative, interview by USITC staff, Washington, Sept. 11, 1992.

[25] Ibid.

[26] Japanese industry representatives, interviews by USITC staff, Tokyo, Sept. 26-Oct. 2, 1992.

[27] European licensing trends are further analyzed in Mueller and Toker, "Mobile Communications in Europe;" Donaldson, Lufkin & Jenrette, *The Cellular Communications Industry, Winter 1991-1992*; and by the Congress of the United States Congressional Budget Office, *Auctioning Radio Spectrum Licenses*.

[28] U.S. industry representatives, interviews by USITC staff, San Francisco, CA, Sept. 22-25, 1992.

[29] Ibid.

[30] However, this may change as a result of recent EC legislation. See section entitled "Procurement" for further discussion.

[31] Spain, Italy, and the Netherlands intend to introduce competition through digital cellular communications but, as of yet, have not licensed the second operator.

[32] U.S. industry representative, interview with USITC staff, Germany, Oct. 5, 1992.

Telecommunications Act of 1984.[33] BT (British Telecom plc) owns 60 percent of Cellnet and Telecom Securicor Cellular Radio (United Kingdom) owns the remaining 40 percent. In 1991, Vodafone was separated from Racal Ltd., a British electronics firm.[34]

Cellnet and Vodafone are not allowed to market their services directly to the public. Rather, resellers and equipment retailers purchase airtime at wholesale prices from these network operators, and they then sell it directly to the public. These resellers receive a commission from the network operators for enrolling subscribers, collecting subscription fees, and providing billing and after-sales services. This distribution system was designed to encourage competition within the industry by preventing cross-subsidization and unequal access to the wireline network.[35]

The United Kingdom has not attempted to predetermine the amount of competition which the domestic economy can support. Rather, the British Government has offered licenses to operators who satisfy technical, financial, and business-related (i.e., marketing plan) criteria, for services considered to be technologically feasible.[36] This licensing philosophy has created an environment conducive to technological innovation, in which international cellular service providers encounter little difficulty acquiring licenses for emerging technologies.[37] Simultaneously, this policy has contributed to rapid market penetration and relatively low prices for cellular services (see figure 4-1 and table 4-1, respectively).

The United Kingdom's licensing approach has led to periods of intense competition. Some industry sources have contended that, at times, too many competitors have vied for too small a market.[38] Additionally, it appears that the British approach has, at times, promoted the commercial introduction of emerging services and technologies before they were sufficiently developed.[39] This appears to be the case of Telepoint,[40] which was licensed before a common standard had been implemented.

[33] The 1984 Telecommunications Act also granted Cellnet and Vodafone licenses to run nationwide digital cellular networks after 1991 (U.S. Department of Commerce, Market Research Reports, *United Kingdom Cellular Radio Market*, Mar. 1988).

[34] Shearson Lehman Brothers, (Evan Miller), *Vodafone, Company Update*, Feb. 13, 1992, p. 2.

[35] U.S. Department of Commerce, International Trade Administration, *United Kingdom: Cellular Radio Market Overview*, Market Research Reports, Mar. 1988.

[36] There must also be available spectrum.

[37] U.S. industry representative, interview by USITC staff, San Francisco, CA, Sept. 22-25, 1992.

[38] Ibid.

[39] Organization for Economic Cooperation and Development, *Mobile and PSTN Communications Services: Competition or Complementarity?*, May 20, 1992, p. 39.

[40] Telepoint is a type of cordless telephone that features one way calling, limited mobility, and small handsets. It is considered an "emerging technology" that can be used in the home, office, and through extension of public payphones.

Because both British cellular service providers have recently invested heavily in upgrading their analog cellular systems, there is little incentive to invest in GSM, the pan-European digital cellular network. On the one hand, this could delay British manufacturers and service providers from gaining valuable domestic experience in digital cellular communications and, therefore, impair the international competitiveness of the British industry. On the other hand, as is the case in the United States, British cellular service providers could benefit from the delays and deploy more advanced, future digital networks.

Germany

The German Government originally promoted a monopolistic environment for cellular communications, licensing Deutsche Bundespost Telekom (DBP Telekom), the German TA, as the only analog cellular service operator.[41] This policy, in part, had the effect of generating relatively low penetration rates and expensive services (see figure 4-1 and table 4-1, respectively). However, like many other European governments, the German Government has recently adopted a more liberal approach in managing its cellular communication market.

The German Government is currently attempting to enhance the international competitiveness of its cellular industry by introducing competition into the domestic cellular market. It has awarded a digital cellular license to Mannesmann Mobilfunk GmbH (MMF), a private sector consortium, led by Mannesmann AG, a German industrial concern, with the participation of Pacific Telesis (United States), Cable & Wireless (United Kingdom) and Lyonnaise des Eaux (France). It is reported that the foreign members of this consortium will offer MMF the marketing, operating, and manufacturing expertise, as well as the financial resources, necessary to compete with the well-established DBP Telekom.[42]

The German Government has required that MMF deploy a network based exclusively on the GSM standard. This requirement has motivated MMF to bring GSM products to market rapidly, as the firm has no alternative network from which to generate revenue. Although the introduction of competition in the German cellular market was initially delayed by the commercial unavailability of GSM subscriber equipment, GSM subscribership in Germany has grown steadily.[43] The German Government is hoping that early development and deployment of GSM-based cellular communications will give German service operators and equipment manufacturers an early competitive advantage in GSM technology,

[41] DBP Telekom is licensed to offer analog and digital cellular service.

[42] U.S. industry representatives, interviews by USITC staff, San Francisco, Sept. 22-25, 1992.

[43] U.S. industry representative, telephone interview by USITC staff, Washington, DC, Feb. 18, 1993.

which is being promoted worldwide by European manufacturers, service operators, standards agencies, and governments (see section entitled "Standards").

France

In 1985 France Telecom Mobiles, the mobile communications subsidiary of France Telecom, began offering Radiocom 2000, a quasi-cellular service linked to the public switched telephone network.[44] Radiocom 2000 is characterized by low quality, high price, and limited mobility.[45] In 1988, the French Government awarded an analog cellular license to Ligne Societe Francaise du Radiotelephone S.A. (SFR),[46] a privately owned company, majority-controlled by Compagnie Generale des Eaux (CGE), which implemented an analog cellular system. However, because Radiocom 2000 and cellular service are not close substitutes, competition between the services has been modest.[47] Lack of competition could explain the relatively slow improvement in cellular service prices and market penetration (see figure 4-1 and table 4-1, respectively). Meanwhile, the French Government has been a strong advocate of GSM, hoping that a pan-European cellular system will offer French manufacturers and service providers greater economies of scale.

Scandinavia

In 1991, Sweden became the first European country to license three cellular service providers. In Norway, Denmark, and Finland, the respective TAs are currently the sole providers of analog cellular service and future providers of digital service. In 1990 and 1991, the Finnish, Norwegian, and Danish Governments each licensed a second operator to build and manage a GSM (digital) network.[48] The Finnish Government awarded the second GSM license to a consortium of Finnish companies, and the network became operational in three cities in July 1991.[49] The Norwegian GSM license holder is a joint venture of Comvik AS (Sweden) and Orkla Borregaarda (Norway).[50] The Danish GSM licensee, the Dansk Mobiltelefon consortium, includes BellSouth (United States) and Sweden's third cellular licensee, NordicTel (Sweden/United Kingdom). Generally, cellular communications has achieved a very high level of market penetration in the Scandinavian countries (see figure 4-1).

Other

The Italian cellular market is currently characterized by lack of competition and significant pent-up demand. The Italian TA, Societa Italiana per L'Esercizio delle Telecomunicazione (SIP), supplemented its proprietary quasi-cellular network with an analog system in 1990. As a result, cellular subscribership more than tripled in Italy by 1992.[51] However, to recover the TA's investment in the analog network, Italy apparently is delaying the introduction of both competition and the implementation of a digital GSM network.[52]

In 1991, the Portuguese Government granted a second cellular service license to the privately owned Telecel consortium.[53] At the same time, the Government merged the two state-owned telecommunication concerns to create a new publicly owned corporation to provide competing cellular service.[54] The Portuguese example departs from the liberalization approach of most other European countries, whereby the TA gives itself considerable lead time to develop and begin operation of a cellular network before licensing a second, competing service provider.

Spain and the Netherlands have no private cellular service providers, but reportedly plan to award GSM licenses in mid-1993.[55] The Dutch Government, mindful of the high value placed on cellular networks, originally suggested that both the TA and the eventual private operator pay a $265 million fee for their GSM licenses. Industry analysts pointed out that this figure could well exceed the initial building and operating costs of a digital cellular system.[56] In September 1992, however, the Dutch Government withdrew its proposed license fee in favor of a profits tax on both the TA and the private GSM operator.[57]

In Ireland, Belgium, Luxembourg, Austria, and Switzerland, the TA is the sole cellular network operator. There are no current plans for licensing

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[44] Some industry analysts define the French and the Italian mobile communications networks as "quasi-cellular" because these systems essentially provide private mobile radio-telephone service. Department of Commerce, *A Competitive Assessment of the U.S. Cellular Radiotelephone Industry*, pp. 45-46.

[45] European industry representatives, interview by USITC staff, France, Sept. 22-Oct. 9, 1992.

[46] Two foreign service providers, BellSouth of the United States and Vodafone of the United Kingdom, each own a 4-percent financial stake in SFR.

[47] European industry representative, interview by USITC staff, Paris, Sept. 22-Oct. 9, 1992.

[48] "Dansk Mobiltelefon wins GSM operator license," *European Mobile Communications Report*, June 1991, p. 1.

[49] TE&M, Aug. 1, 1991.

[50] Ameritech (United States) and Singapore Telecom have announced plans to purchase 49 percent of this venture. *Mobile Phone News*, Dec. 28, 1992, p. 7.

[51] Shearson Lehman Brothers, *European Mobile Communications*, Dec. 2, 1991, p. 59.

[52] Seth Magleri, "Government, Cash Obstacles to GSM in Europe," *RCR*, Apr. 20, 1992, p. 1.

[53] Pacific Telesis (United States) has a 23-percent stake in the Telecel consortium.

[54] Donaldson, Lufkin & Jenrette, *The Cellular Communications Industry*, winter 1991-1992, p. 9.

[55] "Netherlands To License Second Cellular System," *Mobile Phone News*, May 7, 1992, p. 8.

[56] U.S. industry representative, telephone interview by USITC staff, Apr. 13, 1992.

[57] Mark Newman, "Dutch GSM operators escape license fee but will be taxed on profits," *Mobile Communications*, Sept. 24, 1992, pp. 4-5.

second operators because these markets are too small to support two operators.[58] Greece, with no analog cellular network, recently issued GSM licenses to two consortia. Through an auctioning system, the Greek Government raised $320 million from cellular licenses. The highest bidder, Societa Finanziaria Telefonica (STET) of Italy,[59] was awarded the first license for $160 million, while the second highest bidder, Panafon,[60] was allowed to match the highest bid.[61] The licenses, which are valid for 20 years, prohibit the licensing of additional competitors for 8 years. Afterwards, the Greek Government may offer additional licenses if warranted by new technologies (see section entitled "Personal Communications").[62]

Emerging Cellular Markets

Analog Cellular Systems

In emerging cellular markets, there are two basic models for licensing cellular service providers. In countries where the state-owned monopoly already operates a cellular network, licensing tends to follow the West European model of duopoly licensing whereby the second operator is a private consortium of domestic and foreign companies. This situation is most common in larger Latin American and rapidly industrializing Asian countries. In countries where the cellular market has not yet developed, governments tend to grant limited duration monopoly licenses to public-private partnerships, or to private, usually foreign, firms. The former pattern is unique to Eastern Europe, and the latter is evident in India, Pakistan, and Central America.[63] Many emerging cellular markets are increasingly awarding licenses to the highest bidder through official or unofficial auctions, with revenue maximization being the principal goal, other factors being equal.[64] This strategy could have the effect of precluding smaller companies from competing for licenses in many of these countries (see chapter 5 for further discussion of strategies employed by governments of emerging cellular markets).

Cellular market penetration in most developing nations has generally been much lower than in the United States, Japan, and Europe.[65] This is not surprising, considering the exclusive nature of cellular service, its recent introduction,[66] and the low level of domestic competition that exists in many countries.

Digital Cellular Systems

Generally, emerging cellular markets have only recently introduced analog cellular communication systems. Therefore, it is not expected that these countries will introduce digital systems until they have recovered a significant portion of the capital invested in analog systems, or until capacity shortages become imminent.[67]

Spectrum

The radio spectrum used by cellular communications is a finite, natural resource. Most cellular communication networks utilize the 400, 800, and 900 Megahertz (MHz) frequency bands, while future generations of personal communications will tend to be based in the 1.5 to 2 Gigahertz frequency bands (see section entitled "Personal Communications"). Higher radio frequencies typically require amplifiers to be placed closer together and usually utilize more expensive network equipment.[68] However, communication systems based on higher frequencies also require less powerful cellular phone batteries, which allow handheld portable phones to become smaller and lighter.

The United States, Europe, and Japan allocate and manage spectrum in different ways to promote internationally competitive domestic cellular communication industries. The United States and Europe generally have relied on spectrum scarcity to motivate service operators to migrate from analog systems to more efficient digital systems. However, whereas the United States has relied only on market forces to determine the rate of migration, European countries have provided firms with incentive to construct digital networks by adopting a common digital standard. Meanwhile, Japan has taken another approach, setting aside large amounts of spectrum to ensure sufficient capacity for existing and future technologies.

As illustrated by the following examination of U.S., European, and Japanese strategies, spectrum management and allocation can significantly influence the competitiveness of domestic competitors. Table 4-2 compares the amount of spectrum that these

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[58] Ibid.

[59] STET is the financial holding company for Italy's telecom authority. STET's operational service arm, Societa Italiana per l'Esercizio delle Telecomunicazione (SIP), manages Italy's cellular network. *Mobile Phone News*, Aug. 27, 1992, p. 7.

[60] Panafon is a consortium consisting of Vodafone Group plc (45 percent), France Telecom (35 percent), Intrakom (10 percent), and Data Bank of Greece (10 percent). *Mobile Phone News*, Aug. 27, 1992, p. 7.

[61] State Department Cable, "Award of Cellular Telephone Licenses," Athens 09430, Aug. 13, 1992.

[62] Ibid.

[63] Pyramid Research, Inc., *Cellular Markets in Developing Countries*, Aug. 1991, pp. 35-36.

[64] U.S. cellular industry representative, interview by USITC staff, London, Sept. 23, 1992.

[65] Pyramid Research, Inc., *Cellular Markets in Developing Countries*, Aug. 1991, p. 54.

[66] Ibid.

[67] There are exceptions. For example, the governments of Russia and India have recently awarded GSM licenses, apparently believing that GSM cellular networks will be more cost-effective over the long term because the marginal cost of capacity improvement is relatively small. U.S. industry representative, telephone interview by USITC staff, Washington, DC, Feb. 18, 1993.

[68] U.S. industry representatives, interviews by USITC staff, San Francisco, CA, Sept. 22-25, 1992.

Table 4-2
Spectrum allocation for cellular service in select countries and regions

	United States	Japan	Europe
Spectrum allocated for analog systems	50 MHz	56 MHz	Varies by country
Frequency range (analog)	800-900 MHz	800-900 MHz	450 MHz, 800-900 MHz
Additional spectrum allocated for digital systems	None	80 MHz[1]	None[2]
Frequency range (digital)	800-900 MHz	800-900 MHz, 1.5 GHz	800-900 MHz
Spectrum available for all cellular systems	50 MHz	136 MHz[3]	50+ MHz[3]

[1] This includes spectrum allocated for immediate use, as well as spectrum that has been allocated for use beginning in 1994.
[2] Council Directive 87/372/EEC ensures that the whole of 890-915 MHz and 935-960 MHz bands are reserved exclusively for a pan-European digital cellular communication service.
[3] It is expected that analog systems will gradually be abandoned in Japan and Europe, as service providers adopt digital systems.

Source: Compiled by USITC staff.

countries have allocated for analog and digital cellular communications, as well as frequency bands that will be utilized.

United States

The United States, like many other countries, originally allocated the minimum amount of spectrum required to operate a cellular network. This strategy was based on the common belief that cellular service was a luxury, and that demand would be found primarily among the wealthy.[69] As demand for cellular communications became more widespread, the FCC increased the amount of spectrum allocated for cellular communications from 40 MHz to 50 MHz.[70]

The FCC has allocated significantly less radio spectrum to each domestic cellular service operator than foreign regulating agencies have allocated to their respective cellular service operators. The relative scarcity of available spectrum appears to have induced U.S. service providers to invest in the research and development of future technologies to increase their existing levels of capacity, perhaps to an extent unparalleled by international competitors.

The FCC has allocated equal amounts of spectrum to all licensed cellular service providers, equally encouraging all cellular operators to upgrade their networks while simultaneously allowing market forces to determine which operators would be most successful. Japan and most European countries have chosen a different tactic, generally trying to influence which cellular service provider would succeed through uneven allocation of spectrum. The FCC's strategy seems to have been successful in motivating technological innovation and enhancing the competitiveness of the U.S. cellular communication industry. Many U.S. cellular firms, both service providers and equipment manufacturers, have successfully marketed their technological advantages internationally.

Some members of the U.S. cellular industry, supported by certain members of the U.S. Congress, believe that the cellular industry should be allocated more spectrum, as domestic demand for cellular services continues to increase. However, the reserve of spectrum that is suitable for cellular use is limited. To allocate cellular firms more spectrum, the FCC would need to 1) relocate existing wireless operators to

[69] Ibid.
[70] The FCC first allocated 20 MHz of spectrum to each cellular operator in 1981. In 1986, this amount was increased to 25 MHz per operator.

different frequencies[71] or 2) encourage wireless operators that can technically utilize fixed, wireline networks (e.g., television broadcasters[72]) to relinquish their radio spectrum.[73] Some members of the cellular communication industry and of the U.S. Congress also have advocated legislation that would re-allocate 200 MHz of spectrum reserved for government use[74] to private sector operators.[75] Much of this spectrum is reportedly under-utilized.[76]

Japan

The Japanese Government has been able to allocate greater amounts of spectrum to cellular communications than the United States (see table 4-2), in part because Japan does not have to allocate spectrum for military use. The allocation of more spectrum has helped to ensure a favorable domestic business climate for Japan's cellular industry. However, it does not appear that more spectrum has enhanced the international competitiveness of the Japanese industry, as Japanese service providers and equipment manufacturers have been relatively less competitive internationally than U.S. and European firms (see section entitled "Standards").

In addition, unlike the United States and Europe, the Japanese Government has been more willing to allocate large amounts of spectrum for digital cellular communications. Unlike in the United States and Europe, where service providers are forced to migrate towards digital communications on spectrum previously allocated to analog systems, the Japanese Government has allocated an additional 80 MHz of spectrum to be utilized exclusively for digital cellular communications (see table 4-2).[77] This is intended to provide Japanese service providers ample space to develop and deploy new technologies, without affecting existing analog operations, thereby enhancing the international competitiveness of Japanese equipment manufacturers and service operators in future generations of cellular communications.

[71] See section entitled "Personal Communications."

[72] Those who support the re-allocation of television broadcasters to fixed-land networks contend that television broadcasting can be technically achieved through cables. However, this transition could be costly.

[73] These strategies could be implemented exclusively, or collectively, through such policies as tax incentives.

[74] The National Telecommunications and Information Administration, under the Department of Commerce, administers federal use of spectrum. Reportedly, NTIA has jurisdiction over approximately 40 percent of the frequencies below 5 Gigahertz.

[75] U.S. Congress, *Emerging Technologies Act of 1991*, Report 102-113, 102D Cong., 1st sess., 1991, H.R. 531 and S. 218.

[76] U.S. House, Committee on Energy and Commerce, *Emerging Technologies Act of 1991*, 102D Congress, Report 102-113, June 18, 1991.

[77] NTT, DDI, and IDO received a total of 32 MHz of spectrum in 1992 for digital systems. In 1994, NTT will receive 8 MHz, and Tu Ka and Tokyo Digital Phone will each receive 20 MHz of spectrum in the 1.5 MHz range.

Europe

Unlike in the United States, the European cellular analog licenses were initially granted to monopolies.[78] Consequently, European governments could allocate the same amount of spectrum to cellular communications as the United States, yet effectively offer their single operator twice the capacity. Further, since each national regulating agency independently determined which spectrum would be allocated for its cellular systems, and which access methods and protocols to use, a patchwork of incompatible systems throughout Europe has been created.[79] This incompatibility served to hinder regional roaming, which, in turn, may have delayed market penetration and reduced economies of scale in equipment manufacturing and telephony services.

More recently, the European countries have attempted to manage the region's transition to a common frequency band to encourage the implementation of a pan-European cellular network. The European Commission issued a directive requiring that certain bands in the 800-900 band be reserved exclusively for digital communications (GSM) in each of the member countries.[80] The European Commission has set deadlines for spectrum availability, as well as dates for service to begin. These deadlines, however, have often been rescheduled due to complexities in developing, testing, and deploying necessary equipment (see section entitled "Standards").

Reportedly, some European countries have also reassigned radio spectrum suitable for cellular communications from the military to the private sector.[81] These moves not only alleviate spectrum congestion, but also signal the government's support for cellular communications. This support can become paramount in influencing a firm's decision to invest in increasingly expensive, emerging technologies.[82]

Emerging Cellular Markets

Although emerging cellular markets generally do not have as many users of radio spectrum as do the United States, Japan, and Europe, many emerging

[78] Exceptions are the United Kingdom and Sweden.

[79] In the United States and Japan, all analog communications were based in the 800 to 900 MHz range, making inter-system roaming relatively easy. Conversely, European systems were based in the 450, 800, and 900 MHz bands, thereby making inter-system roaming comparably more difficult.

[80] *Council Directive on the frequency bands to be reserved for the coordinated introduction of public pan-European cellular digital land-based mobile communications in the Community*, 87/372/EEC, OJ No L 196, (July 17, 1987), p. 85.

[81] U.S. industry representative, telephone interview by USITC staff, Washington, DC, Sept. 29, 1992.

[82] U.S. industry representatives, interview by USITC staff, San Francisco, Sept. 22-25, 1992.

cellular markets are experiencing overcrowding due to poorly managed spectrum.[83] Frequently, government regulatory agencies have re-assigned spectrum used by the police, the military, and air-traffic controllers to cellular service providers.[84] Re-allocation processes can result in significant expenditures and delays, as radio equipment must often be either replaced or relocated to make spectrum available. In some countries, private service providers are expected to share the cost of relocating existing users.[85] This practice can effectively preclude smaller firms from offering cellular service in these markets, as start-up costs can increase significantly.

Standards

Analog cellular communication networks were, to a large degree, created in a piecemeal fashion, resulting in the establishment of a plethora of incompatible analog cellular standards. The U.S. cellular communication industry appeared to benefit most from this piecemeal approach, relative to the European and Japanese cellular industries, since its large domestic market offered unparalleled economies of scale. However, as cellular communication industries develop more sophisticated technologies (e.g., digital cellular communications and personal communications), it is generally recognized that most, if not all, national markets will not be large enough to adequately support the costs of independent research and development, production, and deployment.[86] To recoup large research expenditures, network equipment manufacturers will find it necessary to export aggressively.

Consequently, network equipment manufacturers have competed to establish their home country technical standards in as many foreign markets as possible. Often, governments and regional regulatory agencies have taken an active role in persuading foreign countries to adopt the standards supported by firms in the home country.

Table 4-3 illustrates the standards that are being promoted by various cellular communication industries, and the standards-setting agencies that are responsible for developing and promoting these standards. Following table 4-3 is an examination of the openness of standards-setting organizations in the United States, Japan, and Europe, as well as an analysis of the effects of various standards on the relative competitiveness of U.S., Japanese, and European cellular communication firms.

United States

The United States' cellular communication industry benefited greatly from wide international adoption of the analog standard AMPS, a standard based on technology developed by U.S. manufacturers and service providers. This analog standard, as depicted in figure 4-2, supports approximately 60 percent of the world's cellular subscribers and allows U.S. manufacturers to benefit from unmatched economies of scale in equipment manufacturing, while facilitating roaming capabilities in the home market and foreign markets (see figure F-1 for a list of countries that have adopted AMPS).

[83] Pyramid Research, Inc., Aug. 1991, p. 34.
[84] Ibid.
[85] Pyramid Research, Inc., Aug. 1991, p. 35.
[86] U.S. industry representatives, interview by USITC staff, San Francisco, CA, Sept. 22-25, 1992.

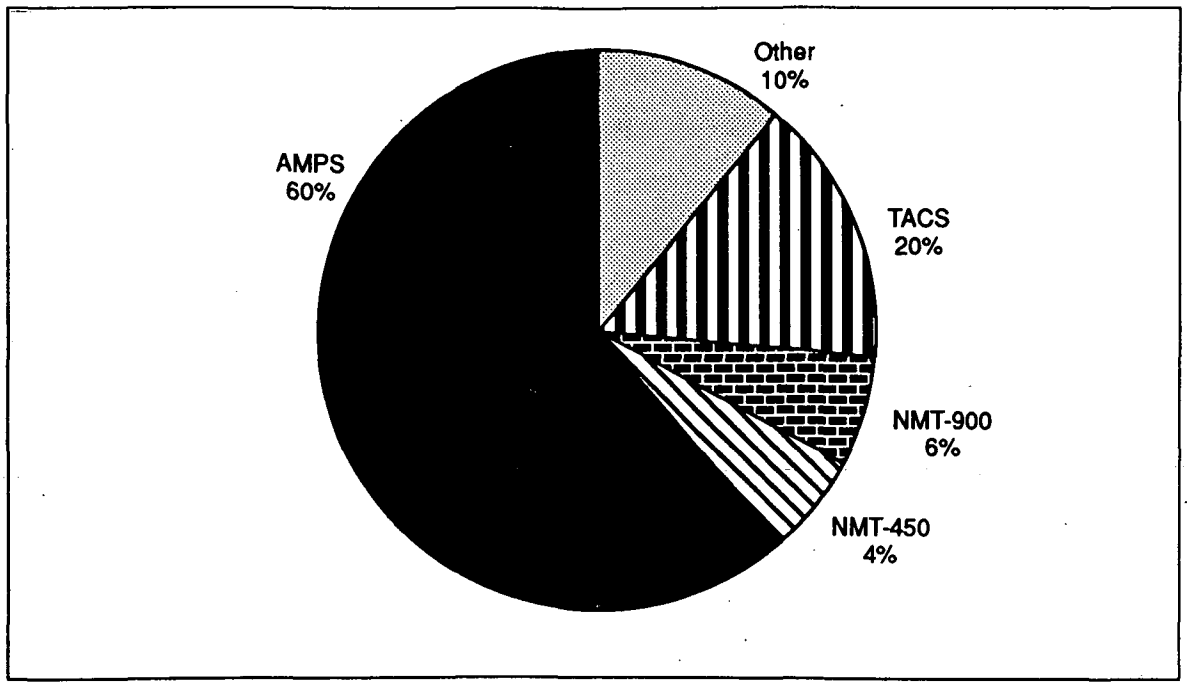
Table 4-3
Standards-setting agencies and access methods for analog and digital cellular service in select countries and regions

	United States	Japan	Europe
Standards-setting bodies	EIA/TIA[1]	MPT/RCR[2]	ETSI[3]
Standard access method for analog	AMPS N-AMPS	HCS J-TACS N-TACS	NMT E-TACS C-NETZ RTMS RC-2000
Standard access method for digital	TDMA CDMA	TDMA	TDMA[4]
Openness of standards-setting process	Unrestricted	Unrestricted	Unrestricted

[1] Electronic Industries Association/Telecommunications Industry Association.
[2] The Research and Development Center for Radio Systems (RCR).
[3] European Telecommunications Standards Institute.
[4] A TDMA derivative, GSM, will be deployed.

Source: Compiled by USITC staff.

Figure 4-2
Worldwide cellular subscribers, by analog system, 1992



Source: U.S. Department of Commerce.

Cellular service providers in the largest U.S. cities are presently moving towards upgrading their analog wireless operations to digital technology to increase the variety of services rendered, and to enhance existing levels of capacity and technological efficiency. The digital standards upon which U.S. manufacturers will base their equipment designs are developed by technicians employed by the private sector, under the auspices of the Telecommunications Industry Association (TIA), an organization that is officially recognized by the American National Standards Institute. The process that is employed to develop these standards is open to any interested party and, compared with the European and Japanese standard-setting process, is generally administered on an "ad hoc" basis.[87] The U.S. standard-setting process relies on many temporary committees to respond to narrowly-focussed standards-related issues rather than on a single permanent organization to handle all standards-related matters. The U.S. standards-setting process for cellular equipment is depicted in more detail in figure 4-3.

The transition to digital technology within the U.S. cellular industry has been determined by market forces rather than by government edict. Digital systems are being deployed only as needed; the larger, more congested MSAs, such as New York, Chicago, and Los Angeles, have priority. The U.S cellular industry has voluntarily adopted a standard (IS-54)[88] to ensure that all equipment will be dual-mode to protect U.S. subscribers from being negatively affected by the piecemeal transition to digital networks. This standard will allow subscribers using digital technology to default to AMPS when they roam into areas covered only by analog systems.[89]

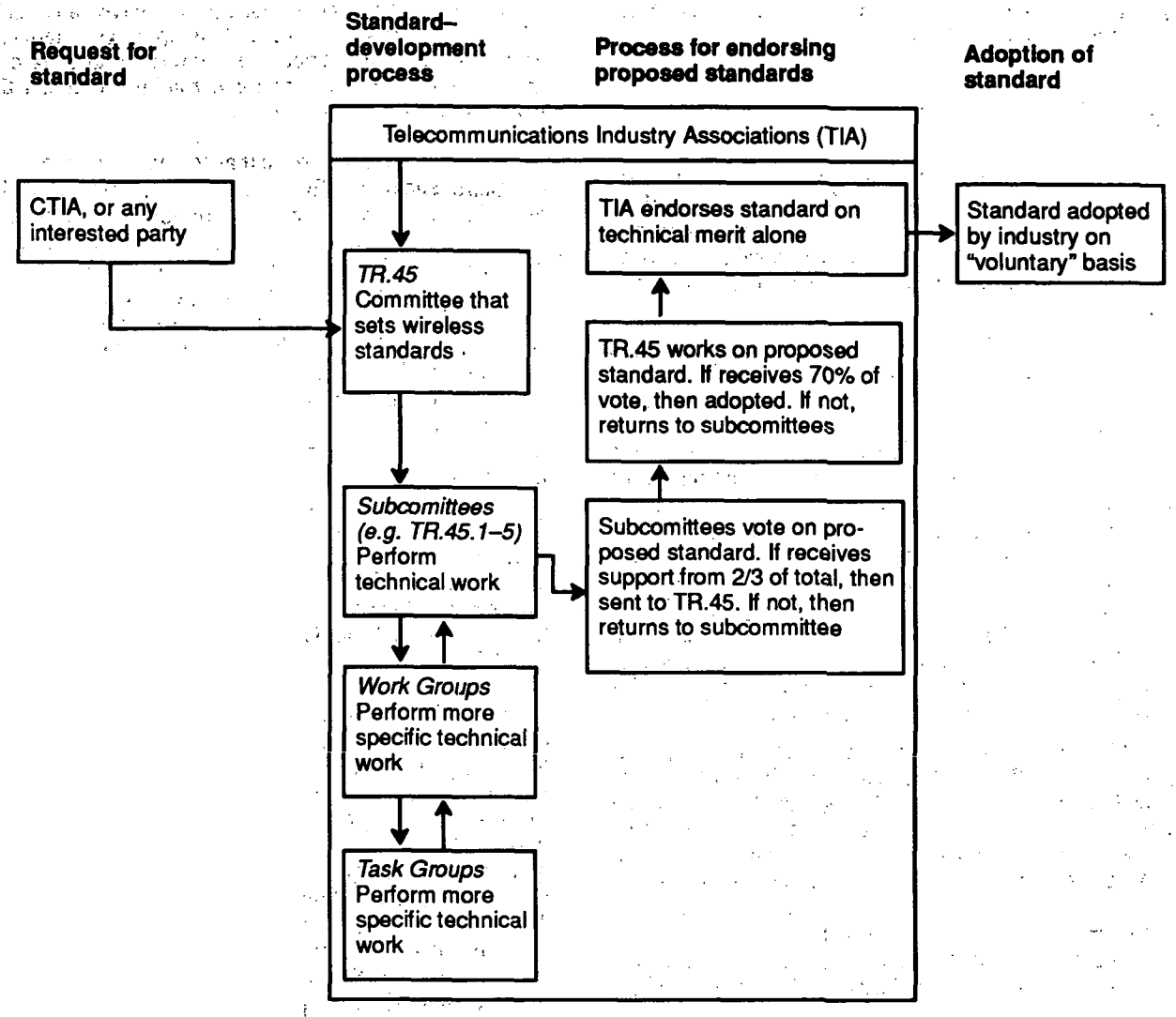
Although the reliance on market forces to determine industry development has generally benefited the U.S. cellular industry, this philosophy poses a potential drawback. Most industry sources agree that competitive markets spur technological advancement and allocate limited resources efficiently. However, within the U.S. cellular industry, the absence of a mandated digital standard appears to have resulted in confusion in the marketplace. Unlike the deployment of analog cellular technology, where the FCC mandated adherence to AMPS, U.S. firms have been left to deploy digital systems without a mandated digital standard. As a result, two incompatible digital standards have emerged, one derived from Time

[87] U.S. industry representatives, interview by USITC staff, Washington, DC, Dec. 1992.

[88] IS-54 ensures that dual-mode equipment is based on TDMA and AMPS. Since the adoption of IS-54, another committee has been formed to develop a similar standard based on Qualcomm's proposed CDMA technology.

[89] Another standard adopted by the U.S. industry, IS-41, provides for the development of a seamless, nationwide network by creating open networks that allow otherwise incompatible switches to be interconnected. Without IS-41, AMPS could not be guaranteed to offer the inter-regional roaming that is necessary for IS-54 to be successful.

Figure 4-3
Standard-setting process in the United States



Source: Compiled by USITC staff.

Division Multiple Access technology, and the other from Code Division Multiple Access technology.

The ramifications of the dissonance within the U.S. cellular communication industry in the international marketplace is unclear. In the short term, competing digital standards appear to have hindered the effectiveness of U.S. equipment manufacturers in promoting their interests internationally. Reportedly, several large foreign service providers have signed on to the European system (GSM) as a result of the confusion in the U.S. market.[90] Additionally, the economies of scale, which were fundamental to the U.S. cellular industry's initial successes (i.e., in analog cellular communications), are jeopardized by the present need to develop two incompatible digital

[90] U.S. and Japanese industry representatives, interview by USITC staff, Washington, DC, fall 1992.

technologies.[91] In the long term, however, the TDMA-CDMA controversy could offer U.S. firms a competitive advantage in technologically superior equipment and operating systems, while possibly preventing domestic firms from investing prematurely in networks that could soon become obsolete.

Japan

The Japanese cellular communication industry was adversely affected by its deployment of a unique analog standard, referred to as NTT's high capacity system (HCS). Adoption of the standard reduced economies of scale and limited sales opportunities in foreign markets.[92]

To prevent these difficulties from recurring, the Japanese cellular industry has adopted a standards-setting process which is open to domestic and foreign participation. The most significant result of an open standards-setting process has been the adoption of a digital standard that is very similar to the U.S. digital standard based on TDMA. Japan's standards-setting process, depicted in figure 4-4, reflects the intent of Japanese cellular service providers and equipment manufacturers to become active players in the international digital cellular marketplace. Such a policy could increase Japanese firms' access to lucrative foreign markets, especially the United States, and, if successful, confer upon these firms the benefits derived from increased economies of scale.[93]

The Japanese Government, as well as its standards-setting agencies, has actively promoted the Japanese digital standards throughout Asia to further the interests of its domestic cellular industry. However, there is concern within the Japanese cellular industry that the Japanese Government adopted this policy too late, as many Asian countries have already selected the European digital standard (GSM), which has been promoted internationally by European governments and by standards-setting agencies since the mid-1980s.[94]

Europe

The European cellular industry developed its analog cellular communication networks in a piecemeal fashion, fragmenting the European market into five distinct markets. Consequently, most European manufacturers did not benefit from economies of scale, and cellular service operators could not easily offer inter-regional roaming.[95] Both of these consequences appear to have adversely affected European subscribership, as reduced economies of scale tended to reinforce higher prices, and difficulties in inter-regional roaming reduced the benefits offered to consumers.

In an attempt to enhance the international competitiveness of European cellular firms, while extending the advantages of a regionally compatible communication network to European consumers, national and regional governments and standards-setting agencies have supported aggressively the development of a single pan-European digital standard. The GSM standard, initially termed "Groupe Speciale Mobile" in 1982, was soon re-labelled "Global System for Mobile Communications" as it became clear to European regulatory bodies that markets outside of the European Community were necessary to support the costs of developing and deploying an internationally competitive digital network. This recognition has assisted GSM in becoming the predominant digital standard throughout Europe, the Middle East, Asia, and the Pacific (New Zealand and Australia), often replacing analog systems that were based on U.S. technology and standards (AMPS).

Fundamental to the development of GSM was the creation of the European Telecommunications Standards Institute (ETSI). ETSI is managed by technicians who are on loan from TAs and industry, full-time, for 2 to 3 years. Participation in the development of standards is open to European and non-European parties that have interests in Europe (ETSI's standards-setting process is illustrated in figure 4-5). Unlike U.S. and Japanese standards-setting agencies, however, participation is contingent upon full acceptance of ETSI's policies and directives. Firms that do not support policies endorsed by ETSI's General Assembly are prevented from participating in the Technical Assembly, which is responsible for formulating technical committees and project teams that perform technical work on standard development. This practice has caused many to question the practical openness of ETSI[96] since certain policies adopted by ETSI are disputed by non-European firms.

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[91] Hong Kong industry representatives, interviews by USITC staff, Hong Kong, Sept. 26-Oct. 2, 1992.

[92] U.S. industry representatives, interviews by USITC staff, San Francisco, CA, Sept. 22-25, 1992.

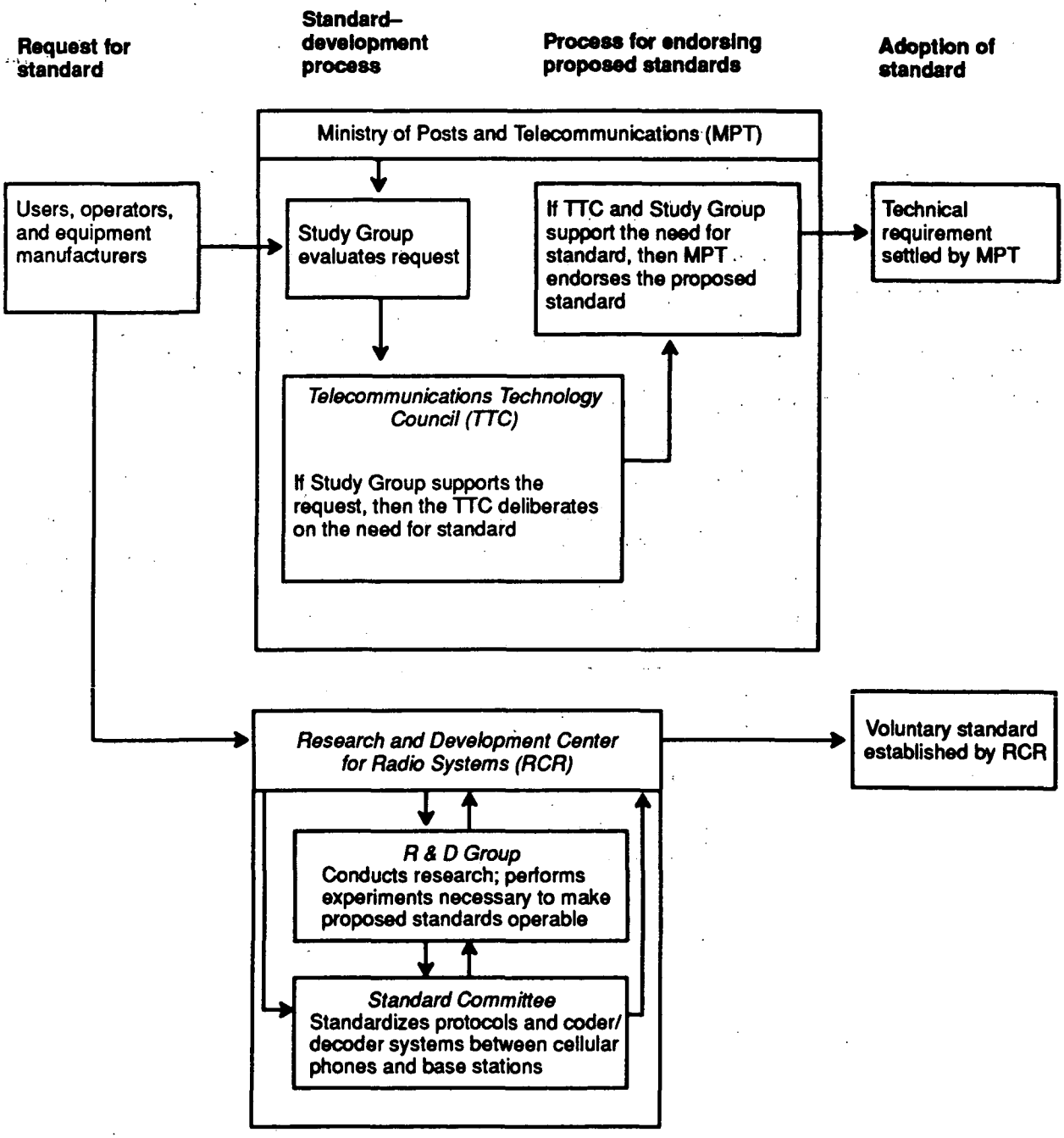
[93] Japanese industry representatives, interviews by USITC staff, Tokyo, Sept. 26-Oct. 2, 1992.

[94] Although such a policy would likely increase competition within the U.S. cellular equipment market, U.S. cellular equipment manufacturers interested in penetrating the Japanese cellular market should also benefit from similar standards, yet probably to a lesser degree.

[95] The Scandinavian countries offer an exception to the European analog cellular experience. In part, this is due to the adoption of the Nordic Mobile Telephone network (NMT). This sophisticated analog system operates on 450 MHz and 900 MHz frequencies, and allows subscribers to communicate freely within the Scandinavian countries. Additionally, it is a system that has been adopted by many governments in Europe (East and West), which has, in turn, significantly increased the economies of scale offered to Scandinavian NMT manufacturers Ericsson and Nokia.

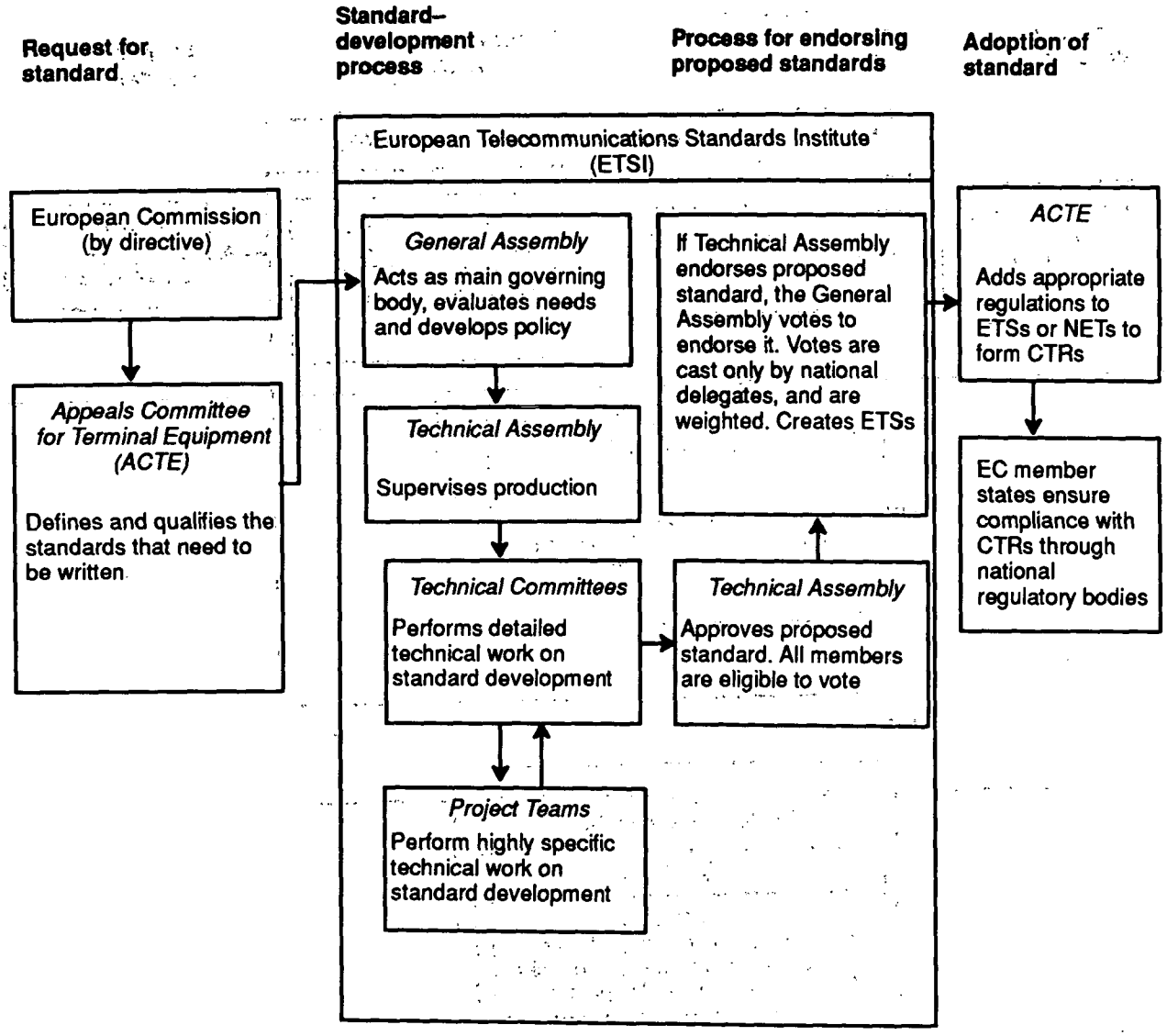
[96] Industry representative, interview by USITC staff, Washington, Nov. 10, 1992.

Figure 4-4
Standard-setting process in Japan



Source: Compiled by USITC staff.

Figure 4-5
Standard-setting process in Europe



Source: Compiled by USITC Staff.

Specifically, ETSI's current intellectual property rights (IPR) draft policy proposes that standards that are accepted as part of GSM will be automatically licensed to all GSM equipment manufacturers, without grant-back provisions. This policy, if adopted by ETSI, could significantly harm the international competitiveness of U.S. manufacturers since GSM is expected to be employed in many large markets throughout the world. Several U.S. industry representatives and U.S. Government officials have expressed concern that mandatory cross-licensing of patents jeopardizes the international competitiveness of U.S. firms, which finance the development of many new technologies.[97] There is also concern that ETSI is

[97] Perceptions regarding intellectual property rights are often colored by cultural biases. In the United States, manufacturers are generally required to finance research and development (R&D) programs. This requirement has caused many U.S. firms to view the fruits of research in a proprietary fashion. In Japan and Europe, conversely, governments often partially finance industry's R&D programs, thereby reducing the amount of risk assumed by the private sector while creating a less proprietary view towards technological advancements.

attempting to create policy that extends beyond the region in which it has jurisdiction (Europe), and that ETSI's draft conflicts with IPR policies supported by the International Organization for Standardization (ISO),[98] an international standards-setting body.

The structure of ETSI, which relies on weighted national voting to create policies endorsed by the General Assembly, effectively precludes non-European firms and governments from influencing ETSI's policies. U.S. equipment manufacturers and U.S. Government officials contend that the voting in the General Assembly, which is conducted on a country-by-country basis, greatly dilutes the influence of foreign equipment manufacturers. They contend that this situation is exacerbated by ETSI's voting procedures that link the weight of a member's vote to the amount of resources (financial and personnel) that a member is required to contribute to ETSI.[99] It has been reported that European regulators and TAs ostensibly control about 60 percent of the voting rights and, therefore, effectively determine ETSI's policies.[100]

Emerging Cellular Markets

Emerging cellular markets have generally settled on one of the three principal analog standards: AMPS, TACS, and NMT. Political ties and historic technical alliances have played a significant role in the selection of these standards.[101] Generally, manufacturers of these three system types have benefitted from economies of scale, which have not been available to equipment manufacturers of system types not accepted by large regions (e.g., Siemens manufactures equipment for C-NETZ, which is primarily used in Germany). Figure F-1 depicts the analog standards adopted by emerging cellular markets, the suppliers of the respective analog contracts,[102] as well as the digital standards that are expected to be adopted by these countries.

Generally, emerging cellular markets that have adopted the AMPS standard are expected to adopt the U.S. digital standards systems. Similarly, those emerging cellular markets that adopted NMT or TACS standards are expected to deploy the European digital system, GSM. However, as the U.S. cellular communication industry continues to deliberate on two potential standards, some emerging cellular markets that are facing immediate or near-term capacity shortages are adopting the European GSM standard, primarily because they view it as more commercially viable.[103]

Modified Final Judgment

In 1949, the Department of Justice filed suit against AT&T, seeking to force the company to divest Western Electric and require the Bell System to make its equipment purchases through a competitive bidding process.[104] The 1956 Consent Decree settled the case by prohibiting AT&T from manufacturing any products not used to provide common-carrier communication services.[105] The decree also forced AT&T and Western Electric to grant licenses for all past and future patents, opening the door for new entrants to commercialize AT&T's technology, while at the same time precluding AT&T from entering other markets.[106]

In the 1970s, as technological advances continued to change the nature of communication services, the Department of Justice reevaluated its earlier position set forth in the 1956 decree. Evidence increasingly supported the idea that, because of new technologies, other companies could efficiently provide certain services in competition with AT&T. In October 1974, the Department of Justice again filed suit against AT&T, charging that it had violated the Sherman Act by monopolizing the market not only for communication equipment but also for interstate communication services, and sought to separate both Western Electric and Bell Laboratories from AT&T.[107] In 1982, the suit was resolved by a compromise that modified the 1956 Consent Decree, known as the Modification of Final Judgment.

The terms of the MFJ required that AT&T divest monopoly lines of business (i.e., local service provision) from its competitive lines of business. In practice, the MFJ required that AT&T jettison its local Bell operating companies (BOCs), which were subsequently organized into seven RHCs on January 1, 1984. The MFJ removed the earlier decree restrictions that limited AT&T's manufacturing to communications equipment and authorized it to enter freely any market

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[98] The ISO IPR policy, which is supported by the American National Standards Institute, calls for the rightholder to agree to license its patents under "reasonable terms" and on "a non-discriminatory basis."

[99] This amount is largely determined by the amount of revenues the firm generates and, so, favors TAs and their suppliers that typically generate substantially larger revenues than do independent equipment manufacturers.

[100] U.S. industry representatives and U.S. Government officials, interview by USITC staff, Washington, fall 1992.

[101] Pyramid Research, Inc., Aug. 1991, p. 49.

[102] It is expected that manufacturers that supply countries with analog systems will have a comparative advantage in supplying digital contracts due to established business relationships, all other factors being equal.

[103] Several of these developing countries had based their analog systems on AMPS.

[104] United States v. Western Electric Co., Inc., and American Telephone and Telegraph Company, Civil Action 17-49 (D.N.J. 1949).

[105] Robert Crandall, *After the Breakup: U.S. Telecommunication in a More Competitive Era*, (Washington, DC: The Brookings Institution, 1991), p. 19.

[106] North American Telecommunications Association, *Industry Basics: Introduction to History, Structure and Technology of the Telecommunications Industry*, Washington DC, 1989.

[107] United States v. American Telephone and Telegraph Co., Civil Action 74-1698 (D.D.C. Nov. 20, 1974).

it chose. The MFJ also placed certain line-of-business restrictions on the activities of the RHCs that forbid the RHCs from entering competitive markets such as manufacturing communication equipment and from providing long distance (inter-LATA) and information services.[108] Also, in 1987, the U.S. District Court for the District of Columbia held that the manufacturing restriction prohibited the RHCs from designing and developing telecommunication equipment and customer premises equipment, as well as fabricating such equipment.[109]

Representatives from the RHCs differ in their estimation of the extent to which the MFJ restrictions have adversely affected their international competitiveness. Some RHC representatives have stated that the MFJ restriction on inter-LATA service has had an adverse affect on the competitiveness of the RHCs relative to the independent wireline and "pure-play" cellular carriers in the United States and has adversely influenced their overall competitiveness. By preventing RHC cellular service providers from offering inter-LATA service, the MFJ requires the RHCs to incur "hand-off" costs which are not required of independent cellular carriers. Absent a waiver, RHCs are required to pay long-distance carriers to provide connection between LATAs, even if the contiguous LATAs are served by the same RHC. Consequently, the RHCs are prevented from offering customers a low-cost, seamless network. As noted in chapter 3, U.S. cellular service providers now compete fiercely in terms of their ability to provide convenient, low-cost seamless coverage. The inability to match independent wireline and "pure-play" cellular service providers in terms of seamless coverage may adversely affect the competitive position of RHCs in their regional markets, depriving them of financial resources needed to maintain their competitiveness in foreign markets.[110]

Cellular service providers' compliance with inter-LATA service restrictions, moreover, is problematic. Reportedly, the 164 LATAs established by the Decree are not always contiguous and do not cover the entire United States. Also, there are 1,387 areas where cellular systems adjoin or overlap.[111] Of these, 1,135 involve LATA intersections.[112] The RHCs have been permitted to file petitions requesting that waivers be granted for certain inter-LATA restrictions on a case-by-case basis. However, the waiver-granting process is often lengthy, averaging 19 months.[113] In an industry that has doubled its number of subscribers in 19 months,[114] this delay is significant. As illustrated by tables G-1 and G-2 in appendix G, 58 specific waivers have been requested by the RHCs (or on behalf of the RHCs by AT&T)[115] since 1983.[116] Of the waivers requested, 24 are still pending. In addition to the individual waivers, the RHCs have requested that the inter-LATA prohibition of the MFJ be removed for mobile and other wireless services.[117] This request was filed with the Department of Justice on December 13, 1991, and is still pending.[118]

The MFJ restrictions also have prevented the RHCs from developing and investing in cellular equipment manufacturing. Several RHCs have noted that, absent the MFJ restriction, the RHCs would develop customized equipment to enhance existing operations.[119] Large equipment manufacturers reportedly have little interest in producing customized equipment due to unfavorable economies of scale.[120] Additionally, some industry analysts contend that the MFJ has indirectly prevented RHCs from gaining certain international contracts, as some foreign governments reportedly prefer to license companies that can provide both service and equipment.[121]

In addition, AT&T's ongoing acquisition of 33 percent of McCaw Cellular Communications, Inc., the United States' largest cellular service provider, poses further regulatory predicaments.[122] Acting within the confines of the MFJ, AT&T is entering another competitive market and will compete directly against a number of the RHCs. Unlike the RHCs, however, AT&T is a predominant manufacturer and supplier of cellular communication equipment, and is the United States' predominant supplier of inter-LATA service.

In terms of international competitiveness, the effects of the AT&T-McCaw alliance may be significant. For McCaw, which has cellular service licenses in Hong Kong and Mexico, the acquisition will eliminate about $2 billion of the firm's $5.3 billion debt and facilitate access to AT&T's manufacturing, marketing, distribution, and research expertise. The alliance may also hasten the provision of new services, such as the establishment of a single nationwide

[108] On July 25, 1991, a U.S. District Court order lifted the information services restrictions on the BOCs.

[109] In United States v. Western Electric, 675 F. Supp. 655 (D.D.C. 1987).

[110] However, U.S. District Court Judge Harold Greene recently issued a generic waiver of the RHCs' previous obligation to obtain permission to participate in foreign ventures that generate international long distance traffic to the United States. "Bell Waiver," *CommunicationsWeek International*, Feb. 15, 1993, p. 3.

[111] Application for a Waiver to Permit Southwestern Bell Corporation to Provide Intersystem Hand-Off Between Adjacent Systems at 26-27, United States v Western Elec. Co., No. 82-0192 (DOJ July 21, 1988).

[112] Ibid.

[113] Report of the Bell Companies on Competition in Wireless Telecommunications Services, 1991, Oct. 31, 1991, p. 153.

[114] Ibid.

[115] AT&T acted on behalf of the BOCs from 1982-84.

[116] U.S. industry representative, telephone interview by USITC staff, Washington, Nov. 13, 1992.

[117] Ibid.

[118] Ibid.

[119] U.S. industry representatives, interviews by USITC staff, San Francisco, CA, Feb. 8-9, 1993.

[120] Ibid.

[121] U.S. cellular industry representatives, interviews by USITC staff, Germany, Sept. 22-Oct. 9, 1992; San Francisco, CA, Sept. 23, 1992; and Washington, DC, Feb. 8-9 and Feb. 18, 1993.

[122] "Implications of AT&T's Step Into Wireless Arena," *Mobile Phone News*, Nov. 16, 1992, pp. 1-3.

telephone number for each cellular telephone user, which is an often-cited feature of personal communications.[123] For AT&T, the alliance presents the opportunity to reverse Ericsson's largest incursion into the U.S. equipment market to date—as a supplier of digital network equipment to McCaw. It also affords AT&T the opportunity to specialize in the production of equipment and services envisioned for personal communications.

Procurement

Procurement of cellular communication equipment is an issue of large concern primarily in Europe. Unlike in the United States and Japan, where cellular service providers are privately owned, at least one major cellular service operator in each European nation typically is owned and managed by the government. As a result, procurement policies in Europe, which appear to offer European cellular equipment manufacturers certain advantages over their international counterparts, have come to the forefront of recent negotiations between the United States and Europe.[124] Table 4-4 summarizes procurement policies in the United States, Japan, and Europe.

The EC Council directive on procurement,[125] which establishes procedures that would open government contracts to bidders from other EC member states, offers EC-based manufacturers a 3-percent price preference over manufacturers located outside of the Community. The directive also allows for the exclusion of bids that do not entail 50 percent or more local content, with respect to the value of products manufactured or services performed.[126]

The ramifications of implementing these procurement policies may place U.S.- and Japanese-based manufacturers at a competitive disadvantage when competing for many European equipment contracts, and could hinder the optimal use of technology by EC service providers. The EC procurement policy could also induce foreign direct investment in EC countries (e.g., the establishment of manufacturing sites) as foreign firms attempt to circumvent local content restrictions.

Personal Communications

In the United States, Japan, and Europe, personal communications are referred to as Personal Communication Services (PCS), Personal Handy Phones (PHP), and Personal Communication Networks (PCN), respectively (see table 4-5). However, the concept of personal communications has been broadly defined in all of these regions as full-featured communications that would offer ubiquitous wireless service through micro-cellular technology, relatively low-cost mobile service, inexpensive portable phones, and personal identification phone numbers. Table 4-5 compares the area of the radio spectrum that likely will house personal communications, the amount of spectrum that each carrier is expected to receive, the firms responsible for incurring the expense of moving incumbent spectrum users, and the technology that will be utilized to offer personal communications in the United States, Japan, and Europe.

[123] Richard Karpinski, "AT&T Strides Into Local Loop With Possible McCaw Deal," *Telephony*, Nov. 9, 1992, pp. 8-9.

[124] In 1992, the Office of the U.S. Trade Representative listed European procurement policies as a barrier to U.S. exports of goods and services (*1992 National Trade Estimate Report on Foreign Trade Barriers*, Office of the United States Trade Representative). In April 1993, negotiations between the U.S. Trade Representative and the European Community resulted in the termination of the price preferences for heavy electrical machinery, such as electric turbines. The price preference for telecommunications equipment remains in place.

[125] *Council Directive on Procurement Procedures of Entities' Operations in the Water, Energy, Transport, and Telecommunications Sectors*, 90/543/EEC, OJ No. L 297 (Oct. 29, 1990). This directive became effective Jan. 1, 1993, in most EC member states. It affects competitive tendering for all telecommunications contracts valued over ECU 600,000 (approximately $720,000).

[126] OJ No. L 297, article 29, (Oct. 29, 1990).

Table 4-4
Procurement policies for cellular communications equipment in select countries and regions

	United States	Japan	Europe
Government affiliated operator	None	None	EC-based firms have a 3% price preference
Private operator	Non-discriminatory	Non-discriminatory[1]	Non-discriminatory[1]

[1] Reportedly, consortia with a home country manufacturer as a member are more likely to obtain a license than those without, all other factors being equal.

Source: Compiled by USITC staff.

Table 4-5
Personal communications in the United States, Japan, and Europe

	United States[1]	Japan[2]	Europe[2]
	Personal Communications Service (PCS)	Personal Handy Phones (PHP)	Personal Communications Network (PCN)
Area of spectrum allocated for personal communications	1.8 - 2.0 GHz	1.9 GHz	1.8 - 2.0 GHz
Initial allocation of spectrum per carrier	20 - 40 MHz[3]	20 MHz	U.K. 50 MHz
Responsible for incurring expense of relocating incumbent to another frequency	New PCS carrier	Incumbent carrier	Incumbent carrier
Technology	Undecided	TDMA	TDMA (GSM standard)

[1] FCC ET Docket No. 92-9, September 17, 1992.
[2] Industry representative, interview by USITC staff, Washington, DC, Nov. 23, 1992.
[3] The FCC has proposed an allocation of 20, 30, or 40 MHz of spectrum, with a preferred option of 30 MHz (FCC Gen. Docket 90-134, ET Docket 92–100, July 16, 1992).

Source: Compiled by USITC staff.

As discussed in chapter 2, personal communications is predicted by some analysts to be a $60 billion industry by the year 2000, serving as many as 150 million people worldwide and 60 million people in the United States. Many of the nations which compete in wireless communications, including the United States, have pursued policies that promote the development of personal communication industries. Many of these nations are attempting to implement personal communications quickly, so that the service and equipment developed by domestic firms can compete successfully in the international marketplace.

The following is an examination of the development of personal communications in the United States, Japan, and Europe.

United States

In the United States, the FCC is currently deliberating over PCS. Recently, the FCC allocated 220 MHz of spectrum for PCS in the 2 GHz range to act as a testing ground for "emerging technologies."[127] The FCC is encouraging firms intending to offer PCS to apply for this spectrum so that industry can develop an advanced PCS system that meets consumer demands, while satisfying FCC technical specifications. Many see this as a strategy that will ensure the deployment of nationally compatible systems that will be widely accepted by consumers. Others believe that these tests delay the offering of PCS to the public unnecessarily, thereby putting U.S. firms at a disadvantage internationally.

The FCC, by proposing that PCS be offered in the 2 GHz range, is placing emerging PCS technologies in direct competition with incumbent microwave users.[128] This is not a situation unique to the U.S. telecommunication industry, as many European and Asian countries also have located microwave users in the 2 GHz range. However, the FCC has shown greater concern for incumbents than have many of its foreign counterparts. For example, the FCC is requiring that PCS operators incur all expenses associated with relocating the fixed microwave user from the 2 GHz range to a "comparable" frequency.[129] Alternatively, many nations that compete with the United States in wireless telecommunications have shown little concern for incumbents, offering little or no compensation to users that are forced to relocate

[127] FCC, *Emerging Technologies Docket No. 92-100*, Sept. 17, 1992.

[128] The 2 GHz range is presently used for microwave communications by utilities, railroads, and the petroleum industry.

[129] FCC, *ET Docket No. 92-9*, Sept. 17, 1992.

from frequencies best suited for PCS. Thus, many of U.S. firms' foreign competitors may experience lower market entry costs.[130]

The FCC is also deliberating over which firms should be entitled to offer PCS in the United States.[131] Those who view the introduction of PCS as an avenue to augment existing levels of competition within the domestic wireless telecommunication market believe that cellular service providers should be restricted in offering PCS[132] (see appendix H for specific firms' proposals). Many of these officials maintain that without restrictions, new PCS firms will not be able to compete effectively, given the existing advantages of cellular service providers (e.g., existing networks, customer bases, and supplier relationships). Conversely, those who view PCS as a natural extension of cellular services assert that many of the services to be offered through PCS can be offered through cellular networks.[133] The latter contend that restricting existing cellular service providers would reduce important economies of scale since the market would be further segmented.

The FCC has proposed several possible licensing areas for PCS to industry, including 487 "basic trading areas" and 49 "major trading areas" (as defined by Rand-McNally), the 164 LATAs, and nationwide licenses.[134] However, industry is divided on which proposal to endorse. Those opposing the adoption of "trading areas" believe that this would further complicate, as well as fragment, the domestic wireless communication market (since cellular would continue to be based on MSAs and RSAs). Those opposing LATAs as the basis of the PCS market believe that customers' needs are no longer reflected by LATA schematics, and that without the removal of MFJ inter-LATA restrictions, existing wireline operators would be at a considerable disadvantage (see section entitled "Modified Final Judgment"). Finally, opponents of nationally licensed operators contend that this would discriminate against smaller operators, as they would be unable to secure the necessary funds.

Japan

The MPT has announced plans to authorize the "Personal Handy Phone System" in the 1.9 GHz band, and has begun to move incumbent microwave users to different frequencies. Presently, Japan plans to reserve 20 MHz for PHP communication, with an ultimate allocation of at least 100 MHz planned.[135] Reportedly, the MPT views personal communications as distinctly separate from services offered by existing cellular service providers, believing that it will satisfy a separate and distinct customer base. Personal communications will reportedly be offered through private networks[136] and, so, will not be subject to foreign ownership restrictions that apply to common carriers.[137] Consequently, it appears that personal communications will develop in a competitive environment, less regulated by government and more regulated by market forces.

Europe

Personal communications in Europe, which is sometimes referred to as PCN or DCS-1800, will be based on GSM standards,[138] yet will utilize a higher frequency band. Like the GSM digital network, the European personal communication standards are expected to be very complex, and result in more expensive, relatively large, handsets. In addition, the technology which is being used for Europe's personal communications may not offer the large capacity available over proposed U.S. systems. However, wide international acceptance of GSM for digital cellular communications will likely create a solid foundation from which to promote European technology and offer the European personal communications industry a significant competitive advantage over its U.S. and Japanese counterparts.

In Europe, the regulating agencies have encouraged the development and deployment of personal communications by rapidly licensing new technologies and allocating the necessary radio spectrum. To date, the United Kingdom has licensed three personal communications operators, and Germany has licensed one quasi-personal communications operator.[139] Most European countries are providing the necessary spectrum by clearing existing services from the frequency band. However, unlike in the United States, incumbents are usually displaced at their own cost. Reportedly, respective governments displace incumbents by declining to renew existing licenses.

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[130] U.S. industry representative, interview by USITC staff, Washington, DC, Oct. 6, 1992.

[131] Although the FCC has proposed a minimum of three PCS licenses at the 2 GHz range, and sought comments on whether four or five licenses would be more

[132] Restrictions that have been suggested range from excluding cellular service providers entirely from the PCS market to excluding them only within areas where they currently offer cellular service.

[133] Either through existing networks, modifications, or increased cell-splitting.

[134] FCC, *Gen. Docket No. 90-314, ET Docket 92-100.*

[135] Kurt A. Wimmer, "Global Development of Personal Communications Services," *Communications Lawyer*, summer 1992.

[136] U.S. Government official, interview by USITC staff, Washington, DC, Oct. 15, 1992.

[137] Certain countries have foreign ownership restrictions on cellular service carriers. In Japan, foreign ownership of cellular systems is limited to 33 1/3 percent. In the United States, foreign ownership is restricted to 25 percent. In Europe, limits of foreign ownership vary by country. For example, no restrictions exist in the United Kingdom and Germany, while foreign ownership is limited to 25 percent in France.

[138] The information in this section is based on USITC staff interviews with U.S. cellular industry representatives, Washington, DC, Oct.-Nov. 1992.

[139] In 1992, two of the British PCN operators, Mercury PCN (Cable & Wireless) and Unitel (US West) merged their operations. See chapter 5, section entitled "Cellular Service Providers" for further discussion.

CHAPTER 5
Competitive Assessment

Chapter Introduction

This chapter evaluates the competitive performance of the U.S. cellular communications industry. Separate discussions are provided for each industry sector because the nature of competition varies in each one, as discussed in chapter 3. Using both qualitative and quantitative analysis, each discussion assesses factors that most significantly influence firms' competitiveness. These key factors, presented in figure 3-1, were identified over the course of more than 70 interviews with industry representatives, research organizations, and government agencies.[1] Cellular service providers' competitiveness is principally influenced by home market experience and government policies. Cellular network equipment producers are most affected by radio research, development, and manufacturing experience; wireline switch manufacturing and marketing experience; and strategic alliances. Finally, cellular phone manufacturers' competitiveness is most affected by radio manufacturing experience, integrated circuit core competency, and advanced manufacturing techniques. Each discussion concludes by identifying new challenges and opportunities awaiting firms in each sector.

Cellular Service Providers

Introduction

Cellular service providers' experiences in their home markets have a significant impact on their international competitiveness, influencing their ability (1) to find partners in foreign markets and (2) to win operating licenses in these markets. Firms that face competition in their home markets are more likely to have developed technical, marketing, and cost management skills, all of which make them attractive as potential consortium or joint venture partners. In turn, firms that have developed these skills enhance the competitiveness of their respective consortia, increasing the likelihood of winning the cellular service license.

[1] Refer to appendix C for a complete list of firms, associations, and government agencies interviewed by Commission staff.

In addition to the experience and skills required of cellular service providers, firms endeavoring to forge partnerships with foreign firms and win foreign cellular service license awards compete in terms of financial resources, government support, and cultural sensitivity. The relative importance of these secondary factors appears to vary by region, but only rarely do they displace experience and expertise as the primary terms of competition (table 5-1). However, because the secondary terms of competition vary so widely among regions, the competitive assessment below is approached on a region-by-region basis.

Table 5-2 provides information on cellular licenses awarded to foreign firms from 1989-93 in key cellular service markets in Western Europe and Japan. Table I-1 provides information regarding foreign licensees in emerging cellular markets. Figure 5-1 shows that U.S. firms have been very competitive internationally; U.S. firms in partnerships and consortia account for 48 percent of all analog cellular service licenses awarded by home country authorities to foreign firms.[2]

Key Cellular Markets

United States

At present, there is no direct foreign participation in the U.S. cellular communications industry. Although section 310.a of the Federal Communications Act of 1934 limits direct foreign ownership of radio licenses to 25 percent, it appears that other factors have also contributed to the lack of foreign participation in U.S. cellular licenses.

The FCC awarded nonwireline cellular licenses from the early to the mid-1980s, when most other countries' cellular industries were either nonexistent or in the earliest stages of development. As a result, foreign firms can participate directly in the U.S. cellular market only by purchasing licenses on the resale market, which has become prohibitively expensive due to aggressive bidding by U.S. firms.[3]

[2] The "Summary and Outlook" section of this discussion provides information on the distribution of foreign digital cellular service licenses.

[3] European industry representatives, interview by USITC staff, London, Sept. 23, 1992.

Table 5-1
Factors influencing international competition, by regions and countries

Region/Country	Primary factors		Secondary factors		
	Experience	Skills[1]	Financial Resources	Government Activity	Cultural Factors
Key foreign markets					
Europe	X	X		X	
Japan				X	X
Emerging foreign markets					
Asia/Pacific	X	X	X		X
Latin America	X	X	X		X
Eastern Europe & former Soviet Union	X	X	X		X

[1] Includes cost management, technical, and marketing expertise.

Source: Compiled by USITC staff.

Due in part to the efficiencies of enlarging contiguous service areas, the largest U.S. cellular service providers have acquired additional cellular licenses in adjoining markets.[4] Bidding among the primary U.S. service providers has resulted in a concentrated industry in the United States, with McCaw Cellular Communications, GTE, and the Bell regional holding companies controlling about 74 percent of the total market as measured by number of total subscribers.[5]

Overall, therefore, the U.S. cellular service market is a relatively unattractive foreign investment prospect, in large part due to the high price of market entry and the entrenched positions of the largest firms. Foreign investors appear to be more interested in emerging cellular markets, where competition tends to be less intense.

A few foreign firms have participated indirectly in the U.S. cellular communications industry by purchasing equity stakes in "pure-play" cellular companies. In 1989, British Telecom diversified its operations by purchasing a 22-percent stake in the parent company of McCaw Cellular Communications, the largest U.S. cellular service provider.[6] However, BT has little or no operating responsibilities in the individual McCaw cellular markets.[7] In 1992, AT&T announced plans for the acquisition of BT's stake in McCaw, as well as an additional 11 percent of McCaw stock.[8] When the acquisition is completed, there will be no foreign participation in the U.S. cellular service industry.

[4] U.S. industry analyst, interview by USITC staff, New York, NY, May 6, 1992.

[5] Donaldson, Lufkin & Jenrette, *The Cellular Communications Industry*, spring 1992, p. 12.

[6] Ibid.

[7] U.S. industry representative, interview by USITC staff, Kirkland, WA, Feb. 10, 1993.

[8] AT&T purchased $400 million of McCaw stock in February, 1993. "Digest," *Washington Post*, Feb. 24, 1993, p. D2. For competitive implications of the transaction, see chapter 4, section entitled "Modified Final Judgment."

Europe

In Western Europe, foreign entry to individual countries' cellular communication markets has coincided with the introduction of competition in the telecommunications arena. Many governments have used the advent of GSM, the pan-European digital cellular standard, to license private service providers to compete with the former monopoly cellular service provider.[9] Most of the available European licenses have been awarded to consortia of local and foreign firms.[10] It appears that both the governments and the lead companies in the private cellular consortia have reason to welcome foreign participation in the industry. The EC member state governments, under pressure from the EC Competition Directorate, have apparently used the cellular communications industry to demonstrate their commitment to telecommunications liberalization. The lead companies benefit from the overall experience and expertise of foreign cellular service providers, particularly the U.S. RHCs, the most active foreign participants in the European cellular market.

[9] In 1989, the British Government introduced additional competition in the industry by licensing three personal communications providers to compete with the two existing cellular service providers. Mercury, the second British wireline carrier, automatically received one of the personal communications licenses. The others were awarded to consortia composed largely of non-British firms.

[10] To date, only the Finnish GSM consortium has no foreign participation. PTT Ministry representatives stated that no foreign firms expressed interest in the license. Finnish PTT representative, interview by USITC staff, Helsinki, Sept. 30, 1992.

Table 5-2
Foreign participation in cellular licenses, key foreign markets, 1993

Country/City	Partners	Ownership	Award Date	Comments
		(Percent)		
Denmark	*Dansk Mobiltelefon*		1991	GSM license.
	BellSouth (US)	29.0		NordicTel group: Vodafone (UK), SAS,
	GN Great Northern (Denmark)	51.0		Volvo and other Swedish firms. $120 million
	NordicTel (Sweden/UK)	20.0		investment 1990-2000 for system construction.
France	*Societe Francaise du Radiotelephone (SFR)*		1989	Analog (NMT) and GSM licenses
	Compagnie Generale des Eaux (France)	42.0		
	BellSouth (US)	4.0		
	Vodafone (UK)	4.0		
	Fabricom (Belgium)	25.0		
	Magneti Marelli (Italy)	25.0		
Germany	*E-Plus*		1993	1.8 GHz PCN license. Network will cost $1.2 billion
	Thyssen AG (Germany)	28.0		to build.
	Veba AG (Germany)	28.0		
	Bell South (US)	21.0		
	Vodafone (UK)	16.0		
	Caisse des Depots (France)	2.0		
	Other German companies	5.0		
Germany	*Mannesmann Mobilfunk*		1989	GSM license.
	Mannesmann AG (Germany)	51.0		$500 million-$1 billion front-end investment.
	Pacific Telesis (US)	26.0		
	Deutsche Genossen Bank (Germany)	10.0		
	Lyonnaise des Eaux (France)	8.0		
	Cable & Wireless (UK)	5.0		
Greece	STET (Italy)	100.0	1992	GSM license.
				Submitted highest bid of $160.9 million.
				Both Greek licenses: 20 years' duration,
				but exclusive for only 8 years. STET is the
				holding company for Italy's PTT, SIP.
Greece	*Panafon*		1992	GSM license. 2nd highest bid — $160.3 million, ahead
	Vodafone (UK)	45.0		of Motorola's $130.2 million bid. The other short-listed
	France Telecom	35.0		US bidders — US West (originally part of Panafon
	Intracom (Greece)	10.0		consortium), Southwestern Bell, Pacific Telesis
	Data Bank (Greece)	10.0		and AT&T — withdrew before final decision
				was made.
Japan	*TU-KA Cellular Tokyo*		1991	1.5 GHz digital license. Expected on-line
Tokyo/Nagoya	Nissan (Japan)	26.0		1994. Capitalized at $29 million.
	DDI (Japan)	26.0		
	Motorola (US)	8.0		
	GTE (US)	3.0		
	US West (US)	2.0		
	NYNEX (US)	1.0		
	BT (UK)	5.0		
	Sony (Japan)	5.5		
	Hitachi (Japan)	5.5		
	Rogers Cantel (Canada)	2.0		
	Various Japanese firms	16.0		

Table 5-2—Continued
Foreign participation in cellular licenses, key foreign markets, 1993

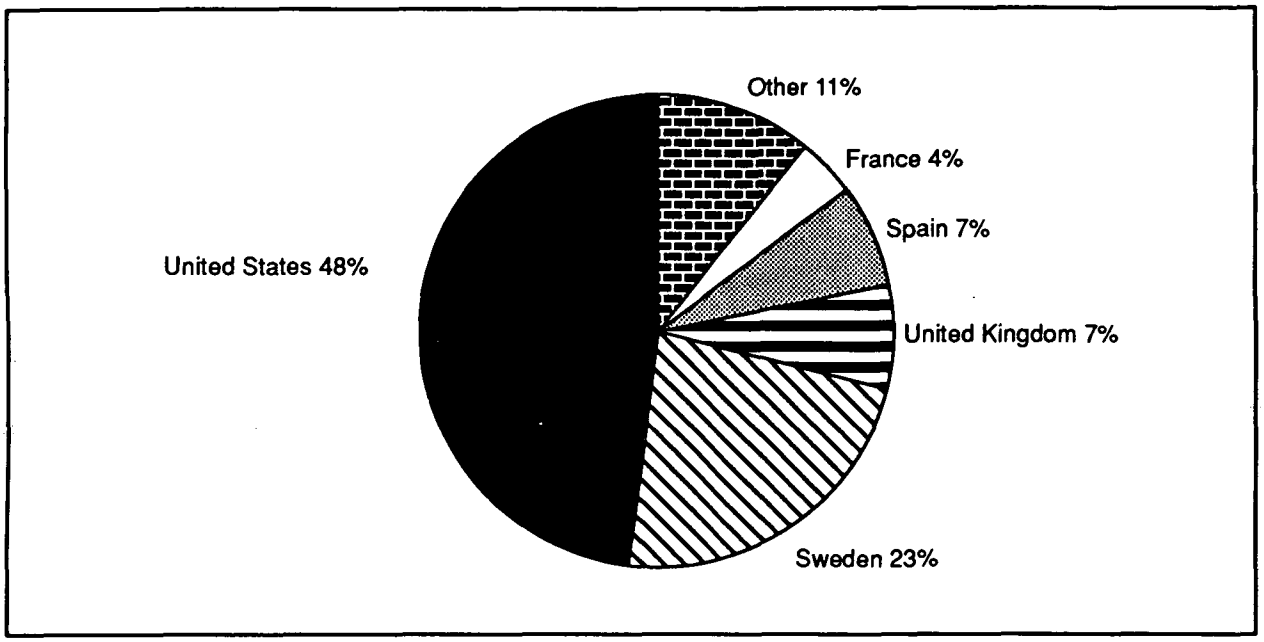
Country/City	Partners	Ownership	Award Date	Comments
		(Percent)		
Japan				
Osaka/Kobe/Kyoto	*TU-KA Cellular Kansai*		1991	
	Nissan Motors (Japan)	34.0		
	Kobe Steel (Japan	9.0		
	Hitachi (Japan)	9.0		
	BT (UK)	5.0		
	Marubeni (Japan)	5.0		
	Matsushita (Japan)	6.5		
	NYNEX (US)	2.0		
	GTE (US)	1.5		
	Motorola (US)	0.25		
	Other Japanese firms	27.25		
Japan	*Kansai Digital Phone Company*		1991	1.5 GHz digital license. Service to begin in 1994. Captialized at $29 million.
Osaka/Kobe/Kyoto	Japan Telecom Ltd.	27.0		
	Pacific Telesis (US)	13.0		
	West Japan Railway	12.0		
	Toyota (Japan)	11.0		
	Cable & Wireless (UK)	7.2		
	Various Japanese firms	29.8		
Japan	*Tokyo Digital Phone Company*		1991	Expected on-line by 1994. Capitalized at $29 million.
Tokyo/Nagoya	Japan Telecom, Ltd.	29.5		
	Pacific Telesis (US)	15.0		
	Tokai Railway (Japan)	12.0		
	Metrophone Group (Japan)	12.0		
	Cable & Wireless (UK)	8.0		
	Toyota (Japan)	4.0		
	Nippon Steel (Japan)	4.0		
	Other Japanese firms	15.5		
Norway	*Netcom GSM*		1991	GSM license.
	Comvik (Sweden)	33.0		In January 1993, Ameritech International (US) and Singapore Telecom agreed to purchase a 49.9 percent stake in Netcom.
	Orkla Borregaard (Norway)	67.0		
Portugal	*Telecel*		1991	15-year GSM license. PacTel will invest $44 million, 1991-1994. Expected on-line in 1993. Foreign ownership limited to 25 percent.
	Espirito Santo (Portugal)	31.25		
	Amoria (Portugal)	31.25		
	Pacific Telesis (US)	23.00		
	Efacec (Portugal)	6.25		
	Centrel (Portugal)	6.25		
	LCC (US)	2.00		

Table 5-2—Continued
Foreign participation in cellular licenses, key foreign markets, 1993

Country/City	Partners	Ownership	Award Date	Comments
		(Percent)		
Sweden	NordicTel (Sweden/UK)	100.0	1991	Third GSM license. NordicTel consortium also owns 20% of Denmark's second GSM license.
The Netherlands			To be awarded	GSM license. Bidders include consortia led by the 3 major Dutch banks and Millicom International Cellular (Sweden/US). BT (UK), GTE (US), PacTel (US) and Mannesmann Mobilfunk (Germany) are among the foreign companies vying for positions in the consortia.
Italy			To be awarded	GSM license. Foreign bidders include Vodafone (UK), with a 25 percent stake in the FIAT-led consortium; Swedish Telecom, Bell Atlantic (US) and Cellular Communications, Inc. (US) in the Olivetti-led consortium; Pacific Telesis (US) in a group of small and mid-sized Italian companies; and BellSouth and Millicom in an ENI-led group. Award has been delayed because the state-owned operator contends that its contract grants it a monopoly on cellular service through 2004.

Source: Compiled by USITC staff from various issues of *Communications Week International, Telephony, Mobile Phone News, FCC Report,* and *Mobile Communications.*

Figure 5-1
Share of analog cellular service licenses awarded to foreign firms, by countries of licensees, 1993



Source: Compiled by USITC staff.

Consortia formation

In Western Europe, the first stage of market entry for foreign firms takes place at the consortium level. Consortia are usually led by major local industrial concerns seeking to diversify their operations. Internationally successful cellular service providers typically are those that can find local partners with political influence, financial resources, and familiarity with the national market.[11] These local firms, usually having no previous involvement in the telecommunications industry, look to foreign telecommunication service providers for technical expertise.[12]

In Western Europe, highly valued areas of expertise are marketing, network management, software development (particularly vital for network design and the establishment and operation of billing systems), and customer service. West European consortia leaders also search for firms with "entrepreneurial spirit" forged in competitive home markets.[13] As a result, RHCs such as the cellular subsidiaries of Pacific Telesis and BellSouth, and British and Swedish cellular service providers Vodafone and Comvik, to a lesser extent, are the major participants in new West European license consortia.

In addition, certain lead companies in license consortia reportedly value the RHCs because in the past they have brought support from the U.S. Government.[14] This is especially helpful with regard to regulatory issues. For example, Pacific Telesis is a partner in the Mannesmann Mobilfunk consortium that holds the private GSM cellular license in Germany. When MMF encountered difficulties with DBP Telekom, the German telecommunications authority, on issues such as leased line tariffs and the ability to construct microwave transmission links, the U.S. Government assisted MMF in persuading the German Ministry of Posts and Telecommunications to achieve a favorable settlement of the dispute.[15]

Government licensing

In the second stage of market entry, governments decide which consortia will receive cellular licenses. West European governments generally choose the winning consortia on the basis of the best overall

[11] U.S. industry representatives, interview by USITC staff, San Francisco, CA, Feb. 9, 1993.

[12] In addition, U.S. participation in foreign license consortia may serve as a means of technology transfer for the lead companies that seek to diversify away from their core businesses and enter the telecommunications service provision market.

[13] U.S. industry representative, interview by USITC staff, London, Sept. 22, 1992; Robert L. Simison, "Babes in Europeland: Fenced in at Home, Regional Firms See Greener Grass in Europe," *Wall Street Journal*, Oct. 4, 1991, p. R5.

[14] European industry representative, interview by USITC staff, Germany, Oct. 5, 1992.

[15] Ibid.

technical qualifications and marketing plans. These governments also consider bidders' financial resources and plans for improving service quality and geographic coverage.[16] The latter two qualifications are increasingly important, given governments' interest in expanding the market for cellular communications and developing the high quality telecommunications infrastructure required for overall economic competitiveness.

Cellular service providers' relationships with equipment manufacturers sometimes play a role in the governments' final decisions. As reported in chapter 4, representatives of certain RHCs believe that the Modified Final Judgment's prohibitions on designing and developing network equipment and software leaves them at a competitive disadvantage because such restrictions limit cooperative efforts.[17] Others state that the MFJ ban on equipment manufacturing does not significantly disadvantage the RHCs relative to foreign competitors.[18] Some RHC representatives report that the prohibition on manufacturing gives them more flexibility in equipment procurement, and therefore, more leverage with equipment manufacturers.[19]

Japan

In 1991, the Japanese Ministry of Posts and Telecommunications (MPT) awarded nationwide digital cellular licenses to Digital Phone Group and Tu Ka Cellular Phone Company, Japanese-led consortia with many foreign participants. The MPT's decision to license additional cellular service providers, resulting in a total of four in each region, appears to have been influenced significantly by the premise that additional service providers would result in larger markets for equipment manufacturers, thus beginning a so-called virtuous circle of greater economies of scale, lower terminal equipment prices, increased subscriber growth, and finally, further increases in equipment sales.[20]

The Japanese licensing process is less transparent than West European processes, and tends to be conducted on an informal, verbally communicated basis. It appears that telecommunication service licenses are awarded through negotiations with the MPT, the winner being the firm or consortia whose business plans best conform to MPT's objectives.[21] With respect to the Japanese cellular communication service market, some degree of foreign participation apparently was one of the MPT's goals, given the trade friction between the Japanese and U.S. Governments.[22] However, certain industry sources have alleged that foreign firms' proposed stakes in the licensed consortia were negotiated downward by the MPT.[23] Thus, table 5-2 shows that, with the exception of Pacific Telesis' participation, foreign stakes in Digital Phone Company and Tu Ka Cellular are relatively small.

Foreign firms principally are investors in Japan's new digital cellular ventures and apparently will not have significant roles in the construction and operation of the networks,[24] something analogous to BT's participation in McCaw in the United States. Technological, marketing, and cost management expertise do not appear to have been major factors in the Japanese lead companies' selection processes. Apart from foreign firms' ability to provide the funds necessary to purchase stakes in the cellular service licenses, the lead companies' selection criteria are unclear. However, because there are eight foreign firms in the two new digital license consortia, it is possible that all foreign parties that expressed interest in participating were accommodated.[25]

Despite the limitations, most non-Japanese firms are eager to invest in Japan's cellular communications industry. One U.S. firm, for instance, views participation in the digital consortia as a relatively low-risk, low-cost means of entering the Japanese telecommunications market and learning about the business climate and opportunities in Japan. Representatives of this firm also suggest that foreign firms' participation is designed to demonstrate to the MPT a willingness to conform to the rules of the Japanese system.[26]

Emerging Cellular Markets

In emerging cellular markets, foreign telecommunication service providers have been instrumental in the development of cellular communications. Governments in emerging markets tend to view cellular communications as an attractive short-term means of satisfying demand for basic telecommunication services, given inadequate wireline networks and the time and financial resources required for modernization. Generally, these governments lack the investment funds and the technical and managerial skills that are required to build and operate cellular networks. Therefore, in light of growing demand for reliable communication services, particularly on the part of business customers, the participation of foreign firms is seen as a means of introducing basic telecommunication services rapidly and efficiently at minimal cost to the government.

[16] Ibid.

[17] U.S. industry representative, telephone interview by USITC staff, Washington, DC, Sept. 8, 1992.

[18] U.S. industry representatives, interview by USITC staff, Washington, DC, Aug. 19, 1992. See chapter 4 for a full discussion of the MFJ provisions and their effects.

[19] Ibid.

[20] Japanese industry representatives, interviews by USITC staff, Tokyo, Sept. 26-Oct. 2, 1992.

[21] Ibid.

[22] For further background, see Laura D'Andrea Tyson, "Managing Trade By Rules and Outcomes," *California Management Review*, fall 1991, pp. 121-131.

[23] Japanese industry representatives, interviews by USITC staff, Tokyo, Sept. 26-Oct. 2, 1992.

[24] Ibid.

[25] Ibid.

[26] U.S. industry representative, interview by USITC staff, Washington, DC, Jan. 7, 1993.

Governments generally welcome foreign participation in cellular communications ventures because foreign companies typically provide much-needed finance capital, technical expertise, and management skills.[27] The public sector or local partners generally contribute domestic capital to cover the cost of labor, construction material, and other operational expenses. In public-private partnerships, governments generally obtain their share of capital through loans and credits from multilateral institutions such as the World Bank and the European Bank for Reconstruction and Development.[28]

The lack of transparency in the cellular licensing process makes it difficult to determine the relative importance of the various competitive factors in many emerging cellular markets. In the initial stages of the licensing process, some governments solicit bids and then compile a short list of candidates based on their technical, business, and financial proposals. At this stage, monetary and political considerations also appear to be important selection criteria. Many governments have awarded licenses to the highest bidder through formal or informal auctions, with revenue maximization being the principal goal.[29]

The Polish cellular licensing process provides a good example of informal auctioning. According to industry sources, after reviewing the applications on the basis of technical and business factors, the Polish Government chose several finalists and announced that the winning bidder would be asked to make a cash "donation" for the modernization of the wireline telephone network.[30] At this point, short-listed candidates such as U S West and Swedish Telecom International withdrew their applications and the license was awarded to a consortium of Ameritech and France Telecom, reportedly on the basis of their ability and willingness to offer $70 to $100 million.[31] Venezuela provides an example of a formal auction-based licensing procedure; BellSouth won the license after submitting a bid of $100 million.[32]

In other cases, cellular licenses in emerging markets have apparently been awarded through a non-competitive process involving negotiations between the relevant authorities and the consortia proposing to build and operate a cellular network.[33] Governments that lack the necessary experience to judge competitive bids on the basis of relative merit tend to favor this option as a means of expediting the process.[34] Negotiated licensing procedures are most common in Eastern Europe, the former Soviet Union, and smaller countries, such as Sri Lanka and Guatemala. Some of the negotiated licenses were won on the basis of the foreign firms' pre-existing relationships with government agencies or officials. For example, U S West, which won licenses in Hungary and Russia, established and maintained contacts with telecommunication officials in Hungary and the Soviet Union during the 1980s.[35]

Because cellular service is often used as a substitute for antiquated or congested wireline telephone service in emerging markets, governments in certain emerging markets tend to favor firms or consortia that can rapidly construct cellular networks.[36] For example, one of the conditions placed on potential GSM licensees in Hong Kong was that 50 operational cell sites be constructed within 6 months of the license award. McCaw, a member of the consortium that won the license, has asserted that its extensive experience in the fast-paced U.S. market provided it with the ability to achieve this goal.[37]

Finally, many industry sources have cited "reputation," "entrepreneurial spirit," and "the influence of the U.S. Government" as being important intangible factors that contribute to the competitiveness of U.S. firms in international license consortia in emerging markets.[38] During the 1980s, the U.S. Government negotiated on behalf of firms like Motorola to open the Japanese market to U.S. telecommunications equipment and services.[39] As a result of this precedence, the Korean Government reportedly encouraged Korean lead companies to seek out U.S. cellular service providers to participate in license consortia.[40] It appears that the Korean Government sought to avoid a repetition of the difficult trade negotiations that took place between the U.S. and Japanese Governments.

A considerable number of foreign companies are seeking to provide cellular service in emerging markets. The RHCs, McCaw, GTE, and the European TAs tend to focus on the larger emerging markets with obvious commercial potential whereas smaller players such as Millicom International Cellular (MIC), a majority Swedish-controlled joint venture of Comvik (Sweden) and Millicom, Inc. (United States), tend to

[27] U.S. industry representative, interview by USITC staff, Bedminster, NJ, Apr. 13, 1992.

[28] Ibid.

[29] U.S. industry representative, telephone interview by USITC staff, Washington, DC, Nov. 18, 1992; U.S. industry representative, interview by USITC staff, London, Sept. 22, 1992; U.S. industry representative, interview by USITC staff, New York, NY, Nov. 23, 1992.

[30] "Telecommunications in Eastern Europe: Finding Their Voice," *The Economist*, Feb. 8, 1992, p. 74.

[31] U.S. industry representative, interview by USITC staff, London, Sept. 23, 1992.

[32] Pyramid Research, 1991, p. 264.

[33] Andreas Evagora, "Ukraine Readies Mobile," *CommunicationsWeek International*, May 25, 1992, p. 4.

[34] Ibid.

[35] Gary Slutsker, "It's Who You Know," *Forbes*, July 6, 1992, p. 46; Steven Titch, "The Liberalization Express Roars Through Hungary," *Telephony*, June 3, 1991, pp. 36-44.

[36] U.S. industry representative, interview by USITC staff, New York, NY, Nov. 23, 1992.

[37] Representatives of McCaw Cellular Communications, interview by USITC staff, Kirkland, WA, Feb. 10, 1993.

[38] Ibid.

[39] For further background, see Laura D'Andrea Tyson, "Managing Trade by Rules and Outcomes," *California Management Review*, fall 1991, pp. 121-131.

[40] U.S. and Korean industry representatives, interviews by USITC staff, Seoul, Oct. 2-5, 1992.

specialize in smaller emerging markets such as Lithuania, Sri Lanka, and Costa Rica.[41] It appears that MIC's international strategy involves building networks and developing markets in various countries with a view toward eventual resale of the licenses.[42] For example, Millicom was one of the earliest foreign participants in the Hong Kong cellular market. In 1991, it sold its stake in the Pacific Link license to the other major partner in the consortium for $150 million.[43] Yet, it appears that as more countries move toward auction-based licensing, MIC and other small companies will find it increasingly difficult to compete for international cellular licenses.[44]

Whereas the RHCs' technical, marketing, and cost management expertise has served them well in Western Europe, it has not enhanced their competitiveness to an equal extent in many emerging markets. This situation is partly due to the prevalence of monopoly licensing in some of these markets. However, industry sources believe that U.S. service providers' expertise, combined with governments' interest in technology transfer via the RHCs' long-standing ties with major equipment manufacturers, still work to the advantage of U.S. firms.[45]

Evidence from Statistical Analysis

Statistical analysis performed by USITC staff supports a number of common themes identified in interviews with industry representatives. Using data on 24 service providers, staff sought to examine the significance of factors that were related to the winning of license awards during the period 1988-91 in Europe, Japan, and emerging cellular markets.[46]

Although it was impossible to measure directly the technical, marketing, or cost management expertise that stem from home market experience, industry sources provided data on several sorts of experience that contribute to this expertise. As the following tabulation shows, a service provider's probability of winning each new foreign license award increased with its experience, measured by the number of subscribers in its home market. The probability of winning an award was also greater for firms that had experience in competitive home markets, indicating the significant influence of government licensing practices. Furthermore, firms were more likely to win awards in countries that (1) had adopted a technical standard in which the firms had experience or (2) were located in a region where the firms had prior marketing presence. Experience with relevant standards and prior marketing presence are believed to contribute to the development of technical and marketing expertise among cellular service providers. In addition, the latter factor may reflect greater cultural sensitivity, which helps firms to find local partners and win license awards.

Factor	Effect on winning	Statistical confidence level
Experience	Positive	95 percent
Competitive home market	Positive	95 percent
Experience with adopted standard	Positive	99 percent
Prior regional marketing presence	Positive	99 percent

The statistical significance or confidence levels for all these variables are relatively high. Nevertheless, it appears that these variables account for only one-fifth of the observed variation in the data. Nonquantifiable factors that contribute to the development of cost management expertise, or provide more precise measurements of firms' experience or technical and marketing expertise, likely account for much of the remaining variation. Other unobserved factors, such as financial resources and government support, may also account for variation in the data.

Summary and Outlook

Each cellular licensing process is unique; countries have different requirements for network configuration, geographic coverage, and service offerings. Firms' ability and willingness to accommodate the special needs of various governments play an increasingly important role in the international competition for cellular licenses, particularly in emerging markets. At present, the most internationally successful service providers are those that operate in competitive domestic markets. Competition provides these firms with broad experience; cost management, technical, and marketing expertise; and the operational flexibility required to compete abroad. U.S. industry representatives believe that the RHCs' international competitive advantage in the global cellular communications industry will continue, given the scope of their experience in the United States (table 5-3).

Government policy will clearly continue to play an important role in both the domestic and international development of cellular communications. Government decisions regarding spectrum allocation, licensing, and technical standards shape the domestic environment in which cellular service providers compete, and cellular service providers' experiences in home markets influence performance in the international arena.

[41] MIC is participating in a consortium chosen by the Russian Government to provide cellular service in Moscow.

[42] Sterett Pope, "Staking Claims as the World Goes Wireless," *Global Finance*, June 1992, p. 57.

[43] "Millicom To Sell Interest in Hong Kong Cellular Operation," News Release, Millicom, Inc., Aug. 20, 1991.

[44] U.S. industry representative, interview by USITC staff, New York, NY, Nov. 23, 1992.

[45] Industry representatives, interviews by USITC staff, Europe and Asia, Sept. 22-Oct. 9, 1992 and Sept. 26-Oct. 2, 1992.

[46] For details of the methods used and results, see appendix J.

Table 5-3
Selected company skills

	Network configuration	Billing	Marketing	Software	Cost management
United States:					
RHCs	X	X	X	X	X
United Kingdom:					
Vodafone	X		X	X	X
Sweden:					
Millicom International Cellular	X				X

Source: Compiled by USITC staff.

Industry observers and representatives have expressed concern that the lack of a single U.S. digital cellular standard may put U.S. service providers at a competitive disadvantage in the global cellular market. Nevertheless, U.S. providers have competed successfully for digital licenses in Europe and Asia. U.S. firms, in partnerships and consortia, account for 48 percent of all digital cellular service licenses awarded by home country authorities to foreign firms (figure 5-2).

More worrisome to U.S. cellular service providers are regulatory decisions regarding the deployment of personal communications.[47] The FCC has been somewhat slower than some of its foreign counterparts in taking action regarding licensing and spectrum allocation for PCS (figure 5-3). As a result, the provision of personal communication services in the United States may be delayed as U.S. regulatory bodies deliberate over a number of issues, including how to remove and compensate incumbent users of spectrum ultimately assigned to personal communications, and which firms may provide personal communications. Some industry observers contend that if U.S. firms lag significantly behind foreign competitors in deploying personal communications in the home market, the international competitive position of these firms may deteriorate because they will lack the experience that has proved critical in winning entry to foreign cellular service markets to date.[48]

In July 1992, the FCC requested comments on PCS. Comments were to include preferences regarding cellular service providers' eligibility for PCS licenses, geographic service areas, licensing procedures, and technical parameters.[49] Appendix H provides a sample of industry responses.

Until key decisions regarding personal communications are made in the United States, it appears that U.S. firms are attempting to limit adverse effects on their competitiveness by aggressively pursuing foreign personal communications licenses. US West participates in the British personal communications market through its ownership of the Unitel PCS network.[50] Furthermore, the German Government recently awarded a quasi-personal communications[51] license to a consortium in which BellSouth is a partner.[52] The other short-listed consortia in Germany included U.S. service providers as well.[53]

[47] Earle Mauldin, group president, BellSouth Mobile Enterprises and Thomas E. Wheeler, president and CEO, Cellular Communications Industry Association, testimony before the United States International Trade Commission, Jan. 27, 1993; F.C.C., *Notice of Proposed Rule Making and Tentative Decision*, Report No. DC-2175, Gen. Docket 90-314, ET Docket 92-100, July 16, 1992.

[48] Earle Mauldin, group president, BellSouth Mobile Enterprises and Thomas E. Wheeler, president and CEO, Cellular Communications Industry Association, testimony before the United States International Trade Commission, Jan. 27, 1993.

[49] "PCS Notices of Proposed Rule-Making: Should Cellular Carriers Be Included in PCS Services?" *Mobile Phone News*, July 30, 1992, pp. 2-3.

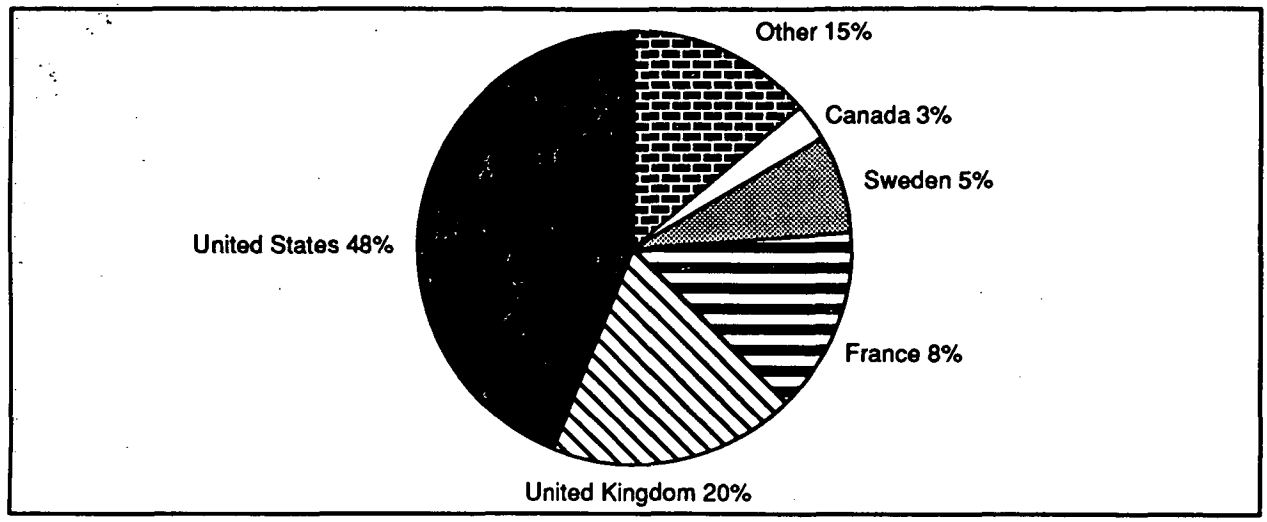
[50] Pacific Telesis was one of the original participants in the MicroTel PCS group, but sold its 25-percent stake in 1991. Similarly, Motorola sold its stake in the Mercury PCS group in 1991.

[51] The service license provides for use of a spectrum range typically reserved for personal communications, around 2 GHz, and microcellular architecture in certain areas. The German Government, however, does not at this time consider the recently awarded license to be a personal communications license per se. Representative of BellSouth, telephone interview by USITC staff, Washington, DC, Feb. 21, 1993.

[52] BellSouth, press release, "BellSouth consortium chosen as second private cellular operator in Germany," Feb. 4, 1993.

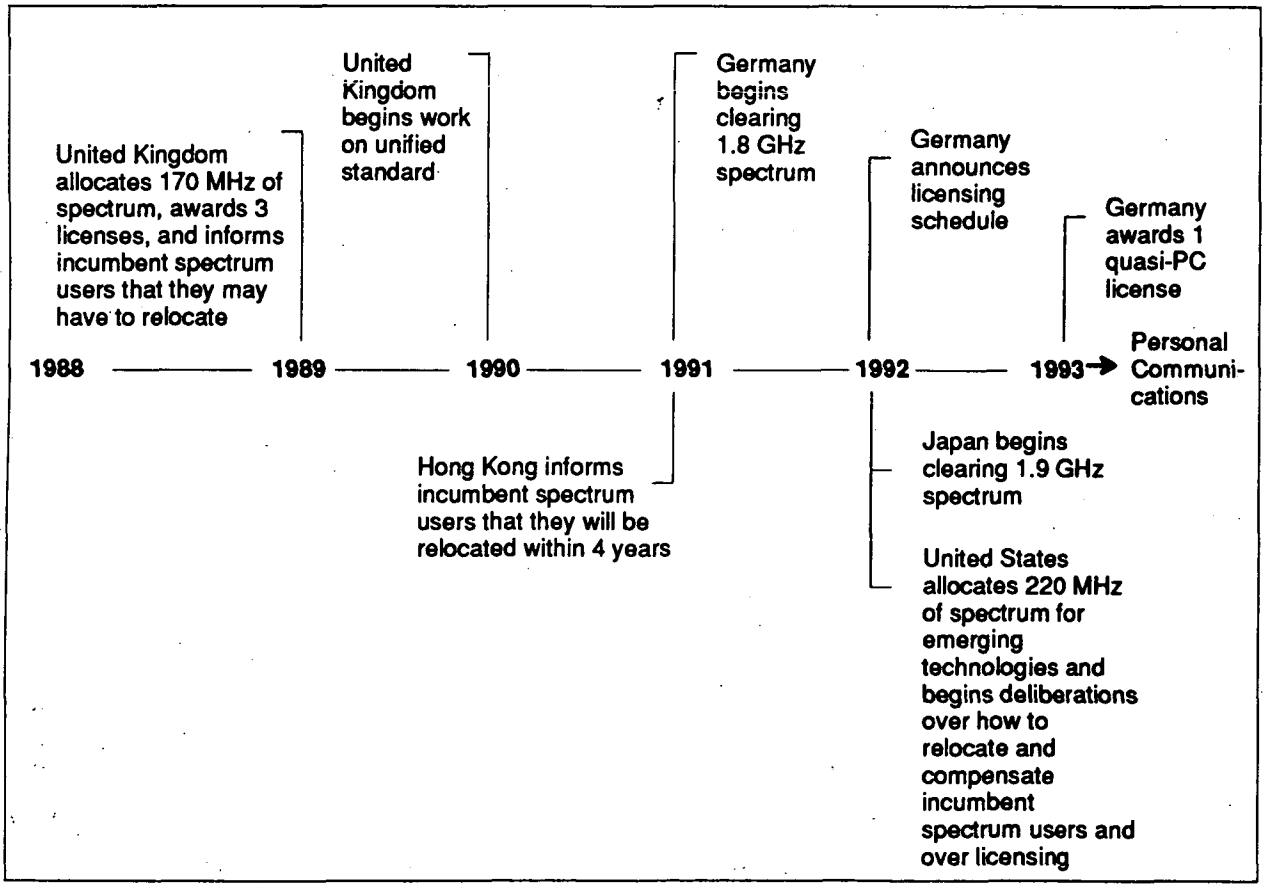
[53] U.S. Department of State, "Telecoms: E-1 Decision Expected at the End of Week," message reference 02123, Jan. 27, 1993.

Figure 5-2
Share of digital cellular service licenses awarded to foreign firms, by countries of licensees, 1993



Note.—Because of rounding, shares do not add up to 100 percent.
Source: Compiled by USITC staff.

Figure 5-3
Personal communications deployment, 1988-93



Source: Kurt A. Wimmer, "Global Development of Communication Services," *Communications Lawyer*, summer 1992, pp. 7 and 23-27.

Cellular Network Equipment Manufacturers

Introduction

As discussed in chapter 3, cellular network equipment manufacturers compete principally in terms of technical capabilities, price, and after-sales service. Competitiveness is best indicated by systems contract awards won in foreign countries. Factors that most significantly influence firms' ability to compete on these terms are radio research, development, and manufacturing experience, and wireline switch manufacturing and marketing experience. Also influencing the competitive environment are strategic alliances, designed to compensate for technical deficiencies and to enhance research and marketing efforts (see chapter 3). Specific effects of these characteristics and practices are listed in table 5-4.

Six major network equipment manufacturers, Ericsson (Sweden), Motorola (United States), AT&T (United States), Northern Telecom (Canada), Nippon Electric Corporation (NEC, Japan), and Nokia Corporation (Finland), dominate the global market for cellular network equipment. Table 5-5 lists the foreign systems contracts awarded to these firms and the number of subscribers supported by each manufacturer's equipment. By both measures, Ericsson leads in terms of market share, and Motorola places second. AT&T is the third-largest manufacturer as measured by number of global subscribers, but these subscribers are concentrated in the United States. AT&T has won only 1 percent of systems contracts awarded to firms competing outside their respective home markets.

Factors Influencing Competitiveness

Radio Research, Development, and Manufacturing Experience

On average, network equipment manufacturers reportedly spend approximately $200 to $300 million per year on radio research,[54] which is a key factor in determining the technical capabilities of cell site equipment, particularly radio base station equipment (see table 5-6). New radio technologies have improved transmission quality, reduced equipment size, and increased electrical efficiency.[55] Perhaps most importantly, however, research and development, in tandem with strategic vision and experience, effectively increases firms' sales opportunities. More specifically, manufacturers that conduct the research necessary to adapt radio base station equipment[56] to multiple analog and digital standards measurably increase the number of markets where they can compete for systems contracts.[57] Past experience with adapting other radio equipment for overseas markets helps to focus research and development efforts, leading manufacturers rapidly down new learning curves and ultimately reducing the total research and operational costs required to bring newly configured products to market.

Analog cellular standards

Major manufacturers of cellular network equipment focus chiefly on transmission standards used in the home market or on derivatives of these standards (see table 5-7). Nearly all foreign analog systems contracts awarded to AT&T, Motorola, Northern Telecom, and NEC have used AMPS and AMPS-based standards, such as TACS and HCS. Nokia specializes in the relatively antiquated NMT 450 standard, but also produces cell site equipment for the more advanced NMT 900 standard. Only Ericsson has reported substantial sales of both NMT and AMPS-based network equipment.

Ericsson's commitment to producing equipment for all predominant analog standards enables it to sell cellular network equipment throughout the world. It appears that this strategic commitment, coupled with Ericsson's long-standing involvement in Scandinavian, European, Latin American, and Asian telecommunications markets, has positively influenced Ericsson's share of the global market for analog cellular network equipment (figure 5-4).[58] In contrast, Motorola and AT&T's focus on AMPS-based standards, to the virtual exclusion of NMT standards, has clearly limited sales opportunities in significant overseas markets, including Western Europe, Eastern Europe, and the former Soviet Union.

NEC produces equipment for the AMPS-based HCS standard and has marketed the system in Japan successfully. Although it is reported that the HCS standard is technologically superior to many competing analog technologies, in large part due to the incorporation of advanced frequency splitting techniques, NEC has fared poorly in selling HCS systems overseas. NEC accounts for only 9 percent of foreign-awarded analog systems contracts. Japanese industry analysts indicate that NEC's small global market share is in part attributable to NTT's control of

[54] U.S. industry representative, telephone interview by USITC staff, Washington, DC, Dec. 12, 1992; and Japanese industry representatives, interviews by USITC staff, Tokyo, Sept. 26-Oct. 2, 1992.

[55] Japanese industry representatives, interviews by USITC staff, Tokyo, Sept. 26-Oct. 2, 1992.

[56] Analog and digital technical standards, called access methods, determine the manner in which radio base station equipment and cellular phones communicate.

[57] An important caveat to this argument exists. Namely, a firm that chooses to produce network equipment for a single standard may still pursue a great many systems contracts as long as the standard adopted by the firm is promoted aggressively in global markets.

[58] Steward, "The World Report '92," pp. 20-28.

Table 5-4
Factors influencing the competitiveness of network equipment manufacturers

Factor	Principal effects
Radio research, development, and manufacturing experience ...	• Broadens product range • Improves transmission quality • Reduces cell equipment size • Improves electrical efficiency
Wireline switch manufacturing and marketing experience	• Reduces research and development costs • Identifies potential clients • Improves software-based functions • Improves call data processing
Strategic alliances	• Augments technical expertise • Improves systems integration • Improves after-sales service

Source: Compiled by USITC staff.

HCS-related patents. NTT is inexperienced in overseas markets, and was slow to agree to market the system to foreign service providers.[59]

Digital cellular standards

As in the analog cellular systems market, manufacturers' ability and willingness to produce radio base station equipment for competing digital standards significantly influences global market share. However, the increased cost of developing digital systems, compared with the cost of developing analog systems, has hindered many firms' ability to develop radio base station equipment for multiple standards (see table 5-8).

Only two firms, Motorola and Ericsson, presently produce, or have committed to produce, radio base station equipment complying with the world's three predominant digital cellular standards: GSM, JDC, and the United States' TDMA standard. Recently awarded digital systems contracts suggest that flexibility with respect to digital standards has helped Ericsson and Motorola to maintain their global competitiveness (figure 5-5). Motorola, along with AT&T and Northern Telecom, has additionally committed to producing radio base station equipment using CDMA technology if this technology forms the basis for a second U.S. digital standard.[60]

Wireline Switch Manufacturing and Marketing Experience

Past experience designing and manufacturing wireline switches significantly reduces the expense of developing cellular switches. Network equipment manufacturers indicate that they spend more than $1.5 billion to develop cellular switches.[61] Software development costs reportedly account for 70 to 80 percent of total development costs.[62] Switch software development is expensive because software must be upgraded at least once every two years, and because cellular switches perform extremely complex tasks. In addition to directing call routing through both cellular and wireline networks, cellular switches must locate subscribers, control hand-offs between cells, and provide inter-system roaming.[63]

According to industry representatives, manufacturers with experience designing and manufacturing wireline switches — AT&T, Northern Telecom, Ericsson, Nokia, and NEC — have successfully transferred much of their wireline switch technology to cellular switches. Synergies between the two research areas result in substantial cost savings and improve firms' abilities to design large capacity switches with attractive software-based functions and advanced data processing capabilities.[64] For example, in the 1970s, Ericsson, in cooperation with Televerket, the Swedish TA, developed its Automatic Exchange Electronic (AXE) switch for traditional wireline telecommunication networks.[65] In 1981, Ericsson adapted it for cellular networks by adding cellular-specific software to the AXE switch's system architecture. The cellular AXE switch reportedly possesses many of its wireline counterpart's

[59] Japanese industry analysts, interviews by USITC staff, Tokyo, Sept. 26-Oct. 2, 1992.

[60] U.S. industry representative, interview by USITC staff, Washington DC, Feb. 4, 1993.

[61] U.S. industry representative, interview by USITC staff, Washington, DC, June 18, 1992.

[62] Cellular network equipment manufacturers also utilize advanced manufacturing techniques to assemble a switch's electronic components.

[63] Hong Kong industry representative, interview by USITC staff, Hong Kong, Oct. 7-9, 1992.

[64] U.S. industry representative, interview by USITC staff, Washington, DC, June 18, 1992.

[65] Eli Noam, *Telecommunications in Europe*, (London: Oxford University Press), 1992, p. 206.

Table 5-5
Selected international cellular network equipment contracts, 1981-92

Supplier	Country	Purchaser	Frequency Types	Number of Subscribers	Year Installed
AT&T	Korea	Public operator	800–AMPS	105,000	1984
AT&T	Philippines	Public operator	800–AMPS	(1)	1991
DMCS[2]	Belgium	Public operator	900–GSM	(1)	1991
DMCS/ECR[3]	Germany	Public operator	900–GSM	(1)	1991
ECR 900	Netherlands	Public operator	900–GSM	(1)	1991
ECR 900	France	Private consortium	900–GSM	(1)	1991
Ericcson	Denmark	Public operator	450–NMT	51,240	1982
Ericsson	Faroe Is.	Public operator	450–NMT	1,430	1989
Ericcson	Hungary	Public/private joint venture	450–NMT	8,300	1990
Ericcson	Iceland	Public operator	450–NMT	12,100	1986
Ericsson	Indonesia	Public operator	450 NMT	12,100	(1)
Ericsson	Luxembourg	Public operator	450–NMT	870	1986
Ericsson	Malaysia	Public operator	450–NMT	48,700	1985
Ericsson	Morocco	Public operator	450–NMT	1,000	1987
Ericsson/Philips	Netherlands	Public operator	450–NMT	71,000	1985
Ericsson/Mitsubishi	Norway	Public operator	450–NMT	147,310	1981
Ericsson	Oman	Public operator	450–NMT	2,600	1985
Ericsson	Russia	Public/private consortium	450–NMT	(1)	1991
Ericsson/Phillips	Saudi Arabia	Public operator	450–NMT	16,000	1981
Ericsson	Spain	Public operator	450–NMT	67,210	1982
Ericsson	Sweden	Public operator	450–NMT	246,630	1981
Ericsson/Nokia	Thailand	Public operator	450–NMT	35,700	1986
Ericsson	Tunisia	Public operator	450–NMT	650	1985
Ericsson	Yugoslavia	Public operator (Croatia)	450–NMT	2,000	1990
Ericsson	Yugoslavia	Public operator (Slovenia)	450–NMT	(1)	1991
Ericsson	Canada	Public operator	800–AMPS	250,000	1986
Ericsson	Australia	Public operator	800–AMPS	366,060	1987
Ericsson	Venezuela	Private consortium	800–AMPS	7,800	1988
Ericsson	Taiwan	Public operator	800–AMPS	86,400	1989
Ericsson	Mexico	Private consortium	800–AMPS	36,000	1989
Ericsson	Curacao	Public operator	800–AMPS	800	1989
Ericsson	Taiwan	Public operator	800–AMPS	188,000	1989
Ericsson/NEC	Chile	Private consortium	800–AMPS	(1)	1989
Ericsson	Pakistan	Private joint venture	800–AMPS	4,500	1990
Ericsson	Pakistan	Private joint venture	800–AMPS	3,500	1990
Ericsson	El Salvador	Private joint venture	800–AMPS	(1)	1992
Ericsson	New Zealand	Public operator[4]	800–AMPS	67,900	1987
Ericsson	Hong Kong	Private joint venture	900–ETACS	47,000	1989
Ericsson	Malaysia	Public operator	900–ETACS	31,600	1989
Ericsson	Italy	Public operator	900–ETACS	493,140	1990
Ericsson	Malta	Public operator	900–ETACS	1,990	1990
Ericsson	Kuwait	Public operator	900–ETACS	(1)	1991
Ericsson	Nigeria	Public operator	900–ETACS	(1)	1991
Ericsson	Singapore	Public operator	900–ETACS	11,000	1991
Ericsson	Norway	Public operator	900–GSM	(1)	1991
Ericsson	Switzerland	Public operator	900–GSM	174,560	1987
Ericsson/Siemens	Germany	Private consortium	900–GSM	(1)	1991
Ericsson/Motorola	Spain	Public operator	900–GSM	(1)	1991
Ericsson/Orbitel	Finland	Public operator	900–GSM	(1)	1991

See notes at end of table.

Table 5-5—Continued
Selected international cellular network equipment contracts, 1981-92

Supplier	Country	Purchaser	Frequency Types	Number of Subscribers	Year Installed
Ericsson	Sweden	Public operator	900–GSM	(1)	1992
Ericsson	Denmark	Public operator	900–GSM	(1)	1992
Ericsson	Denmark	Public operator	900–NMT	125,690	1986
Ericsson	Sweden	Public operator	900–NMT	321,550	1986
Ericsson	Norway	Public operator	900–NMT	87,120	1986
Ericsson	Cyprus	Public operator	900–NMT	5,130	1988
Ericsson	Netherlands	Public operator	900–NMT	91,100	1989
Ericsson	Ireland	Public operator	900–TACS	31,930	1985
Ericsson	China	Public operator (Zhuhai)	900–TACS	2,700	1987
Ericsson	China	Public operator (Guangzhou)	900–TACS	7,000	1987
Ericsson	China	Public operator (Shenzhen)	900–TACS	5,000	1987
Ericsson	China	Public operator (Qinghuangdao)	900–TACS	400	1987
Ericsson	China	Public operator (Beijing)	900–TACS	3,000	1988
Ericsson	Macao	Public operator	900–TACS	5,010	1988
Ericsson	China	Public operator (Shanghai)	900–TACS	4,000	1989
Ericsson	UAE	Public operator	900–TACS	21,000	1989
Ericsson	China	Public operator (Tianjin)	900–TACS	2,500	1990
Ericsson	China	Public operator (Chengdu)	900–TACS	1,500	1990
Ericsson	China	Public operator (Shijiazhuang)	900–TACS	(1)	1991
Ericsson	China	Public operator (Zhanjiang)	900–TACS	(1)	1991
Ericsson	China	Public operator (Shantou)	900–TACS	(1)	1991
Ericsson	Japan	Private consortium	JDC	(1)	1994
Italtel	Italy	Public operator	450–RTMS	74,400	1986
Matra	Italy	Public operator	900–GSM	(1)	(1)
Matra/Alcatel	France	Public operator	200, 400	290,000	1991
Matsushita	Egypt	Public operator	800–AMPS	2,600	1985
Motorola	Austria	Public operator	450–NMT	63,020	(1)
Motorola	Israel	Private operator	800–AMPS	23,890	(1)
Motorola	Indonesia	Public operator	800–AMPS	2,000	(1)
Motorola	Korea	Public operator	800–AMPS	160,000	1984
Motorola	Indonesia	Public operator	800–AMPS	4,000	1984
Motorola	Bolivia	Private consortium	800–AMPS	(1)	1986
Motorola[5]	Argentina	Private consortium	800–AMPS	20,000	1987
Motorola[5]	Chile	Private consortium	800–AMPS	(1)	1987
Motorola[5]	Hong Kong	Private consortium	800–AMPS	42,000	1987
Motorola	Mexico	Private consortium	800–AMPS	200	1989
Motorola	Uruguay	Private consortium	800–AMPS	(1)	1989
Motorola	Bangladesh	Public/private joint venture	800–AMPS	(1)	1989
Motorola	Thailand	Public operator	800–AMPS	35,000	1990
Motorola	Samoa (Am.)	Public operator	800–AMPS	800	1990
Motorola	Dominican Republic	Private operator	800–AMPS	3,000	1990
Motorola	Brunei	Public operator	800–AMPS	3,500	1990
Motorola	Guatemala	Private joint venture	800–AMPS	800	1990
Motorola	Chile	Private joint venture	800–AMPS	(1)	1991
Motorola	Mexico	Private consortium	800–AMPS	800	1991
Motorola	Mexico	Private consortium	800–AMPS	100	1991
Motorola	Philippines	Private joint venture	800–AMPS	1,200	1991
Motorola[5]	Mexico	Private consortium	800–AMPS	200	1991

See notes at end of table.

Table 5-5—Continued
Selected international cellular network equipment contracts, 1981-92

Supplier	*Country*	*Purchaser*	*Frequency Types*	*Number of Subscribers*	*Year Installed*
Motorola	Sri Lanka	Private joint venture	900–ETACS	1,800	1991
Motorola	Japan	Private operator	900–JTAC	(1)	1991
Motorola	Austria	Public operator	900–TACS	51,290	1992
Motorola	Spain	Public operator	900–TACS	41,240	(1)
Motorola	China	Public operator (Fuzhou)	900–TACS	(1)	1989
Motorola	China	Public operator (Jinan)	900–TACS	(1)	1992
Motorola	China	Public operator (Xiamen)	900–TACS	(1)	1987
Motorola	China	Public operator (Beijing)	900–TACS	2,500	1989
Motorola	China	Public operator (Shanghai)	900–TACS	1,500	1989
Motorola	Ghana	Private operator	900–TACS	(1)	1987
Motorola	Japan	Private operator	JTAC	259,200	1990
Motorola	Mexico	Private consortium	800–AMPS	(1)	1990
Motorola/Siemens	Sweden	Private operator	900–GSM	(1)	1989
NEC	Puerto Rico	Public operator	800–AMPS	24,000	1986
NEC	Philippines	Public operator	800–AMPS	32,000	1987
NEC	Singapore	Public operator	800–AMPS	60,000	1988
NEC	Chile	Private consortium	800–AMPS	9,353	1989
NEC	Brazil	Public operator	800–AMPS	1,200	1990
NEC	Jamaica	Public operator	800–AMPS	(1)	1991
NEC	Brazil	Public operator	800–AMPS	2,500	1990
NEC, Ericsson	Kuwait	Public operator	900–ETACS	(1)	1986
NEC	Hong Kong	Private operator	900–TACS	57,350	1984
NEC	Bahrain	Public operator	900–TACS	7,590	1986
NEC	China	Public operator (Shenyang)	900–TACS	1,000	1989
NEC	China	Public operator (Dailian)	900–TACS	600	1990
NEC	Kenya	Public operator	900–TACS	(1)	1992
NEC	Japan	Public operator	NTT	738,000	1979
NEC	Japan	Public operator	NTT	221,000	1988
Nokia	China	Public operator (Liao He)	450 NMT	600	1986
Nokia	China	Public operator (Daqing)	450 NMT	500	1987
Nokia	Lithuania	Public/private consortium	450–NMT	(1)	1992
Nokia	Belguim	Public operator	450–NMT	49,450	1982
Nokia	Czechoslovakia	Public/private consortium (Prague and Bratislava)	450–NMT	(1)	1991
Nokia	Finland	Public operator	450–NMT	149,750	1992
Nokia	Turkey	Public operator	450–NMT	34,500	1989
Nokia	France	Private operator	450–NMT	85,000	1991
Nokia	Estonia	Public/private consortium	450–NMT	550	1991
Nokia	Cyprus (Northern)	Public operator	450–NMT	1,000	1989
Nokia	Sweden	Private consortium	900–GSM	(1)	1992
Nokia	Denmark	Private consortium	900–GSM	(1)	1991
Nokia	Algeria	Public operator	900–NMT	1,500	1988
Nokia	Finland	Public operator	900–NMT	137,520	1991
Nokia	Thailand	Private consortium	900–NMT	20,000	1986
Nokia/Ericsson	Russia	Public/private consortium	450–NMT	(1)	1989
Nokia/Siemens/ Philips	Finland	Private consortium	900–GSM	(1)	1990

See notes at end of table.

Table 5-5—Continued
Selected international cellular network equipment contracts, 1981-92

Supplier	Country	Purchaser	Frequency Types	Number of Subscribers	Year Installed
Northern Telecom	Bahamas	Public operator	800–AMPS	3,000	1987
Northern Telecom	Barbados	Public operator	800–AMPS	(1)	1988
Northern Telecom	Bermuda	Public operator	800–AMPS	1,600	1988
Northern Telecom	Brazil	Public operator	800–AMPS	7,500	1990
Northern Telecom	Canada	Public operator	800–AMPS	(1)	1990
Northern Telecom	Mexico	Private joint venture	800–AMPS	100	1990
Northern Telecom	Mexico	Private consortium	800–AMPS	(1)	1990
Northern Telecom	Mexico	Private consortium	800–AMPS	(1)	1991
Northern Telecom	Mexico	Private consortium	800–AMPS	(1)	1990
Northern Telecom	Mexico	Private consortium	800–AMPS	22,000	1988
Northern Telecom	Mexico	Private consortium	800–AMPS	600	1989
Northern Telecom	Mexico	Private consortium	800–AMPS	50	1989
Northern Telecom	Peru	Public/private consortium	800–AMPS	(1)	1989
Northern Telecom	Puerto Rico	Private operator	800–AMPS	(1)	1990
NovAtel	Canada	Public operator	800–AMPS	(1)	1990
NovAtel	Chile	Private consortium	800–AMPS	3,400	1989
NovAtel	China	Public operator	450–NMT	1,000	1991
NovAtel	Costa Rica	Private consortium	800–AMPS	2,500	1985
NovAtel	Mauritius	Private joint venture	900–ETACS	1,300	(1)
NovAtel	Peru	Private joint venture	800–AMPS	4,700	(1)
Plexsys	Cayman Is.	Public operator	800–AMPS	1,500	1987
Plexsys	Zaire	Private operator	800–AMPS	4,000	1988
Plexsys	St. Kitts	Public operator	800–AMPS	(1)	1989
Plexsys	St. Martin	Public operator	800–AMPS	(1)	1991
Siemens	South Africa	Public operator	450–C–NETZ	9,550	1986
Siemens	Portugal	Public operator	450–C–NETZ	12,570	1989
Siemens	Austria	Public operator	900–GSM	(1)	1991
Siemens/Alcatel (SEL)	Germany	Public operator	450–C–NETZ	532,250	1986

[1] Not available.
[2] Philips (Netherlands) and Bosch (Germany) joint venture.
[3] Alcatel(France), Nokia (Finland), and AEG (Germany) consortium.
[4] Telecom New Zealand was privatized in 1990.
[5] Supplier also participates in the operation of the network.

Sources: Pyramid Research, *Cellular Markets in Developing Countries*, 1991; and U.S. Department of Commerce, *A Competitive Assessment of the U.S. Cellular Radiotelephone Industry*, 1988.

Table 5-6
Cellular network equipment manufacturers' corporate-wide expenditures on research and development, 1990

Firm	Corporate sales	Corporate R&D	R&D as a share of sales
	1,000 dollars		*Percent*
AT&T	(1)	(1)	(1)
Motorola	10,855	1,008	9
Northern Telecom	(1)	(1)	(1)
Ericsson	7,965	860	11
Nokia	5,780	295	5
NEC	22,626	2,083	8

[1] Not available.

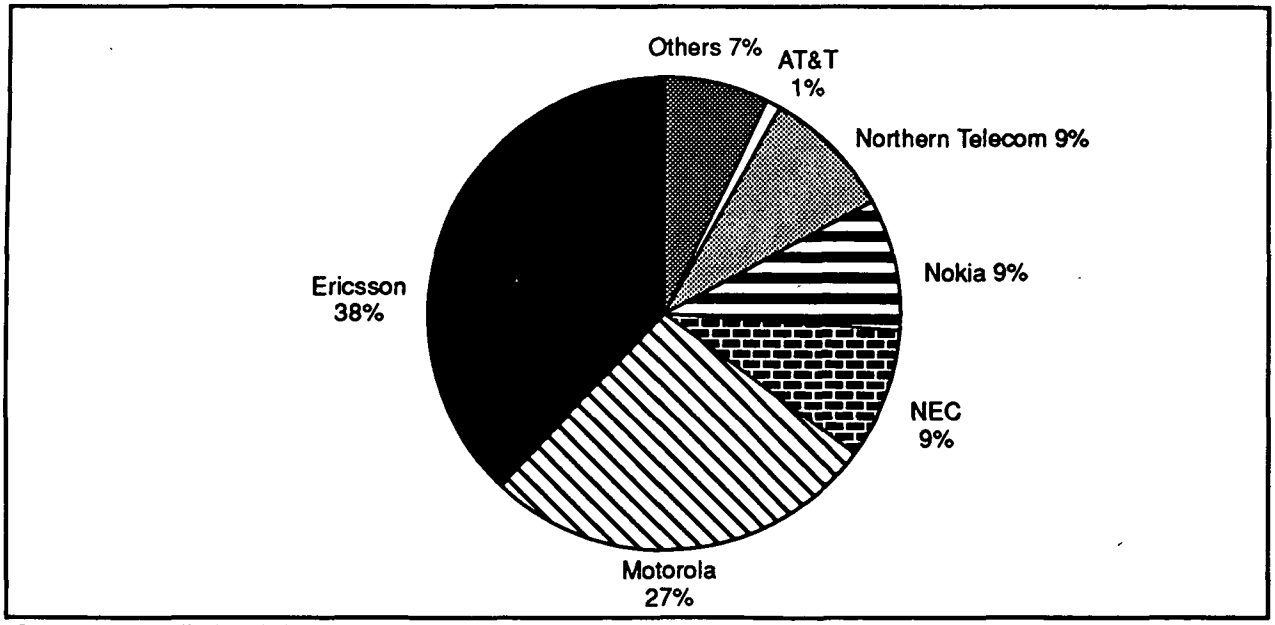
Source: Compiled by USITC staff.

Table 5-7
Percentage share of firms' analog systems contracts, by technical standards, 1991

	AMPS - based standards			NMT standards	
Manufacturer	AMPS	NTT HCS	TACS	NMT 450	NMT 900
AT&T	100	0	0	0	0
Ericsson	30	0	32	30	8
Motorola	75	0	23	2	0
NEC	47	13	40	0	0
Nokia	0	0	0	80	20
Northern Telecom	100	0	0	0	0

Source: Estimated by USITC staff.

Figure 5-4
Share of analog cellular systems contracts awarded to foreign firms, by firms, 1991



Source: Compiled by USITC staff.

Table 5-8
Expected digital cellular standards availability[1], by network equipment manufacturers

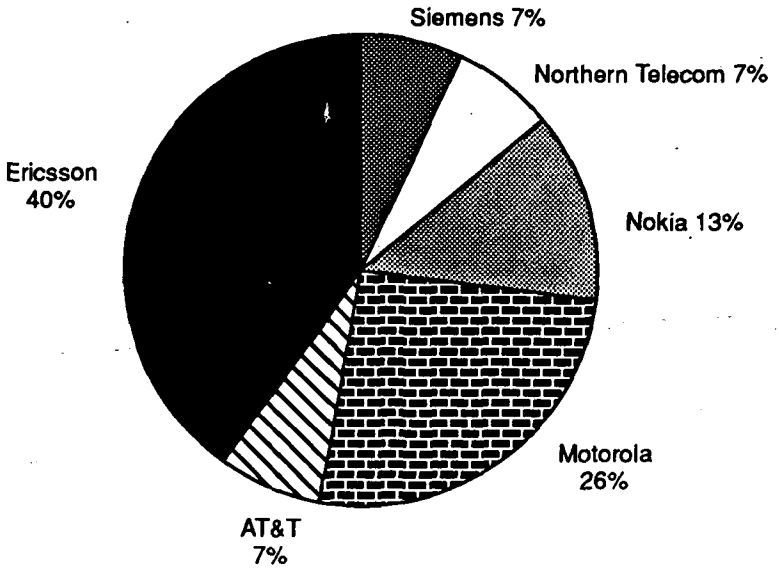
Manufacturer	TDMA	CDMA	GSM	JDC
Ericsson	■		■	■
Motorola	■	■	■	■
NEC	■			■
Northern Telecom[2]	■	■	■	
NovAtel[2]	■			
Nokia			■	
AT&T	■	■		■
Alcatel			■	
Siemens			■	
Hughes	■			
Mitsubishi Electric			■	■
Matra			■	

[1] Shaded areas indicate firms' manufacture of, or commitment to manufacture, network equipment corresponding to the digital technical standard noted above.

[2] Northern Telecom has recently acquired NovAtel.

Source: Compiled by USITC staff.

Figure 5-5
Share of digital cellular systems contracts awarded to foreign firms, by firms, 1991



Source: Compiled by USITC staff.

advantages, such as low failure rates, high calling capacity, superior call processing, and user-friendly software features.[66] In addition, longstanding supplier relationships between wireline systems contractors and foreign service providers appear to confer advantages on wireline switch manufacturers. Foreign TAs account for more than 70 percent of the cellular network equipment sales recorded by Ericsson, Nokia, and NEC. In contrast, TAs appear to account for only one-third of the network equipment sales recorded by Motorola, which has little prior experience in marketing wireline network equipment.[67]

Strategic Alliances

When combined with global marketing efforts, the ability to manufacture both high-quality cellular switches and cell site equipment has enhanced network equipment manufacturers' competitiveness. Some cellular service providers, including many of those in emerging cellular markets, prefer to purchase network equipment from horizontally integrated systems manufacturers (i.e., those that produce both switches and cell site equipment) since the service providers lack the technical expertise required to fully integrate equipment manufactured by different firms. In addition, it is reported that horizontally integrated systems manufacturers have typically provided the best network-wide, after-sales service. Although a number of firms produce both cellular switches and radio base station equipment (table 5-9), it appears that integrated systems manufacturing, in tandem with aggressive marketing efforts in emerging cellular markets, have significantly enhanced Ericsson's global competitive position.[68]

Given many service providers' preference for horizontally integrated network equipment manufacturers, a number of suppliers have found it beneficial to form alliances with other firms to compete successfully for systems contracts. During the 1980s, alliances typically took the form of "original equipment manufacturer" (OEM) agreements. Both AT&T and Northern Telecom supplemented in-house production by purchasing OEM equipment from companies that made complementary network equipment. AT&T incorporated radio equipment manufactured by Kokusai (Japan) into its Autoplex system, and Northern Telecom incorporated radio equipment manufactured by General Electric Corp. (United States) into its NTX and M-NTX systems. Motorola, on the other hand, supplemented its in-house switch manufacturing operations by purchasing cellular

[66] U.S. industry representative, interview by USITC staff, Washington, DC, Aug. 14, 1992; Hong Kong industry representative, interview by USITC staff, Hong Kong, Oct. 7-9, 1992.

[67] U.S. Department of Commerce, *A Competitive Assessment of the U.S. Cellular Radiotelephone Industry*, June 1988; Pyramid Research, *Cellular Markets in Developing Countries*, 1991.

[68] Hong Kong industry representative, interviews by USITC staff, Hong Kong, Oct. 7-9, 1992.

Table 5-9
Network equipment manufacturers' product range, 1992

Manufacturer	Switches	Cell Site Equipment
Ericsson	Yes	Yes
Motorola	Yes	Yes
NEC	Yes	Yes
Northern Telecom	Yes	No[1]
NovAtel	No[1]	Yes
Nokia	Yes	Yes
AT&T	Yes	Yes
Alcatel	Yes	No
Siemens	Yes	No
Hughes	No	Yes
Mitsubishi	No	Yes
Matra	No	Yes

[1] Northern Telecom has recently acquired NovAtel.

Source: Compiled by USITC staff.

switches manufactured by DSC Communications Corporation (United States).[69]

Escalating research costs and the increasing complexity of designing and manufacturing cellular switches and radio base station equipment have resulted in the proliferation of strategic alliances among firms in recent years (see table 5-10). Increasing research and development costs have motivated firms, such as Philips AG (the Netherlands) and Bosch Telekom AG (Germany), to form research partnerships. Cellular service providers' preference for horizontally integrated systems suppliers has motivated other firms, such as Mitsubishi Electric Corporation (Japan) and Siemens (Germany), to form marketing joint ventures. The confluence of both high research costs and service providers' preferences has motivated firms, such as Motorola and Northern Telecom, to form partnerships encompassing both research and marketing. Many of these joint ventures are geographically confined, at least initially. For instance, the Motorola-Northern Telecom joint venture, named Motorola-Nortel, is focused solely on North America, Latin America and the Caribbean.[70]

Motorola-Nortel enhances the competitive position of both Motorola and Northern Telecom by combining Motorola's expertise in radio base station equipment with Northern Telecom's expertise in switching technology.[71] In the short term, this alliance enables both companies to offer complete cellular network systems comparable to those offered by such firms as AT&T, NEC, Ericsson, and Nokia.[72] In the long term, the partnership allows both firms to focus available resources on core strengths, enhancing future competitiveness (see section entitled "Outlook").[73]

Evidence from Statistical Analysis

Statistical analysis performed by USITC staff supports certain themes identified in discussions with industry representatives. Using data on five network equipment manufacturers (Ericsson, Nokia, Motorola, NEC, and Northern Telecom) and 103 contract awards, staff sought to confirm the significance of several factors for the winning of new systems contracts during the period 1987-91.[74]

Proxies were available for two factors identified in the discussion above, namely, radio research, development, and manufacturing experience, measured by the number of technical standards that firms support;[75] and wireline switch manufacturing and marketing experience, measured by annual sales of central office switches.[76] As the following tabulation shows, these two factors were found to be statistically significant.

[69] U.S. industry analyst, interview by USITC staff, New York, NY, Apr. 20, 1992.

[70] "Natural Combination: Motorola-Nortel, New Company, Stakes Out Future Cellular Markets," *Communications Daily*, Feb. 11, 1992, pp. 1-2.

[71] "Northern Telecom, Motorola Form Cellular Venture for Americas" *Electronic News*, Feb. 17, 1992.

[72] Donaldson, Lufkin, and Jenrette, *The Cellular Communications Industry*, winter 1991-1992, p. 33.

[73] With regard to the Motorola-Northern Telecom partnership, the implications of Northern Telecom's recent purchase of NovAtel, a cell site equipment manufacturer, are as yet unclear.

[74] The data cover non-North American contract awards. Because AT&T has been active almost exclusively in the North American market, data pertaining to the firm have been excluded. For details of the methods used and results, see appendix J.

[75] The number of standards a firm offers is a result of its radio research, development, and manufacturing experience, but the effect of this variable on contracts may capture the benefits of greater sales opportunities as well as the benefits of experience.

[76] In addition, one other potentially important factor, research and development expenditures, was initially considered. Due to measurement problems, however, a

Table 5-10
Selected cellular network equipment joint ventures, by countries or regions

Region/ country/ company	Partners	Share of ownership	Start-up date	Apparent reason for joint venture
North America:				
NovAtel	Northern Telecom Techtronic	63% 37%	1992	M,D
Motorola-Nortel	Motorola Northern Telecom	50% 50%	1992	M,D
Astronet	Mitsubishi Electric Siemens - Stromberg Carlson	49% 51%	1989	M
Europe:				
European Cellular Radio Consortium 900 (ECR 900)	AEG Alcatel Nokia	(1)	1987	M,D
DMCS 900	Philips Bosch Telekom	(1)	(1)	D
NT Matra Cellular Systems	Northern Telecom Matra	50% 50%	1992	M
	Matra Orbitel Ericsson Telettra	(1)	1987	M,D

See note at end of table.

Table 5-10—Continued
Selected cellular network equipment joint ventures, by countries or regions

Region/ country/ company	Partners	Share of ownership	Start-up date	Apparent reason for joint venture
Europe—Continued:				
MET	Matra Ericsson	([1])	1989	D
Orbitel	Racal Plessey	50% 50%	1987	M,D
Orbitel	Vodafone Ericsson	50% 50%	1991	M,D
Japan:				
Ericsson - Toshiba Telecommunications	Ericsson Toshiba	60% 40%	1992	M,D

[1] Not available.

Note.—D = Development of cellular technologies.
M = Market access or joint marketing venture.

Sources: "Northern Slates NovAtel Buy," *Electronic News,* May 25, 1992; "Northern Telecom Agrees to Acquire Most of NovAtel's Assets from Alberta," *The Wall Street Journal,* May 22, 1992; and Elsevier Technology, *European Mobile Communications.*

Factor	Effect on contracts won	Statistical confidence level
Radio experience	Positive	99 percent
Wireline switch experience	Positive	99 percent

No suitable proxy was developed to measure the effect of strategic alliances. Comparable information regarding the nature and extent of strategic alliances was not available for all network equipment manufacturers.

Summary and Outlook

Extensive interviews with predominant network equipment manufacturers suggest that the principal factors currently affecting firms' competitiveness are radio research, development, and manufacturing experience; wireline switch manufacturing and marketing experience; and strategic alliances. Radio research, development, and manufacturing experience aids firms' efforts to improve transmission quality, reduce equipment size, increase electrical efficiency, and most importantly, reconfigure cell site equipment for different analog and digital standards. Experience in manufacturing and marketing wireline switches lowers research and development costs and helps firms to sell equipment to potential clients. Corporate alliances augment one firm's expertise and experience with that of another, typically in the research and marketing arenas, and allow firms to specialize so as to remain competitive.

The predominant manufacturers of network equipment at present are Motorola, AT&T, Northern Telecom, Ericsson, Nokia, and NEC. The largest of these are Motorola and Ericsson, jointly accounting for two-thirds of global sales of all (analog and digital) cellular systems. Motorola and Ericsson have both invested significant resources in radio research and manufacturing. Cellular service providers, operating systems based on a variety of technical standards, accord both firms high marks in terms of transmission quality. Ericsson's experience in manufacturing and marketing wireline switches and its ability to provide complete analog and digital systems appears to explain the firm's slight lead over Motorola in terms of market share. Motorola's inexperience in manufacturing switches for wireline networks appears to leave the firm without the resources required to design and construct large capacity cellular switches, the demand for which has increased in response to subscribership growth.

[76]*Continued*
variable reflecting research and development expenditures was excluded from this statistical presentation. For a discussion of the measurement problems associated with research and development expenditures, refer to appendix J.

Although other firms are preparing to enter the cellular network equipment manufacturing industry as digital cellular networks are deployed, industry representatives suggest that the six predominant cellular network equipment manufacturers will retain industry leadership for the next 3 to 5 years. Factors that will significantly influence the future competitive position of network equipment manufacturers are the adoption of digital technical standards and open systems architecture.

Adoption of Digital Standards

As discussed earlier, Motorola and Ericsson are committed to produce cellular network equipment for all predominant digital standards. Other key firms have chosen to produce cellular network equipment only for certain digital standards, usually those under consideration in the home market, or those that closely correspond to standards under consideration in the home market. For instance, AT&T and NEC will produce systems conforming to the similar U.S. and Japanese TDMA-based standards.

In the past, firms that chose to produce equipment conforming to only one or two analog standards tended to remain niche players unless one of the standards was widely adopted, as was the AMPS standard. Similarly, firms that have chosen to manufacture equipment for one or two digital standards likely will remain niche players unless one of the standards adopted by these firms is promoted aggressively overseas. To date, only the GSM standard has been promoted aggressively in overseas markets. For this reason, such firms as Nokia, Alcatel, Siemens, and Matra, all of which have chosen to pursue contracts solely for GSM systems, may emerge as active participants in the global market for cellular equipment despite their concentration on a single digital standard.

Relative to a firm like Motorola, which will design, manufacture, and market GSM and other systems, Nokia, Alcatel, Siemens, and Matra may derive short-term advantages from their single-purposed research and development programs and their greater manufacturing economies of scale. Relative to firms like AT&T and Hughes, which will not be competing to supply GSM equipment, Nokia, Alcatel, Siemens, and Matra may derive an advantage from the aggressive international promotion of the GSM standard, which effectively increases their bidding opportunities in the global market. The U.S. industry has expressed concern that, because the returns on its investment in technology will be far less than those derived by European firms specializing in GSM, their home market standard, the competitive position of U.S. firms in an industry characterized by high research and development expenditures may ultimately be weakened.[77]

[77] C.P. Shankar, vice president, Wireless Digital Development and Cellular Sales and Marketing, Hughes Network Systems, testimony before the United States International Trade Commission, Jan. 27, 1993;

Open Systems Architecture

Open systems architecture provides for standardized interfaces between switches and radio base stations, facilitating interconnection of network components produced by different firms.[78] The gradual adoption of open systems architecture, already incorporated into GSM networks, likely will reinforce trends toward specialization and strategic alliances in the short term, and perhaps intensify price competition in the long run.[79] Selected open systems contract bids are listed in table 5-11.

Most horizontally integrated cellular network equipment manufacturers have been reluctant to embrace open systems architecture. Open systems architecture likely will result in more fluid relationships between systems contractors and service providers. In contrast with today's typical systems contracts, in which the contract is usually awarded to one firm, open systems contracts may be shared by multiple firms, without special arrangements for protocol coordination or systems integration. Moreover, service providers will not be bound, as a matter of practicality, to return to original systems contractors for additional network equipment as cellular subscribership increases. Instead, service providers may initiate a new round of competitive bidding among manufacturers to supply additional network equipment.

As markets adopt open systems architecture, after-sales service and systems integration will be simplified, reducing the present advantage held by horizontally integrated network equipment manufacturers. In addition, horizontally integrated service providers will no longer be able to compensate for technical or cost disadvantages in manufacturing certain systems components by capturing, maintaining, or increasing advantages in manufacturing other components. Cellular service providers will be able to piece together cellular networks using those switches and radio base stations that provide requisite technical capabilities at the most competitive price, irrespective of manufacturer.

Industry representatives speculate that the adoption of open systems architecture will motivate further specialization among network equipment manufacturers. In an open systems environment, it will become much more difficult for horizontally integrated manufacturers such as Ericsson, Nokia, and NEC to remain internationally competitive suppliers of both cellular switches and cell site equipment. The ability of each manufacturer to fund both radio and switching research and development will likely decrease, motivating them to focus resources on areas where they are most competitive.[80]

The trend toward greater price sensitivity may be temporarily mitigated as service providers make the transition to digital systems and personal communication systems and as significant improvements in network equipment come to market. For example, Motorola is developing automated radio base stations with built-in computer processors that enable base stations to execute some of the routing and hand-off functions currently performed by cellular switches. The radio base station's computer processors will be able to assess equipment operating conditions and make adjustments of radio channel allocations. Reportedly, these radio base stations will sell for a premium during the short term since they enable cellular service providers to offer better service and reduce overall operating costs.[81]

Cellular Phone Manufacturers

Introduction

As discussed in chapter 3, cellular phone manufacturers principally compete in terms of price, design features, talk-time, size and weight. Competitiveness is best indicated by global market share. These firms principally derive competitive advantage from radio manufacturing experience, integrated circuit (IC) core competency, and advanced manufacturing techniques. Specific effects of these characteristics and practices are listed in table 5-12.

As illustrated in table 5-13 cellular phone sales in the three largest markets during 1990 were concentrated among five companies: Motorola, Nokia, Matsushita Communications, Mitsubishi Electric, and NEC. Motorola is headquartered in the United States; Nokia, in Finland; and NEC, Matsushita, and Mitsubishi, in Japan. These companies account for roughly 65 percent of total cellular phone sales in the United States, Japan, and Europe. Toshiba, Uniden, OKI, and NovAtel are large manufacturers as well, with each one's aggregate market shares being approximately the same as those of Mitsubishi and

[77]—*Continued*
U.S. industry representatives, interview by USITC staff, Washington, DC, Nov. 17, 1992.

[78] Network equipment manufactured by different firms can also be connected by cellular service providers, provided that they hire or consult systems integrators with the ability to interconnect equipment with different proprietary protocols.

[79] Augie K. Fabela, Jr., Chairman, Plexsys International Corporation, testimony before the United States International Trade Commission, Jan. 27, 1993; and U.S. industry representatives, interviews by USITC staff, Seoul, Oct. 5, 1992, and Washington, DC, Sept.-Oct. 1992.

[80] Augie Fabela, Chairman, Plexsys International Corp., testimony before the United States International Trade Commission, Jan. 27, 1993; U.S. industry representatives, interviews by USITC staff, Seoul, Oct. 5-6, 1992; and European industry representative, interview by USITC staff, Hong Kong, Oct. 7-9, 1992.

[81] U.S. industry representative, telephone interview by USITC staff, Washington, DC, Mar. 1, 1993.

Table 5-11
Selected open systems or cooperative network equipment bidding, 1981-92

Country	Service provider	Manufacturers	Manufacturers' Responsibilities	Actitivity	Year
Germany	DBP Telekom	Siemens Alcatel	(1)	C	1986
Germany	Mannesmann Mobilfunk	Siemens Motorola	switches cell site equipment	O	1991
Germany	DBP Telekom ECR 900	DMCS 900	(1)	O	1991
Netherlands	Netherlands PTT	Philips Ericsson	cell site equipment switches	(1)	1985
Norway	Telemobil Norwegian	Ericsson Mitsubishi Electric	switches cell site equipment	(1)	1981
Russia		Hughes Network Systems Alcatel	cell site equipment switches	C	1992
Saudi Arabia	PTT	Philips Ericsson	cell site equipment switches	(1)	1981
Sweden	Televerket	Mitsubishi Electric Siemens-Stromberg Carlson	cell site equipment switches	O	(1)
Japan	NTT	Mitsubishi Electric NEC	cell site equipment cell site equipment, switches	O	(1)
Japan	IDO	Mitsubishi Electric NEC	cell site equipment cell site equipment, switches	O	(1)
Japan	IDO	AT&T NEC	(1)	C	1992

See note at end of table.

Table 5-11—Continued
Selected open systems or cooperative network equipment bidding, 1981-92

Country	Service provider	Manufacturers	Manufacturers' Responsibilities	Actitivity	Year
Japan	([1])	Motorola NEC	([1])	C	1992

[1] Not available.
Note.—O = Open systems sales.
C = Cooperative bidding.
Sources: U.S. Department of Commerce, *A Competitive Assessment of the U.S. Cellular Radiotelephone Industry,* Dec. 1991; "AT&T, NEC Make Joint Bid in Japan on Cellular System," *The Wall Street Journal,* July 3, 1992; "NEC, Motorola in Telecom Deal," *Financial Times,* July 15, 1992; "In Quest for Billions, GM's Hughes to Bring Phones to Tatarstan," *The Wall Street Journal,* Aug. 21, 1992.

Table 5-12
Factors influencing the competitiveness of cellular phone manufacturers

Characteristics/ Practices	Principal effects
Radio manufacturing experience	• Increases quality • Broadens product line
Integrated circuit core competency	• Reduces size and weight • Increases talk-time • Expands design features
Advanced manufacturing techniques	• Reduces price • Reduces size and weight • Improves after-sales service

Source: Compiled by USITC staff.

Table 5-13
Cellular phone manufacturers' market shares in key markets, 1990

Firm	U.S. sales	Japan sales	Europe sales	Total sales	Market share
	In units				*Percent*
Motorola	629,200	25,200	208,800	863,200	23
Matsushita	450,300	55,500	48,700	554,500	15
Nokia	277,000	(1)	111,400	388,400	11
Mitsubishi	272,100	55,500	(1)	327,600	9
NEC	130,900	60,100	83,500	274,500	7
Toshiba (Audiovox)	238,000	5,900	(1)	243,900	7
Uniden	218,200	(1)	(1)	218,200	6
OKI	186,900	17,700	(1)	204,600	6
NovAtel	123,600	5,900	(1)	129,500	4
Shintom	96,600	(1)	(1)	96,600	3
Technophone	67,700	(1)	(1)	67,700	2
Ericsson	21,800	(1)	27,800	49,600	1
Alcatel	(1)	(1)	27,800	27,800	1
Philips	(1)	(1)	27,800	27,800	1
Siemens	(1)	(1)	20,900	20,900	1
Fujitsu	16,000	4,600	(1)	20,600	1
Others	(1)	(1)	174,000	174,000	5
Total	2,728,300	230,400	730,700	3,689,400	100[2]

[1] Less than 500 units.
[2] Market shares do not sum to 100 percent due to rounding.

Source: *Cellular Brand Sales*, June 1991; Evan Miller, Lehman Brothers, *Nokia - Company Report*, Jan. 1992; and "The Digital Cellular Subscriber Equipment Market in Japan."

NEC. However, these second tier firms have significant sales only in the U.S. market; they are not globally competitive in the same sense as are the largest five cellular phone manufacturers.

Factors Influencing Competition

Radio Manufacturing Experience

Experience derived from developing and manufacturing mobile radio terminals and paging equipment confers two principal benefits on cellular phone makers. Radio manufacturing experience enables firms to produce phones that transmit and receive voice conversations clearly, a key customer requirement. Most importantly, however, previous experience in adapting other types of radio equipment for use outside the home market enhances the ability of firms to develop broad product lines, allowing them to provide phones for a wide range of foreign and domestic customers and to attract interest from cellular phone dealers and retailers (see table 5-14).[82] Broad product lines simplify dealers' and retailers' product sourcing, while simultaneously expanding their pool of potential customers.

Breadth of cellular phone lines may be measured in terms of the number of phone models with different design features, or by conformity to various technical standards (e.g., AMPS, HCS, TACS, GSM). Development of new design features is aided principally by manufacturers' previous experience in developing new antennas and other radio components. In addition, manufacturers with previous radio manufacturing experience report that they are better able to anticipate consumer demand for new features, enhancing their ability to bring popular phones to market ahead of competitors. For example, Motorola's early experience in manufacturing paging and mobile radio equipment led the firm to anticipate the future demand for cellular phones and, afterward, to anticipate customers' desire for lighter cellular phones with more talk-time and advanced design features. Motorola's experience also motivated the firm to develop portable phones when most of its competitors focused on carphones. Earlier experiences in manufacturing other wireless communications devices also enabled Motorola to provide seven carphones and two portable phones to the U.S. market in less than a year after the first commercial cellular service licenses were awarded.[83]

To broaden product line in terms of standards conformity, manufacturers typically reconfigure existing cellular phones. Past experience in reconfiguring other radio equipment better enables firms to modify radio architectures, antennas, and frequency filters to adapt phones to different analog and digital transmission standards.[84]

Table 5-15 illustrates the product range of the five largest cellular phone manufacturers. Motorola, Nokia, and to a lesser extent, Mitsubishi, offer the broadest array of phones, with the first two offering more than 20 different models each. Of these three firms, only Motorola currently manufactures phones for all four predominant analog standards; Nokia does not produce phones for Japan's NTT analog standard, and Mitsubishi does not produce phones conforming to Scandinavia's NMT standards. Motorola's commitment to producing both a broad range of phone models and phones for all predominant analog standards, clearly has expanded the firm's sales opportunities.

[82] Herschel Shosteck Associates, *The Retail Market of Cellular Telephones*, vol. 8, (Silver Spring, 1991), pp. 19-24.

[83] Joseph Morone, *Winning in High-Tech Markets*, (Boston: Harvard Business Press, 1993), p. 77.

[84] These different transmission standards have different technical specifications, and often require modified antennas, frequency filters, and different integrated circuits. Japanese industry representative, interview by USITC staff, Tokyo, Sept. 26-Oct. 2, 1992.

Table 5-14
Radio manufacturing experience of cellular phone manufacturers

Firm	Radio products
Motorola	Microwave radio, short-wave radio, pagers
Matsushita	Television receivers, radio broadcast receivers
Mitsubishi	Radio broadcast receivers, microwave radios, television receivers
Nokia	Television transmitters
NEC	Radio broadcast receivers, microwave radios, television transmitters and receivers

Source: Compiled by USITC staff.

Table 5-15
Product breadth of largest cellular phone makers, 1992

Manufacturer	Model Range	Analog standards available			
		AMPS	TACS	NMT	HCS
Motorola	Broad	Yes	Yes	Yes	Yes
Matsushita	Narrow	Yes	Yes	Yes	Yes
Nokia	Broad	Yes	Yes	Yes	No
Mitsubishi	Broad	Yes	Yes	No	Yes
NEC	Narrow	Yes	Yes	No	Yes

Source: Compiled by USITC staff.

Integrated Circuit Core Competency[85]

Leading cellular phone manufacturers agree that competency in designing integrated circuits is important. Companies with core competency in this area can generally develop the smaller, more efficient, and more powerful integrated circuits required for increasingly sophisticated and user-friendly cellular phones.[86] Incorporating large-scale integrated (LSI) circuits reportedly has been vital in reducing analog phone size and weights (figure 5-6).[87] The electrical pathways in smaller ICs have been reduced, diminishing electrical power loss, and thereby increasing talk-times (figure 5-7).

All five of the predominant cellular phone manufacturers design cellular-specific integrated circuits, although they sometimes cooperate with specialized integrated circuit manufacturers to produce the ICs.[88] Four of the five largest cellular phone makers — Motorola, Matsushita, Mitsubishi and NEC — cooperate closely with other divisions of their companies to manufacture integrated circuits for use in cellular phones (table 5-16). According to industry sources, vertical integration has enabled these manufacturers to incorporate in their phones more advanced integrated circuits, such as ASICs (application specific integrated circuits)[89] and power amplification circuits, as early as one year before these integrated circuits become available on the open market.[90]

Nokia is unique among the five largest cellular phone makers in that the firm does not produce the integrated circuits used in its cellular phones. However, Nokia does not appear to be disadvantaged at present since it seems to have maintained effective control of the design of integrated circuits produced by its suppliers.[91] In the short run, Nokia's strategy reportedly offers the firm many of the advantages associated with vertical integration at a much lower cost.[92] However, in the long run, Nokia's continued success appears to be contingent upon the firm's ability to maintain influence over the manufacturing operations of independent integrated circuit producers.

Table 5-17 compares the design features, weight, and talk-time of portable phones introduced to the U.S. market in 1992. Many design features have become standardized; advanced features such as alphanumeric memory, call restrictions, and one-touch dialing are available on most models. Phone weight and talk-time differ most, and are therefore probably better indicators of core competency in integrated circuit design and manufacturing. Motorola's MicroTac Lite model appears to be the most advanced portable currently on the market, offering both the lightest weight and the longest talk-time. NEC's P600 and P400 models follow closely behind, with roughly comparable weight and talk-time. Nokia's 101 model compares well in terms of talk- and standby-times, but compares unfavorably in terms of weight and memory.[93]

Advanced Manufacturing Techniques

Industry sources note that cellular phone makers generally use advanced manufacturing techniques to lower the production costs of all cellular phones and to reduce the size and weight of portable phones.[94] These

[85] Core competencies are an organization's collective learning about developing and applying diverse skills to the design and production of high-quality, low-cost products.

[86] Manufacturers have largely replaced cellular phone mechanical parts with more electrically efficient and compact integrated circuits.

[87] Japanese industry representatives, interviews by USITC staff, Tokyo, Sept. 26-Oct, 2, 1992.

[88] U.S. and Japanese industry representatives, interviews by USITC staff, Washington, DC, Nov. 18, 1992 and Atlanta, GA, Dec. 3 and 4, 1992.

[89] ASICs are sophisticated integrated circuits that rapidly process large amounts of data.

[90] Japanese industry representatives, interviews by USITC staff, Tokyo, Sept. 26-Oct. 2, 1992; and U.S. industry representatives, interviews by USITC staff, Atlanta, GA, Dec. 3-4, 1992.

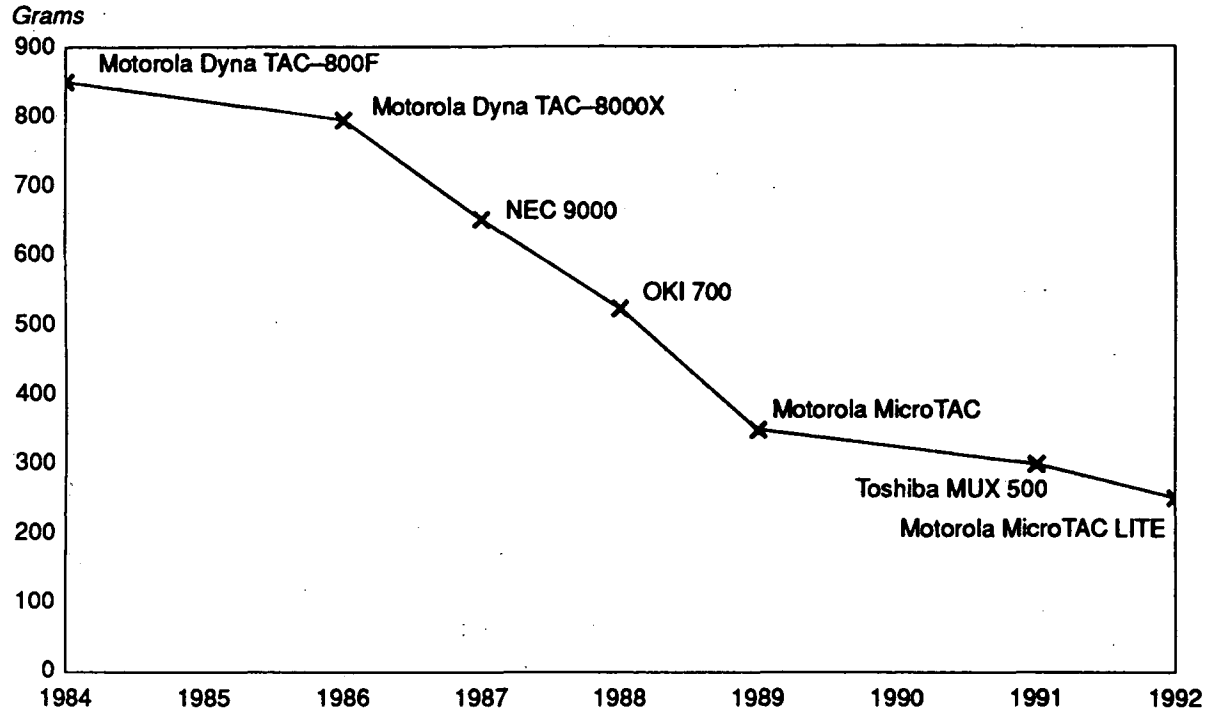
[91] U.S. industry representative, interview by USITC staff, Washington, DC, Dec. 1992.

[92] European industry representatives, interviews with USITC staff, Helsinki, Sept. 30, 1992.

[93] Jennifer L. Hinkle, "The Portable Phone Roundup," *Cellular Business*, June 1992, pp. 28-40.

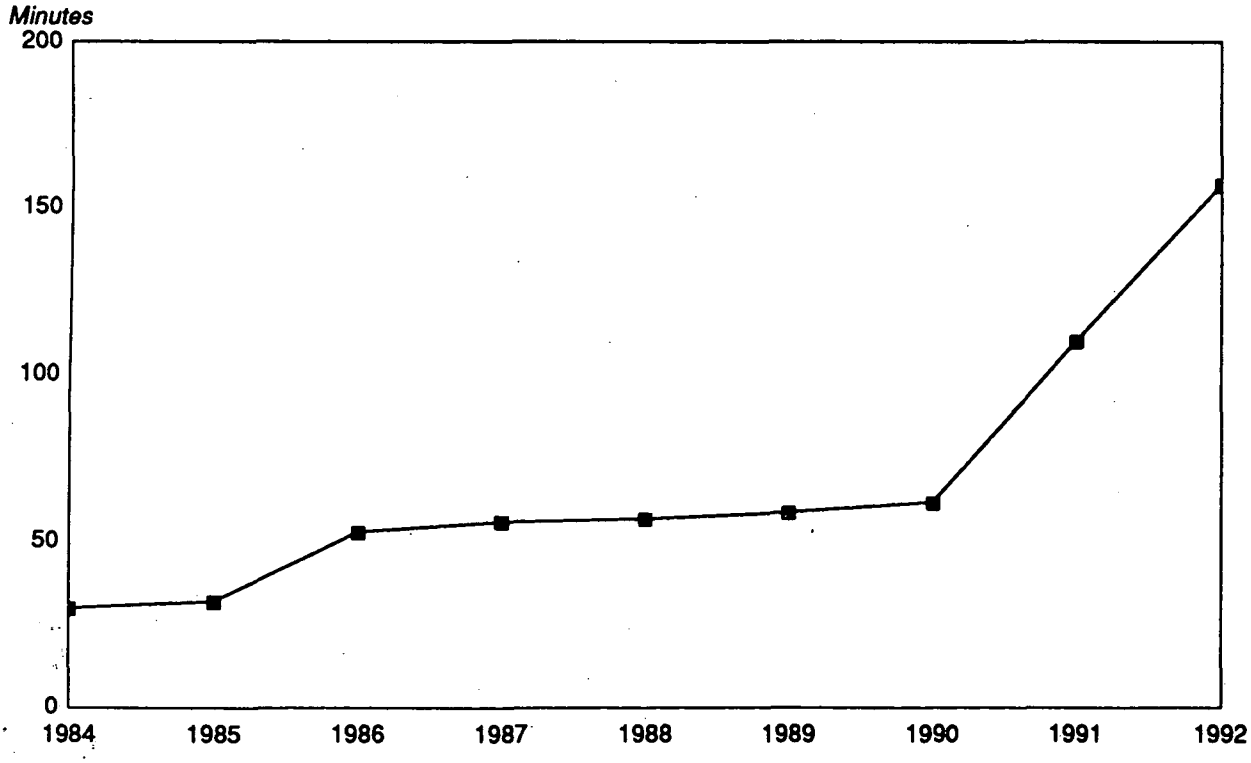
[94] Japanese industry representatives, interviews by USITC staff, Tokyo, Sept. 26-Oct. 2, 1992.

Figure 5-6
Trends in portable phone weights in the U.S. market, 1984–92



Source: Herschel Shosteck Associates, Ltd., *Retail Market of Cellular Telephones, Figure 7.1.*

Figure 5-7
Selected U.S. portable phone talk times (measured in minutes), 1984-92



Source: Motorola, Inc.

Table 5-16
Cellular phone makers' semiconductor[1] sales, 1990

(Millions of dollars)

Company	Semiconductor sales	Corporate sales
Motorola	2,740	10,855
Matsushita	1,795	38,804
Mitsubishi	2,245	19,237
Toshiba	4,710	27,485
Oki Electric	1,115	4,072
NEC	4,820	22,262
Fujitsu	2,885	16,484
Ericsson	290	7,965

[1] Semiconductors are a sub-group of integrated circuits.

Source: Compiled by USITC staff.

techniques include automated component placement, automated process controls, and automated quality control.[95]

The most important advanced manufacturing technique is automated component placement, and the key automated component placement technology is surface mounting.[96] Surface mounting allows cellular phone makers to place small components more closely together than is possible with human labor. Surface mounting reduces assembly labor costs and increases assembly accuracy.[97] Increased assembly accuracy provides for smaller[98] and more durable cellular phones.[99]

Automated process control also enables cellular phone makers to reduce manufacturing costs and improve cellular phone quality. Most cellular phone manufacturers use automated process controls, such as bar code reading systems to manage inventories. Certain firms, such as Technophone, a subsidiary of Nokia, and Oki also use robotic manufacturing apparatus and automated material planning requirement systems to manage component procurement and phone assembly.[100] Automated process controls reportedly increase productivity and, thereby, reduce manufacturing costs. These controls also enhance firms' flexibility, allowing manufacturers to respond more rapidly to changing consumer preferences and expectations.

Automated quality control programs minimize product defects, improving overall product quality and reducing cellular phone prices. Computerized, statistics-based quality control programs, such as Motorola's Six Sigma program[101] and automated manufacturing control systems, quickly and accurately identify equipment and production error. Also, automated sampling methods, such as Motorola's computerized quality tests, are employed by many firms to verify the quality of inputs and intermediate goods.

Advanced manufacturing techniques will likely become increasingly important as price competition intensifies due to technological diffusion and market entry. Cellular phone manufacturers increasingly compete in terms of price and will be required to manage costs effectively to compete successfully (figure 5-8). Firms that continue to employ and improve advanced manufacturing techniques should be well-positioned to compete in a market that is expected to become a price-sensitive consumer electronics market.

Evidence from Statistical Analysis

Statistical analysis performed by USITC staff supports certain themes identified in interviews with industry representatives. Applying data on sixteen cellular phone manufacturers, staff evaluated the relationships of several factors to these firms' market

[95] Ibid.

[96] Surface mounting is the robotic placement and automated soldering of components on printed circuit boards.

[97] Several industry sources estimate that labor costs account for less than 20 percent of portable phone manufacturing costs. Industry representatives, interviews by USITC staff, Japan, Korea, and Hong Kong, Sept. 26-Oct. 9, 1992.

[98] "Ultra-small Portable Telephones Look for a Bigger Market Role" *JEE*, Nov. 1991, p. 64.

[99] Surface mounting's increased accuracy increases the durability of a phone by reducing manual soldering and wiring. In the event that a phone is dropped, surface mounted component assemblies are less likely to break than manually processed assemblies.

[100] "Mobile Makers Vie for Space in U.S. Market", *JEI*, Aug. 1990; "Brainstorming in the Sauna: Inside the Nokia-Technophone Merger," *Electronic Business*, Nov. 18, 1991; and European industry representative, interview with USITC staff, London, Sept. 25, 1992.

[101] The Motorola Six Sigma program is a corporate-wide effort to reduce the firm's product defect level to only 3.4 in every 1,000,000 products.

Table 5-17
Design features available on portable phones introduced in 1992

Item	Matsushita Panasonic	Mitsubishi Electric	Mitsubishi Electric	Motorola	Motorola	Motorola	Motorola
Product Name	VIP HH700	Diamondtel 99X	3000	Ultra Classic	Business Classic	Microtac Lite	Alpha Ser
Dimensions (inches) (LxWxD)	6x3x.7	6.3x2.2x9	6.3x2.2x.95	21.5 Cubic	13.5 Cubic	5.25x2.37x1	5.25x2.37
Weight (ounces)	9.4	10.5	10.4	16.5	10.7	7.5	10.1
RF power output	0.6W	0.6W	0.6W	0.6W	0.6W	0.6W	0.6W
Dual mode or analog	Analog	Analog	Analog	Analog	Analog	Dual Mode	Analog
Repertory memory capacity[1]	200	99	111	99	99	101	101
Alphanumeric memory[2]	Yes	Yes	Yes	Yes	No	Yes	Yes
Call restriction[3]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Volume adjustment	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dual NAM[4]	Yes	Yes	Yes	Optional	Yes	Yes	Yes
Auto redial	Yes	Yes	Yes	Yes	Yes	Yes	Yes
One-touch dialing	Yes	Yes	Yes	No	No	Yes	Yes
Call-in-absence indicator	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Signal strength indicator	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Low battery indicator	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continuous talk time (minutes)	55	45	48	66/132	30/100	45/150	30/100
Standby time (hours)	11	9	9	15/30	8/26	8/12/24	8/24
Recharge time (hours)	1-5	1-8	1-8	([5])	([5])	1-1.5	.5-1
Car kit charger	No	Yes	Yes	Yes	Yes	Yes	Yes
Suggested retail price	$1,200	$995	$999	$750	$1,250	$1,200-$2,500	$795-$999

See notes at end of table.

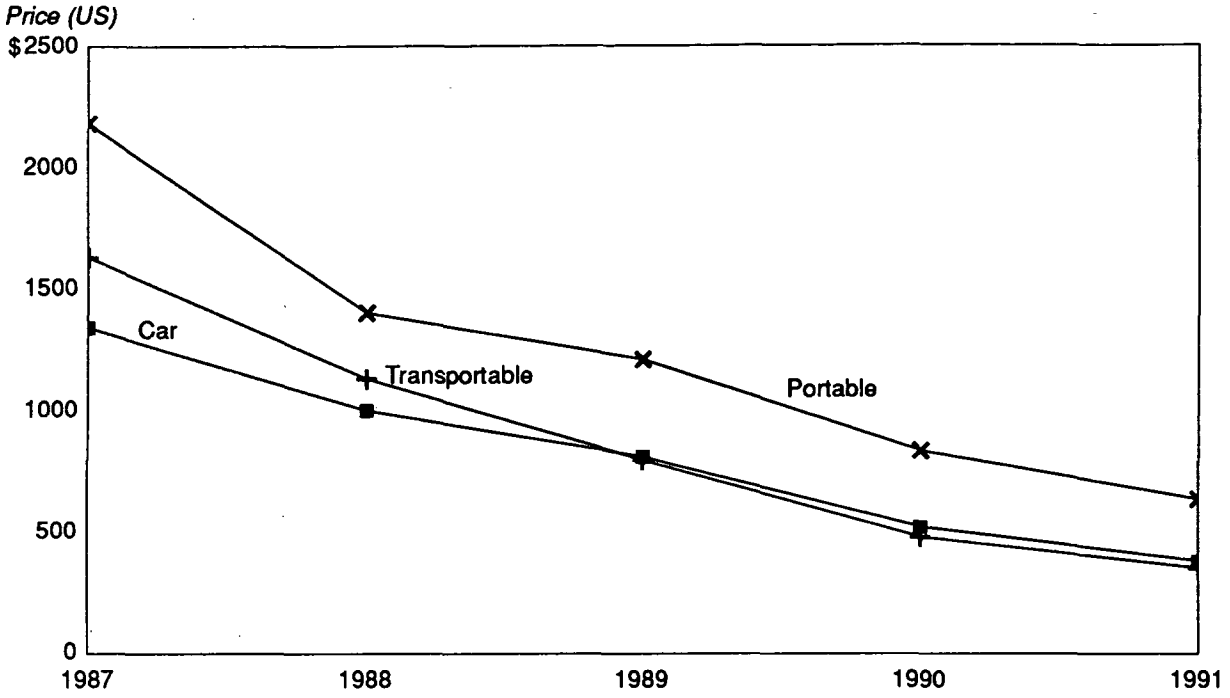
Table 5-17—Continued
Design features available on portable phones introduced in 1992

Item	NEC America	NEC America	NEC America	NEC America	Nokia Mobile	Nokia Technophone
Product Name	P600	P400	P300	P200	NOKIA 101	PC205
Dimensions (inches) (LxWxD)	6x2.2x1.2	6x2.2x1.2	7.2x2.3x1	7.2x2.3x1	6.6x2.2x.8	7.5x2.25x.87
Weight (ounces)	7.7	7.7	14	14	9.7	13
RF power output	0.6W	0.6W	0.6W	0.6W	0.6W	0.6W
Dual mode or analog	Analog	Analog	Analog	Analog	Analog	Analog
Repertory memory capacity[1]	99	40	99	40	50	100
Alphanumeric memory[2]	Yes	No	Yes	No	Yes	Yes
Call restriction[3]	Yes	Yes	Yes	Yes	Yes	Yes
Volume adjustment	Yes	Yes	Yes	Yes	Yes	Yes
Dual NAM[4]	Yes, Quad	Yes	Yes, Quad	Yes	Yes	Yes
Auto redial	Yes	Yes	Yes	Yes	Yes	Yes
One-touch dialing	No	No	No	No	Yes	No
Call-in-absence indicator	Yes	Yes	Yes	Yes	Yes	Yes
Signal strength indicator	Yes	Yes	Yes	Yes	Yes	Yes
Low battery indicator	Yes	Yes	Yes	Yes	Yes	Yes
Continuous talk time (minutes)	60/120	60/120	80	80	45/130	60/90
Standby time (hours)	12/24	12/24	14	14	11/30	13/21
Recharge time (hours)	1-8	1-8	1-8	1-8	4-11	4.5-13
Car kit charger	Optional	Yes	Yes	Yes	No	Yes
Suggested retail price	$1,399	$1,199	$1,150	$999	$799	$699

[1] Repertory memory capacity: Amount of phone numbers a phone's memory can store.
[2] Alphanumeric memory: Alphabetical and numerical characters can be stored in memory.
[3] Call restrictions: Restricts unauthorized transmissions of cellular phone calls.
[4] Dual NAM: Dual Number Assignment Module. Allows phones to register as local terminals in different service areas.
[5] Not available.

Source: "The Portable Phone Roundup," *Cellular Business*, June 1992.

Figure 5-8
Retail prices[1] of cellular phones, U.S. market, 1987-91



[1] These prices do not reflect discounts or promotional prices.

Source: Herschel Shosteck Associates, Ltd, *Retail Market of Cellular Telephone Sales*, Vol. 8, No. 4.

shares in the United States, Europe, and Japan in 1990.[102]

Proxies were available for two of the factors highlighted by the qualitative discussion: radio manufacturing experience, measured by breadth of product line;[103] and core competency in integrated circuits, measured by annual sales (see the following tabulation).[104] As the following tabulation shows, these factors were found to be statistically significant.

Factor	Effect on regional market shares	Statistical confidence level
Radio manufacturing experience	Positive	95 percent
Integrated circuit expertise	Positive	95 percent

[102] For details of the methods used and results, see appendix J.

[103] Breadth of product line is largely a result of radio manufacturing experience, but the measured effect of the variable may reflect greater sales opportunities as well as the benefits of experience.

[104] In addition, one other potentially important factor, research and development expenditures, was initially considered. Due to measurement problems, however, a variable reflecting research and development expenditures No suitable proxy was developed to measure the effect of advanced manufacturing techniques. Comparable data on manufacturing techniques employed by all cellular phone manufacturers are not available.

Summary and Outlook

Extensive industry interviews with predominant cellular phone manufacturers suggest that radio manufacturing experience, integrated circuit design and manufacturing competence, and advanced manufacturing techniques are the principal factors influencing competitiveness. Radio manufacturing experience reportedly enhances firms' ability to broaden product lines, both in terms of model design and standards compliance, with the ultimate result being an expanded universe of sales opportunities. Core competencies in integrated circuit design and manufacturing enhances the ability of firms to produce more user-friendly cellular phones of all types, and smaller and lighter models of transportable and portable phones. Advanced manufacturing techniques ultimately improve the durability and reduce the cost of cellular phones.

[104]—*Continued*
was excluded from this statistical presentation. For a discussion of the measurement problems associated with research and development expenditures, refer to appendix J.

Among all cellular phone manufacturers, only Motorola has double-digit market shares in the United States, Japan, and Europe. Motorola's preeminence appears most attributable to the firm's ability and willingness to produce a broad range of cellular phone models, adaptable to all predominant analog standards. In addition, it seems that Motorola matches or exceeds its principal competitors in terms of cultivating integrated circuit core competency and employing advanced manufacturing techniques.

The digitalization of cellular communications and the advent of personal communications present all cellular phone manufacturers with new opportunities and challenges. The deployment of digital networks provides niche suppliers with the opportunity to claim larger shares of the global cellular phone market. Such firms include Hughes (United States); a host of Japanese firms, including Toshiba, Uniden, Oki, Shintom, and Fujitsu; and European firms, such as Ericsson (Sweden), Alcatel (France), Phillips (Netherlands), and Siemens (Germany). Several Japanese firms have accentuated their commitment to become important global suppliers by establishing overseas facilities (see table 5-18).

For firms that were prominent suppliers of analog cellular phones, the deployment of digital networks requires the redoubling of corporate efforts to maintain competitiveness. Overall, however, it appears likely that firms that were successful in the analog cellular phone market by virtue of their radio manufacturing experience, integrated circuit core competency, and advanced manufacturing techniques, will be significant competitors in the global market for digital cellular phones and personal communication phones. Radio manufacturing experience, particularly experience in producing the present generation of analog cellular phones, will aid efforts to adapt phones to prevailing digital standards. All major suppliers of analog phones have committed to producing cellular phones for all three digital standards: GSM, JDC, and the United States' TDMA standard.

Continued development of integrated circuit design and manufacturing skills, and the implementation of advanced manufacturing techniques, reportedly will be key factors affecting firms' abilities to develop the smaller, lighter, and cheaper phones that are integral to the development of personal communications. It is likely that the ability to produce low-cost phones will be especially important. Recently, cellular phone manufacturers have displayed a willingness to engage in intense price competition. During the last half of 1992, Motorola and Nokia reduced prices in the U.S. market by 10 to 20 percent in maneuvers that were widely interpreted as efforts to increase market share.[105] During the fall of 1992, price competition spilled over into the European market, where Motorola reduced both analog and digital cellular phone prices by 35 to 40 percent, enticing Nokia, Ericsson, and Orbitel to follow suit.[106]

[105] U.S. industry representative, interview with USITC staff, Washington, DC, Nov. 17, 1992.

[106] "Motorola 30 Percent Price Cut Sparks German GSM Price War," *Mobile Communications*, Sept. 24, 1992, p. 1; industry analyst, interview with USITC staff, London, Sept. 23, 1992.

Table 5-18
Japanese cellular phone manufacturers' estimated production in units, by locations, 1990-91

Company	Plant location	Estimated 1990 annual production	Estimated 1991 annual production
Matsushita	Japan	96,000	180,000
	USA	180,000	240,000
	UK	60,000	120,000
Mitsubishi	Japan	120,000	225,000
	USA	144,000	300,000
	Australia	18,000	18,000
	France	(1)	30,000
NEC	Japan	240,000	420,000
	USA	120,000	150,000
	Australia	5,000	60,000
	Mexico	(1)	60,000
	UK	60,000	84,000
Toshiba	Japan	84,000	196,000
	USA	96,000	224,000
Fujitsu	Japan	60,000	98,000
	USA	120,000	120,000
Oki	Japan	120,000	200,000
	USA	180,000	300,000

[1] Not available.

Source: Calculated by USITC staff, based upon "Digital Cellular Subscriber Equipment in Japan" and upon interviews of Japanese industry representatives, Sept. 26-Oct. 2, 1992.

CHAPTER 6
Principal Findings

Ten years after the initiation of cellular communications services in the United States, U.S. service providers and equipment manufacturers are among the most competitive firms in the global cellular communications industry. The U.S. industry, however, faces many present and future challenges as personal communication markets develop, as transitions to digital networks and open systems architecture occur, and as markets for cellular phones and cell site equipment mature.

Cellular Service Providers

Present Competitive Position

Approximately half of the cellular service licenses awarded to foreign service providers have been awarded to U.S. firms, principally the Bell regional holding companies. Chief foreign competitors are found principally in Europe, with Swedish and British firms jointly accounting for roughly one-quarter of all foreign license awards. It seems that the key factor underlying the superior competitive position of these firms is the presence of competition in home markets where firms develop skills that make them attractive as partners to foreign firms and consortia, and as licensees to foreign licensing authorities.

Interviews with service providers suggest that when governments issue multiple cellular service licenses, firms typically compete in terms of price, quality, call features, mobility, and geographic coverage. Competition in terms of price induces firms to control costs through better management, greater efficiency, and cost-reducing technologies. In like fashion, competition in terms of quality promotes the development of engineering expertise, particularly in the area of network configuration; competition in terms of call features promotes the development of software programming, systems integration, and marketing expertise; and competition in terms of mobility and geographic coverage reinforces the development of network configuration and systems integration expertise. These areas of expertise, combined with experience in competitive markets, have attracted interest in U.S., British, and Swedish firms from foreign governments and consortia partners. That a great many foreign governments have decided in recent years to introduce competition to telecommunication service markets via cellular communications has proved fortunate for firms that have experienced competition in the home market.

Future Competitive Position

U.S. service providers' past and present experience with competition at home and abroad, with various analog standards, and with various regulatory frameworks will likely serve them well in the future. Experience and the skills developed in response to competition are aiding U.S. firms' efforts to enter new overseas cellular communications markets as these markets open to foreign participation. U.S. firms are well-represented in the international market for digital cellular service, which is the latest generation of cellular communications technology. As shown in chapter 5, U.S. firms currently hold about half of the digital cellular licenses awarded to foreign service providers.

It seems clear that a key development for service providers in the future is the advent of personal communications. Whereas U.S. cellular service providers collected revenues of $5.7 billion dollars in 1991, U.S. service providers of personal communications are expected to generate revenues of $30 to $40 billion by the year 2000. Personal communications will likely spur more intense price competition in the service market because key regulatory agencies in several countries have signalled their intent to license multiple providers (perhaps as many as 5 in the United States), and because personal communications is expected to constitute a close substitute for cellular service.

With respect to personal communication services, the FCC has been somewhat slower than certain foreign counterparts in taking action relevant to PCS (see chapter 5). The provision of personal communication services in the United States may be delayed as U.S. regulatory bodies deliberate over how to remove and compensate incumbent users of spectrum that will be assigned to personal communications, and over where firms may provide personal communications. U.S. cellular service providers have expressed concern that, if U.S. firms lag significantly behind foreign competitors deploying personal communications in the U.S. market, the international competitive position of U.S. firms will

deteriorate since many will lack the experience required of new service providers.[1]

In addition, certain alternatives under consideration by the FCC appear to impose relatively high costs on U.S. personal communication service providers, presenting further obstacles to PCS deployment in the United States. It appears certain that the FCC will require PCS providers to compensate preexisting spectrum occupants for relocation to unoccupied spectrum. In this respect, the United States is unique among other countries that are presently developing personal communications. In the United Kingdom, Germany, and Hong Kong, incumbent spectrum users will likely move to newly assigned spectrum at their own expense. In addition, current service providers in the United States may be precluded from offering personal communications in areas where they currently provide cellular service, increasing the initial cost of deploying personal communication networks.

Overall, U.S. cellular service providers are concerned that plans under consideration by the FCC will place them at an international competitive disadvantage. As depicted in figure 6-1, firms in the United Kingdom, Germany, and Hong Kong are found in the upper left-hand quadrant of the diagram, where the cost of deploying cellular systems is the lowest and where the speed of deployment likely will be most rapid. Firms in these countries will gain the experience necessary to compete overseas and, all else being equal, will move down the cost curve more quickly than U.S. firms at home, better enabling them to compete in terms of price in what is expected to be a price-sensitive market.

Different scenarios appear to confront firms in the United States. Costs associated with compensating incumbent spectrum users may leave market entry costs high relative to those in the United Kingdom, Germany, and Hong Kong, placing domestic firms in the right-hand side of the diagram. The possibility that cellular service providers may have to deploy entirely new networks in new regions would place domestic firms at the far right, where market entry costs are highest. In the best case scenario, U.S. firms would be able to deploy personal communications networks quickly, placing them in the upper right hand quadrant. In the worst case scenario, the pace of deliberation and network construction would move along slowly, placing firms in the lower right hand quadrant of the diagram, where U.S. firms would appear to be at a distinct competitive disadvantage.

Caveats to these scenarios exist. As members of consortia, two U.S. firms, US West and BellSouth, have won personal communication and quasi-personal communication licenses in the United Kingdom and Germany, respectively. Participation in these markets may provide these two firms with the opportunity to develop the skills necessary to win other personal communication licenses, both in the United States and abroad. In addition, current providers of cellular communications in the United States are allowed to migrate toward microcellular network configurations at their discretion, providing them with the opportunity to experiment with personal communications in the 800-900 MHz range. However, U.S. cellular service providers question whether the limited experience gained in these instances will be sufficient to develop an international competitive advantage in personal communication provision.

[1] U.S. International Trade Commission, *In the Matter of: Global Competitiveness of U.S. Advanced Technology Industries: Cellular Communications*, Jan. 27, 1993, p. 13.

Cellular Network Equipment Manufacturers

Present Competitive Position

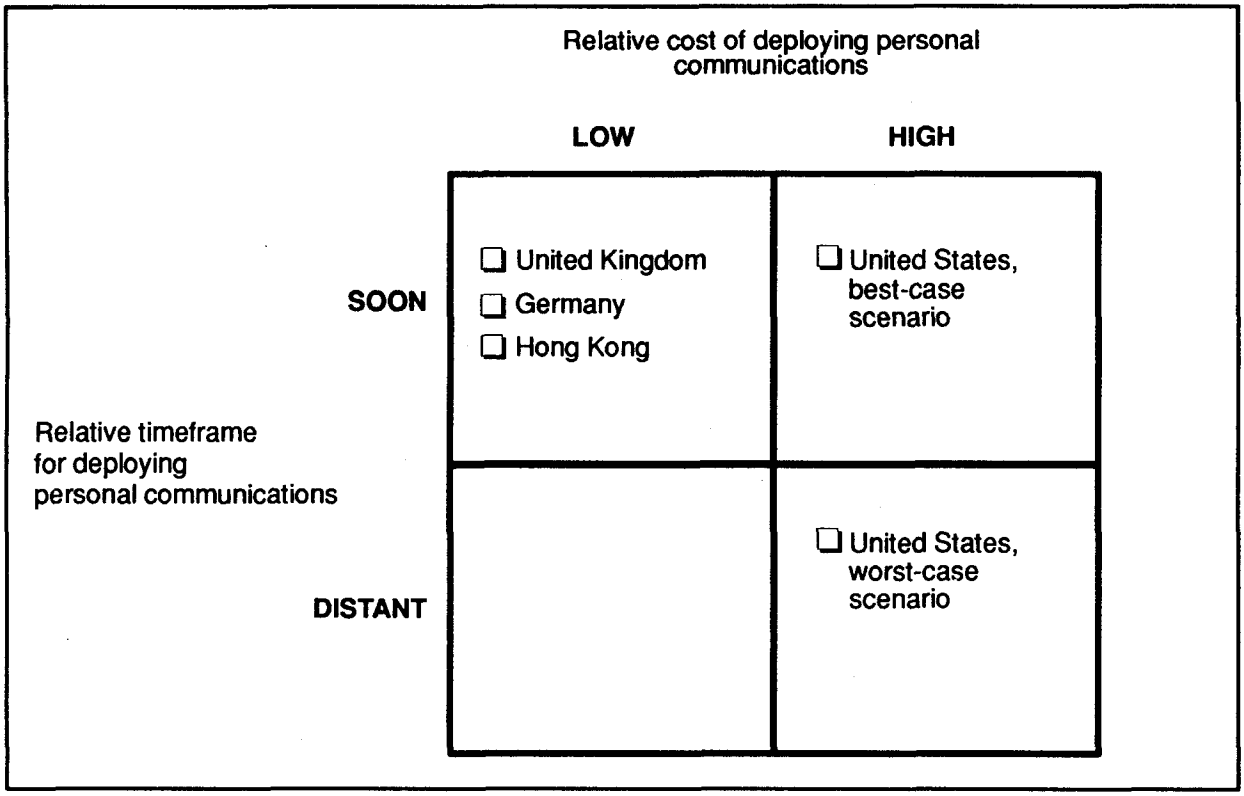
Four firms - Motorola, AT&T, Northern Telecom, and Ericsson - account for nearly 90 percent of global cellular network equipment sales. Motorola and AT&T account for roughly half of all global cellular systems contracts awarded through 1990, although this is largely due to their predominance in the United States, which is the world's largest cellular communications market. Outside the U.S. market, Ericsson appears to enjoy a clear competitive advantage.

Three factors appear to explain Ericsson's competitive advantage in foreign markets. First, Ericsson's ability and willingness to produce equipment for multiple system standards apparently has enhanced the firms's participation in a great many markets. Ericsson is the only manufacturer of network equipment supplying substantial amounts of equipment for networks operating on the AMPS, TACS, and NMT analog standards. Motorola and AT&T have enjoyed fewer sales opportunities as a result of their emphasis on AMPS-based analog standards (including TACS). The inability, or unwillingness, of U.S. firms to produce to the NMT standard appears to have cost these firms market share in Asia, Africa, Eastern Europe, the former Soviet Union, and the Middle East, where the NMT standard has won wide acceptance.

Second, Ericsson has developed and maintained core competencies in both switch manufacturing and cell site equipment manufacturing, establishing a reputation as a supplier of complete, high-quality cellular systems. Motorola, the only other global systems supplier, has seen its reputation as a manufacturer of high quality switches deteriorate, reportedly due in most part to its inability to produce high capacity switches. Ericsson's multiple core competencies accords Ericsson a competitive advantage when bidding to supply cellular systems to service providers that lack the in-house expertise necessary either to integrate equipment manufactured by different equipment manufacturers, or to perform end-to-end maintenance on their network.

Third, Ericsson's global marketing of wireline telecommunications equipment appears to have

Figure 6-1
Future competitive position of cellular service providers in the United Kingdom, Germany, Hong Kong, and the United States



Source: USITC staff.

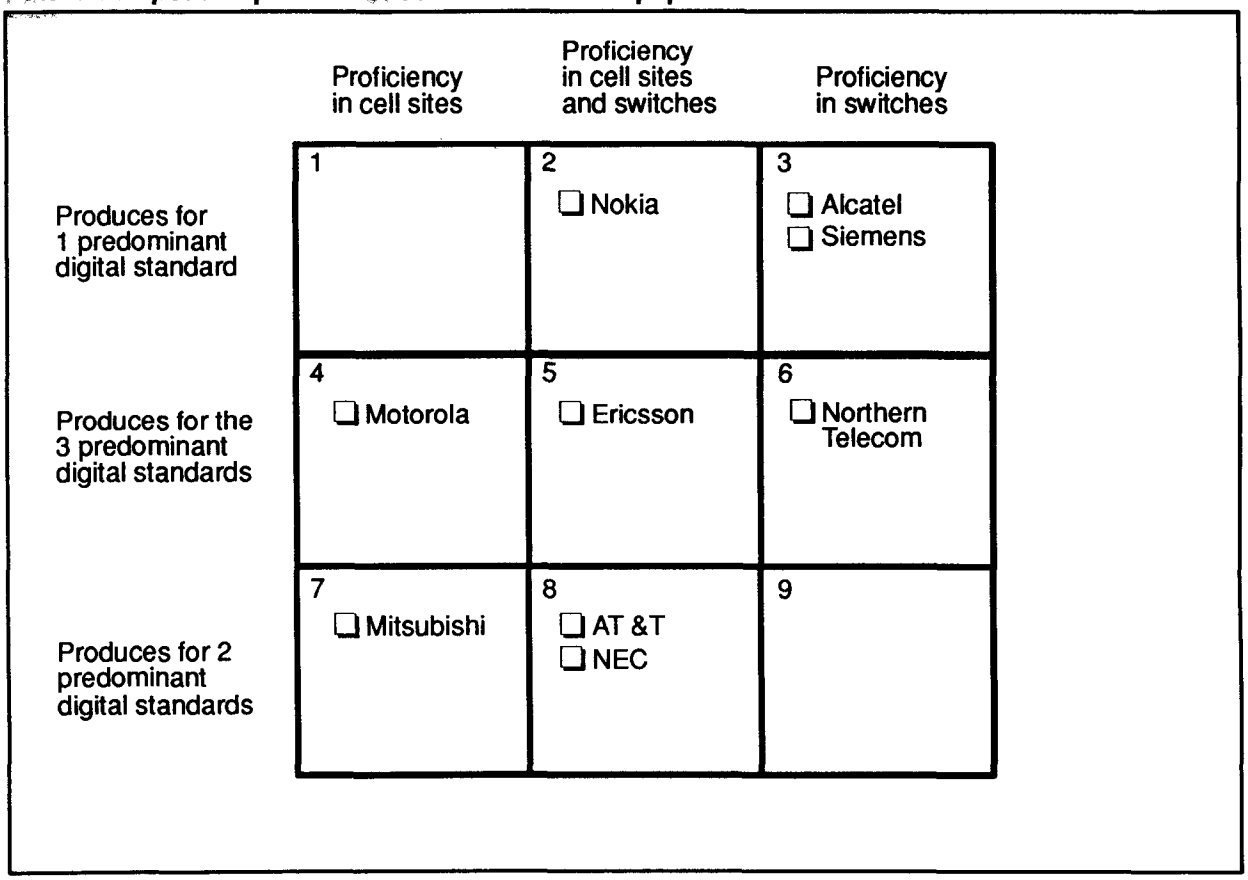
conferred advantage on the firm. Ericsson's long-time supplier relationships with overseas telecommunications service providers has resulted in trust between these firms, leading the service providers to prefer Ericsson's network equipment as they migrate to cellular communications. Over 80 percent of Ericsson's cellular systems contracts have been awarded by national TAs, most or all of which likely have had contact with Ericsson in the market for wireline telecommunications equipment. Motorola and AT&T have had far less experience than Ericsson in foreign wireline telecommunications markets. Motorola sells only a limited number of wireline telecommunications components, and AT&T has traditionally focused on the U.S. market.

Future Competitive Position

For the next 3 to 5 years, network equipment manufacturers will continue to compete principally in terms of technical capabilities, with price competition gradually becoming more important as a result of open systems architecture. Systems contractors' sales opportunities will continue to be constrained by the ability and willingness to produce equipment that conforms to multiple standards. Ericsson's ability to provide systems for all prevalent analog systems will likely continue to confer advantage in developing markets, while its commitment to produce systems for GSM, JDC, and the United States' TDMA standard will be a strength in developed markets. Ericsson's commitment to producing for all predominant digital standards is matched only by Motorola and Northern Telecom.

The relative competitive position of principal network equipment manufacturers is depicted in figure 6-2, where the firms with preferred competitive positions are found in the middle quadrant (quadrant 5). For the next several years, Ericsson is expected to maintain its competitive advantage as a network equipment supplier since it is proficient in designing and manufacturing both switches and cell site equipment, and displays commitment to producing for all three predominant digital standards. AT&T and NEC reportedly match Ericsson in terms of their ability to supply complete cellular systems, but both will produce equipment only for the United States' and Japan's TDMA-based standards. Motorola and Northern Telecom match Ericsson in terms of producing for all digital standards, but industry representatives voice uncertainty concerning these firms' individual abilities to supply both cellular

Figure 6-2
Future competitive position of cellular network equipment manufacturers



Source: USITC staff.

switches and cell site equipment for digital cellular networks. Motorola and Northern Telecom's competitive position relative to Ericsson's is the best in the Western Hemisphere markets, where the Motorola-Nortel joint venture can compete head-on with Ericsson to supply complete cellular network systems.

The advent of open systems, wherein service providers may deploy network equipment manufactured by different firms, will likely have an immense impact on the international network equipment market. With the arrival of open systems, firms are expected to be driven toward specialization in cell site equipment or cellular switches. Over time, the adoption of open systems architecture may erode Ericsson's ability to remain a predominant manufacturer of both cell site equipment and cellular switches. Should Ericsson decide to focus its resources on switch manufacturing, it may be motivated to form an alliance with such firms as Motorola or Mitsubishi, which are reportedly likely to remain focused on the cell site equipment market. Should Ericsson focus on manufacturing cell site equipment instead, it may be motivated to form alliances with Northern Telecom, Alcatel, or Siemens.

Cellular Phone Manufacturers

Present Competitive Position

With 23 percent of the global cellular phone market, Motorola has the largest market share of any firm. With the exception of Nokia, which is based in Finland, Motorola's principal foreign competitors are Japanese electronics firms. Matsushita, Mitsubishi, and NEC jointly account for 30 percent of the global cellular phone market.

Among Motorola's chief strengths are its expertise in advanced manufacturing techniques, especially automated quality control programs, its radio frequency and integrated circuit core competencies, and its broad product range. Combined, these strengths have enhanced Motorola's ability to compete in terms of price, design features, talk-time, and cellular phone size and weight.

Future Competitive Position

Motorola, Nokia, Matsushita, Mitsubishi, and NEC are expected to remain the world's predominant cellular phone manufacturers during the foreseeable future, although their collective share of the global market will likely decline as new producers, especially those from Europe, increase production and sales. The relative position of the 5 largest firms may change from year to year, although it is expected that Motorola will remain the world's largest cellular phone supplier due to its broad range of expertise in both technology and marketing.

It appears that technical core competencies in radio, integrated circuit, and advanced manufacturing techniques will continue to be key attributes of successful cellular manufacturers during the next 3 to 5 years. These competitive strengths will enhance manufacturers' abilities to reduce the price, size, and weight of phones while increasing talk-time, all of which will become more important as cellular networks grow and personal communication systems develop.

As the cellular phone market matures and the requisite manufacturing technology disperses, the effective management of costs, marketing, and distribution will become relatively more important. At present, the markets for carphones and transportable phones do not differ significantly from markets for consumer electronics products, where products compete most intensely in terms of price. It is expected that the market for portable phones will also come to resemble consumer electronics markets over time, although the transition to more sophisticated dual-mode and digital phones may reduce the intensity of price competition from time to time.

Government Regulation

The most significant regulatory policies affecting competitiveness in the cellular communications industry are licensing, spectrum allocation, and standards setting. With respect to licensing, countries that have licensed multiple service providers, such as the United States, the United Kingdom, and Sweden, have generally experienced larger cellular subscribership and lower service prices. Additionally, as countries deploy digital cellular systems, many are following the multiple licensing pattern first established in the United States, enhancing the ability of U.S. firms to participate in foreign markets. Also, as stated earlier, licensing of personal communications service providers is proceeding more slowly in the United States than in the United Kingdom and Germany. This could diminish technological and marketing advantages currently possessed by U.S. cellular firms, as foreign firms could gain valuable marketing and production experience unavailable to U.S. firms.

With respect to spectrum allocation, U.S. industry representatives vary widely in their evaluation of the threat posed to the U.S. industry by spectrum scarcity. On one hand, spectrum scarcity appears to induce creativity and technological advancements. On the other hand, limited spectrum may stymie the development and use of new technologies, ultimately impairing the competitive position of U.S. firms. The United States and Europe are largely relying on market forces to motivate the development and deployment of spectrally efficient digital technologies, whereas Japan has reserved larger amounts of spectrum to ensure sufficient capacity for existing technologies. Spectrum scarcity also affects firms that plan to introduce personal communications services. U.S. licensees may have to bear the cost of relocating incumbent spectrum users, which could further delay and increase costs for the U.S. personal communications industry. It does not appear that European and Asian personal communications providers will experience similar problems.

With respect to standards, the development of a common analog standard enhanced the competitive position of U.S. firms early on, and the lack thereof in Europe imposed clear costs on providers and subscribers alike. Europe's adoption of a common digital standard has reportedly helped European firms to market GSM network equipment to date, and it is reported that the U.S. industry's inability to adopt a common digital standard has adversely affected U.S. firms' sales of cellular network equipment. Standards-setting processes in the United States, Europe, and Japan have remained relatively open, although U.S. industry representatives note concern regarding declining U.S. influence in the European Telecommunications Standards Institute.

APPENDIX A
REQUEST LETTERS

rec'd 6/11/92.
Chairman's Office
DM/FH

United States Senate

COMMITTEE ON FINANCE
WASHINGTON, DC 20510-6200

C L

June 11, 1992

The Honorable
Don E. Newquist
Chairman
U.S. International Trade Commission
500 "E" Street, S.W.
Washington, D.C. 20436

Dear Mr. Chairman:

Global competitiveness of key U.S. industries continues to be of concern and interest to the U.S. Congress. Therefore, the Senate Committee on Finance requests the U.S. International Trade Commission to undertake three additional studies assessing the global competitiveness of advanced technology industries as follow-on studies to the three competitive assessments provided to the Committee during September-October 1991. As noted in the Committee's initial request, providing to the Senate on an ongoing basis impartial and detailed information on the competitiveness of advanced technology industries is a logical extension of the Commission's investigatory role in trade matters.

We approve the Commission's recommendation that the next three studies focus on the U.S. cellular communication, aircraft, and computer industries, and that they be carried out pursuant to sections 332(b), 332(d), and 332(g) of the Tariff Act of 1930. The reports on these three industries should include factors found by the Commission to be relevant to the global competitiveness of these industries as they are considered singly. Such factors may include, but are not limited to, government policies, regulatory and trade impediments, and research and development financing and expenditures. In the aircraft study, the Committee expects the Commission to address the issues of competition in civil aircraft from the Airbus consortium and the proposed acquisition of U.S aerospace technologies and manufacturers by foreign interests.

The Commission is requested to complete the first of these three studies within 12 months, and to conclude the remaining two at three-month intervals thereafter.

Sincerely,

Lloyd Bentsen
Chairman

United States Senate

COMMITTEE ON FINANCE
WASHINGTON, DC 20510-6200

June 21, 1990

The Honorable
Anne Brunsdale
Chairman
United States International
Trade Commission
500 "E" Street, S.W.
Washington, D.C. 20436

Dear Madam Chairman:

As part of its policymaking process, the Senate Committee on Finance anticipates a need for impartial and detailed information on the competitiveness of advanced technology manufacturing industries in the United States. As an independent Federal agency with the authority to investigate the impact of international trade upon domestic industry, it would be a logical extension of the Commission's responsibility to expand and enhance its capacity to provide information on an ongoing basis concerning the relative global competitiveness of American industry.

Accordingly, the Committee hereby requests the Commission to expand its collection of, and ability to analyze, information on the competitiveness of such industries pursuant to sections 332(b), 332(d), and 332(g) of the Tariff Act of 1930.

While the Committee wants the Commission to develop a long-term capacity on a broad range of industries, it recognizes that this expertise must evolve in stages. Thus, the Committee requests initially a two-step investigation. Within three months of the receipt of this letter, the Commission is requested to provide to the Committee a list of industries about which the Commission will develop and maintain up-to-date information. In identifying these industries, the Commission should consider the following criteria, as well as any other criteria it may choose to establish:

-- Those industries producing a product that:

(1) involves use or development of new or advanced technology, involves high value-added, involves research and development expenditures that, as a percentage of sales, are substantially above the national average, and is expected to experience above-average growth of demand in both domestic and international markets; and

(2) benefits in foreign markets from coordinated -- though not necessarily sector-specific -- policies that include, but are not limited to, protection of the home market, tax policies, export promotion policies, antitrust exemptions, regulatory policies, patent and other intellectual property policies, assistance in developing technology and bringing it to market, technical or extension services, performance requirements that mandate either certain levels of investment or exports or transfers of technology in order to gain access to that country's market, and other forms of Government assistance.

At the time the Commission provides this list of industries, the Commission is requested to recommend to the Committee three industries for comprehensive study. In selecting these industries, the Commission should consider, among any other factors it considers relevant, the importance of the industries producing these products to future U.S. global competitiveness; and the extent of foreign government benefits to industries producing competing products.

The Commission's report on these three industries should include, but is not limited to, the following information:

-- Existing or proposed foreign government policies that assist or encourage these industries to remain or to become globally competitive, existing or proposed U.S. Government policies that assist or encourage these industries to remain or become globally competitive, and impediments in the U.S. economy that inhibit increased competitiveness of these U.S. industries.

The Commission should complete the study of these three industries within 12 months of the Committee's approval of the list of recommended industries.

It would be the Committee's intention to review the report carefully in order to determine how to expand, extend, or otherwise modify this request, if necessary, to ensure that future reports continue to yield worthwhile results.

Sincerely,

Lloyd Bentsen
Chairman

APPENDIX B
FEDERAL REGISTER NOTICES

UNITED STATES INTERNATIONAL TRADE COMMISSION
Washington, DC 20436

Investigation No. 332-329

Global Competitiveness of U.S. Advanced-Technology Industries: Cellular Communications

AGENCY: United States International Trade Commission

ACTION: Institution of investigation and scheduling of public hearing.

EFFECTIVE DATE: July 23, 1992

SUMMARY: Following receipt of a request on June 11, 1992, from the Senate Committee on Finance, the Commission instituted investigation No. 332-329, Global Competitiveness of U.S. Advanced-Technology Industries: Cellular Communications, under section 332(g) of the Tariff Act of 1930 (19 U.S.C. 1332(g)).

FOR FURTHER INFORMATION CONTACT: Industry-specific information may be obtained from Mr. Richard Brown (202-205-3438) or Ms. Susan Kollins (202-205-3441). For information on the legal aspects of this investigation contact Mr. William Gearhart of the Commission's Office of the General Counsel (202-205-3091). Hearing impaired individuals are advised that information on this matter can be obtained by contacting the TDD terminal on 202-205-1107.

BACKGROUND: This is one of three competitiveness studies requested by the Committee on Finance in its letter of June 11, 1992. The other two studies concern the aircraft and computer industries, respectively. These three studies are part of a series begun in 1990 at the request of the Committee. In a letter dated June 21, 1990, the Committee asked that the Commission, pursuant to sections 332(b), (d), and (g) of the Tariff Act of 1930, expand its collection of and ability to analyze information on the competitiveness of advanced technology manufacturing industries in the United States. It also asked the Commission to undertake a two part process under which it would (1) within 3 months of receipt of the letter, identify the U.S. advanced-technology industries to be monitored (using the criteria set out by the Committee) and recommend three of those industries as subjects for comprehensive Commission studies; and (2) within 12 months of receipt of a subsequent Committee letter either agreeing with or modifying the Commission's recommendations, submit its reports on the three industries.

In response, the Commission instituted investigation No. 332-294 for the purpose of identifying industries to be monitored and recommending three for comprehensive study. In its report to the Committee in September 1990, the Commission identified ten advanced-technology industries and recommended the following three for comprehensive study: communications technology and equipment, pharmaceuticals, and semiconductor manufacturing and testing equipment. The Committee by letter of September 27, 1990, approved the Commission's recommendations, and the Commission furnished its reports on the three investigations (investigation Nos. 332-301, 332-302, and 332-303) in late September 1991. Notice of the institution of investigation No. 332-294 was published in the Federal Register of July 26, 1990 (55 F.R. 3053), and

notice of the institution of the three comprehensive-study investigations was published in the Federal Register of November 15, 1990.

In the three new studies, the Commission will, as requested by the Committee in its June 11, 1992, letter, seek to examine all factors found by the Commission to be relevant to the global competitiveness of the subject industries, including but not limited to, government policies, regulatory and trade impediments, and research and development financing and expenditures. The Commission will also seek the views of experts on the implications of these factors for U.S. trade interests and policy. As requested, the Commission will submit its first industry report, cellular communications, by June 11, 1993.

PUBLIC HEARING: A public hearing in connection with the cellular communications investigation will be held in the Commission Hearing Room, 500 E Street, SW, Washington, DC, beginning at 9:30 a.m. on January 20, 1993. All persons will have the right to appear by counsel or in person, to present information, and to be heard. Requests to appear at the public hearing should be filed with the Secretary, United States International Trade Commission, 500 E Street, SW, Washington, DC 20436, no later than noon, January 6, 1993. Any prehearing briefs (original and 14 copies) should be filed not later than noon, January 6, and any posthearing briefs should be filed by February 3.

WRITTEN SUBMISSIONS: In lieu of or in addition to appearing at the hearing, interested persons are invited to submit written statements concerning the matters to be addressed by the Commission in its report on this investigation. Commercial or financial information that a submitter desires the Commission to treat as confidential must be submitted on separate sheets of paper, each clearly marked "Confidential Business Information" at the top. All submissions requesting confidential treatment must conform with the requirements of section 201.6 of the Commission's Rules of Practice and Procedure (19 CFR 201.6). All written submissions, except for confidential business information, will be made available for inspection by interested persons in the Office of the Secretary to the Commission. To be assured of consideration by the Commission, written statements relating to the Commission's report should be submitted at the earliest practical date and should be received no later than February 3, 1993. All submissions should be addressed to the Secretary of the Commission at the Commission's office, 500 E Street, SW, Washington, DC 20436.

Persons with mobility impairments who will need special assistance in gaining access to the Commission should contact the Office of the Secretary at 202-205-2000.

By order of the Commission.

Paul R. Bardos

Paul Bardos
Acting Secretary

Issued: July 24, 1992

UNITED STATES INTERNATIONAL TRADE COMMISSION
Washington, DC 20436

Investigation No. 332-329

Global Competitiveness of U.S. Advanced-Technology Industries: Cellular Communications

AGENCY: United States International Trade Commission

ACTION: Rescheduling of public hearing.

EFFECTIVE DATE: August 19, 1992

SUMMARY: The Commission has rescheduled from January 20, 1993, to January 27, 1993, the public hearing in the above captioned investigation. The hearing will be held in the Commission Hearing Room, 500 E Street, SW, Washington, DC, beginning at 9:30 a.m. on January 27, 1993. All persons will have the right to appear by counsel or in person, to present information, and to be heard. Requests to appear at the public hearing should be filed with the Secretary, United States International Trade Commission, 500 E Street, SW, Washington, DC 20436, no later than noon, January 13, 1993. Any prehearing briefs (original and 14 copies) should be filed not later than noon, January 13, and any posthearing briefs should be filed by February 10.

Persons with mobility impairments who will need special assistance in gaining access to the Commission should contact the Office of the Secretary at 202-205-2000.

The investigation was instituted by the Commission on July 23, 1992, under section 332(g) of the Tariff Act of 1930 (19 U.S.C. 1332(g)) following receipt of a request on June 11, 1992, from the Senate Committee on Finance. Notice of institution of the investigation and scheduling of a public hearing was published in the Federal Register of July 31, 1992 (57 F.R. 33971).

FOR FURTHER INFORMATION CONTACT: Industry-specific information may be obtained

from Mr. Richard Brown (202-205-3438) or Ms. Susan Kollins (202-205-3441). For information on the legal aspects of this investigation contact Mr. William Gearhart of the Commission's Office of the General Counsel (202-205-3091). Hearing impaired individuals are advised that information on this matter can be obtained by contacting the TDD terminal on 202-205-1107.

By order of the Commission.

Paul Bardos

Acting Secretary

Issued: August 20, 1992

APPENDIX C
LIST OF COMPANIES, ASSOCIATIONS, GOVERNMENT AGENCIES, AND RESEARCH FIRMS INTERVIEWED BY COMMISSION STAFF

Cellular Service Providers

Ameritech International (United States)
Bell Atlantic Mobile Systems (United States)
BellSouth International (United States)
BT Mobile Communications (United Kingdom)
Comvik (Sweden)
DDI Corporation (Japan)
Deutsche Telepost Consulting GmbH (Germany)
France Telecom Division Mobiles
Hutchinson Telecom (Hong Kong)
Korea Mobile Telecommunications Corporation
Kolon Group (Korea)
Mannesmann Mobilfunk GmbH (Germany)
McCaw Cellular Communications (United States)
Millicom, Inc. (United States)
Nippon Idou Tsushin Corporation (Japan)
NTT Mobile Communications Network, Inc. (Japan)
NYNEX Mobile Communications (United States)
Pacific Telesis International (United States)
Pacific Link (Hong Kong)
PacTel Corporation (United States)
Swedish Telecom Radio
Taehwan Telecommunications (Korea)
Televerket (Sweden)
U S West Spectrum Enterprises International (United States)
U S West NewVector (United States)

Network Equipment Manufacturers

Alcatel NV (France)
AT&T Network Systems (United States)
DSC Communications Corporation (United States)
Ericsson Radiosystems AB (Sweden)
Hughes Network Systems (United States)
Mitsubishi Electric Corporation Communications Equipment Works (Japan)
Motorola, Inc. (United States)
NEC Corporation (Japan)
Northern Telecom, Inc. (Canada)
Plexsys International Corporation (United States)
Telefonaktlebolaget LM Ericsson (Sweden)

Cellular Phone Manufacturers

Ericsson GE Mobile Communications, Inc. (Sweden/United States)
Goldstar Telecommunication, Co., Ltd. (Korea)
Matsushita Communications Industrial Co., Ltd./National Panasonic (Japan)
Mitsubishi Consumer Electronics (Japan)
Motorola, Inc. (United States)
Nokia Mobile Phones (Finland)
Orbitel Mobile Communications, Ltd. (United Kingdom/Sweden)
Uniden (Japan)

Governmental and Quasi-governmental Agencies

Commission of the European Communities
Department of Trade and Industry (United Kingdom)
European Telecommunications Standards Institute (ETSI)
Federal Communications Commission
Federal Ministry of Posts and Telecommunications (Germany)
Hong Kong Economic and Trade Office
Ministry of Posts and Telecommunications (Japan)
Ministry of Communications (Republic of Korea)
Ministry of Transport and Communications (Finland)
Office of Telecommunications (United Kingdom)
Organization for Economic Cooperation and Development (OECD)
Research and Development Center for Radio Systems (Japan)
State of California Public Utilities Commission

Industry Associations, Research Organizations and Publications

American Electronics Association
Cellular Business
Cellular Telecommunications Industry Association (CTIA)
Donaldson, Lufkin & Jenrette
EGIS
Hatfield & Associates, Inc.
Herschel Shosteck Associates
InfoCom Research, Inc. (Japan)
Institute of Electrical and Electronics Engineers, Inc. (IEEE)
L'Industrie Francaise de'Electronique Professionelle
Lehman Brothers Securities International
Mobile Communications, Financial Times Business Information
Nomura Research Institute, Ltd.
Personal Technology Research, Inc.
Pyramid Research
Smith Barney, Harris Upham & Co., Inc.
Telecommunications Industry Association (TIA)
Wissenschaftliches Institut fuer Kommunikationsdienste GmbH (Germany)

APPENDIX D
CALENDAR OF WITNESSES APPEARING AT THE PUBLIC HEARING

As of January 14, 1993

TENTATIVE CALENDAR OF PUBLIC HEARING

Those listed below are scheduled to appear as witnesses at the United States International Trade Commission's hearing:

Subject	:	GLOBAL COMPETITIVENESS OF U.S. ADVANCED-TECHNOLOGY INDUSTRIES: CELLULAR COMMUNICATIONS
Inv. No.	:	332-329
Date and Time	:	January 27, 1993 - 9:30 a.m.

Sessions will be held in connection with the investigation in the Main Hearing Room 101 of the United States International Trade Commission, 500 E Street, S.W., Washington, D.C.

ORGANIZATION AND WITNESS:	TIME CONSTRAINTS
Cellular Telecommunications Industry Association Washington, D.C. Thomas E. Wheeler, President and CEO	10 Minutes
Plexsys International Corporation Naperville, IL Augie K. Fabela, Jr., Chairman	10 Minutes
Hughes Network Systems, Inc. Germantown, MD C. P. Shankar, Assistant Vice President, Celluar Sales and Marketing	10 Minutes
Motorola, Inc. Washington, D.C. Timothy A. Harr, Legal Counsel	10 Minutes

- end -

APPENDIX E
CELLULAR COMMUNICATIONS GLOSSARY

Glossary

Advanced Mobile Phone Service (AMPS): An analog transmission technology which supports approximately 60 percent of the world's cellular subscribers, and 100 percent of U.S. cellular subscribers. AMPS was developed by AT&T and became the basis for several other analog standards found in Europe, Japan, and emerging cellular markets.

Analog: The method of transmitting voice, video, and data electronically where signals correspond to the movement of the transmitted signal. The first generation of cellular communication services is based on analog technology. However, due to capacity limitations, analog systems are expected to be replaced by digital systems.

Bell Regional Holding Companies (RHCs): The seven local telephone service companies divested by AT&T on January 1, 1984. The RHCs are significant participants in the domestic and foreign cellular communication service markets.

Cell: A subdivision of a mobile service area that can vary in size depending on terrain, capacity demands, etc. Each cell is covered by its own low-power transmitter, receiver, and signaling equipment ("cell site equipment").

Cell splitting: A means of increasing the capacity of a cellular system by subdividing cells into smaller cells. Some firms are using this technique to introduce personal communication services.

Code Division Multiple Access (CDMA): A digital cellular transmission technology that separates call packets and scatters them over a wide range of frequencies. Reportedly, systems using CDMA technology would offer 10 to 20 times the capacity of present analog systems. CDMA is one of two digital technologies which will provide the foundation for technical standards used by the U.S. cellular communications industry (see also TDMA).

Digital modulation: A method of encoding information for transmission that is expected to offer greater capacity, deliver better quality, and permit more services than present analog systems.

Extended Time Division Multiple Access (ETDMA): A digital cellular transmission technology that provides for capacity increases exceeding those of TDMA technology. Reportedly, systems using ETDMA technology would offer 17.5 times the capacity of present analog systems.

Global System for Mobile Communications (GSM): The pan-European digital cellular system standard.

Hand-off: The process by which the mobile telephone switching office passes a cellular phone conversation from one cell to another.

Improved Mobile Telephone Service (IMTS): A mobile radio telephony system introduced by AT&T in 1969. IMTS eliminated the need to place calls through mobile operators, and reduced the severe capacity restraints found in earlier MTS networks.

Japanese Digital Cellular (JDC): The Japanese digital standard derived from TDMA technology. The JDC standard is reportedly very similar to the TDMA-based digital standard adopted by the U.S. industry, perhaps providing for greater economies of scale for manufacturers that produce network equipment for either the U.S. or the Japanese markets.

Local Access and Transport Areas (LATAs): The Modification of Final Judgment provided that the U.S. telecommunication service market be separated into approximately 160 LATAs, each generally the size of a large metropolitan area and surrounding countryside.

Metropolitan Statistical Area (MSA): The Federal Communications Commission divided the U.S. cellular communications market into 306 MSAs and 428 Rural Service Areas (RSA). Two cellular carriers were offered operating licenses in each MSA and RSA.

Microcells: Cellular network architecture formed by splitting existing cells into smaller geographic areas, providing for greater network capacity. Microcells are likely to be one element

of personal communication networks, which will utilize very low power transmitters and smaller, lighter portable phones.

Mobile Telephone Service (MTS): Mobile radio telephony introduced by AT&T in 1946. MTS was a precursor of modern cellular communication networks.

Mobile Telephone Switching Office (MTSO): The MTSO houses cellular switches, which control the operations of cellular systems. The MTSO monitors cellular calls, coordinates hand-offs, manages billing information, and interfaces with the traditional wireline network.

Modification of Final Judgment (MFJ): A settlement between the U.S. Department of Justice and AT&T whereby the latter agreed to divest 22 local telecommunication service operating companies and to retain Western Electric, Bell Labs, and long distance service operations. The agreement limited the divested local service providers, later reorganized into the 7 Bell regional holding companies (RHCs), to local service provision. The RHCs can not offer long distance services outside of their respective local access and transport areas or manufacture equipment.

Narrowband AMPS (NAMPS): A technology that reportedly provides for a three-fold capacity increase over analog AMPS systems. In markets that have adopted AMPS systems, NAMPS systems may be offered as alternatives to systems based on TDMA or CDMA technologies.

Nordic Mobile Telephone (NMT): An analog transmission technology originally developed in Scandinavia and later used by service providers in Europe and some developing countries.

Network Equipment: Includes cellular switches and cell site equipment. Cell site equipment includes radio base stations, channel banks, microwave radio equipment, towers, and antennas.

Open Systems Architecture: Systems architecture that standardizes interface protocols, which govern communication between switches and radio base stations. Open systems architecture facilitates communication between network equipment manufactured by different firms, all of which employ unique, incompatible protocols in the absence of open systems procurement.

Personal Communications: Two-way wireless communication using low-powered, small handsets, typically within microcells. It is expected to be offered in several developed country markets in the 2 Gigahertz (GHz) band.

Pico Cells: Microcells that have been further reduced in size. Pico cells are presently used inside tunnels, and may be used for indoor cellular communications in the future.

Pure-Play Service Providers: Cellular service providers that exclusively operate mobile communications networks.

Radio Spectrum: The range of frequencies extending from 10 kilohertz (kHz) to 300 GHz. These frequencies are located below those of visible light and above those of audible sound. Spectrum is a non-depletable, finite, natural resource, that is utilized by wireless communications, such as cellular communications.

Resellers: Cellular service providers that purchase airtime at wholesale prices, and sell cellular service to subscribers at retail prices.

Roam(ing): The ability to use a cellular phone on a system other than the subscriber's home system.

Seamless Roaming: The capability to roam freely throughout a designated region (e.g., in the United States or Europe), using the same cellular telephone.

Search Algorithms: Computerized procedures which establish interfaces between radio base stations and cellular phones.

Telecommunication Authorities (TAs): Publicly-owned telecommunication service providers, some of which are vested with significant regulatory powers.

Total Access Communication Systems (TACS): An analog transmission technology originally developed in the United Kingdom. TACS was the first analog transmission technology designed to transmit to and receive signals from portable phones.

Time Division Multiple Access (TDMA): A digital cellular transmission technology that divides discrete amounts of time on a radio frequency into parts, and then assigns different phone conversations to each part. Reportedly, systems using TDMA technology would offer 3 times the capacity of present analog systems. TDMA is one of two digital technologies which will provide the foundation for technical standards used by the U.S. cellular communications industry (see also CDMA).

APPENDIX F
INTERNATIONAL STANDARDS ADOPTION

Table F-1a
Cellular standards in Asia-Pacific and the analog equipment supplier(s)

Country	AMPS	TACS	NMT	Analog Supplier(s)	GSM	USA-D
Australia	Selected			Ericsson	Selected	
Bangladesh	Selected			Motorola		
Brunei	Selected			Motorola		
China	Selected	Selected	Selected	Motorola Ericsson NovAtel	Expected	
Hong Kong	Selected	Selected		Ericsson Motorola	Selected	
India				n/a	Selected	
Indonesia	Selected		Selected	Ericsson Motorola		
Korea, S.	Selected			Motorola/AT&T		Selected
Malaysia		Selected	Selected	Ericsson/ Radiosystem Sweden Ericsson	Expected	
Pakistan	Selected			Ericsson		
Philippines	Selected			NEC AT&T Motorola		
Singapore	Selected	Selected		NEC Ericsson	Expected	
Sri Lanka		Selected		Motorola		
Taiwan	Selected			Ericsson	Expected	
Thailand	Selected		Selected	Ericsson/Nokia/ Radiosystem Sweden Motorola	Expected	

Source: Pyramid Research, Inc., *Cellular Markets in Developing Countries*; "World Report '92," *Cellular Business*, May 1992; and USITC staff interviews with industry representatives.

Table F-1b
Cellular standards in Latin America and the Caribbean and the analog equipment supplier(s)

Country	AMPS	TACS	NMT	Analog Equipment Supplier(s)	GSM	USA-D
Argentina	Selected			Motorola		Expected
Bahamas	Selected			Northern Telecom		Expected
Bolivia	Selected			Motorola		Expected
Brazil	Selected			NEC Northern Telecom		Expected
Chile	Selected			Ericsson/NEC NovAtel Motorola		Expected
Colombia						Expected
Costa Rica	Selected			NovAtel		Expected
Dominican Republic	Selected			Motorola/AT&T		Expected
Ecuador	Selected			n/a		Expected
El Salvador	Selected			Ericsson		Expected
Guatemala	Selected			Motorola		Expected
Jamaica	Selected			n/a		Expected
Mexico	Selected			Ericsson/ Motorola/ Northern Telecom		Expected
Paraguay	Selected			n/a		Expected
Peru	Selected			NovAtel		Expected
Puerto Rico	Selected			Northern Telecom		Expected
Uruguay	Selected			Motorola		
Venezuela	Selected			Ericsson Motorola		Expected

Source: Pyramid Research, Inc., *Cellular Markets in Developing Countries*; "World Report '92," *Cellular Business*, May 1992; and USITC staff interviews with industry representatives.

Table F-1c
Cellular standards in the Middle East and Africa and the analog equipment supplier(s)

Country	AMPS	TACS	NMT	Analog Equipment Supplier(s)	GSM	USA-D
Algeria			Selected	Nokia	Expected	
Bahrain		Selected		NEC	Expected	
Cyprus			Selected	Ericsson	Expected	
Egypt		Selected		Matsushita	Expected	
Israel	Selected			Motorola		Expected
Jordan	Selected				Expected	
Kenya		Selected		NEC		Expected
Kuwait		Selected		NEC/Ericsson	Expected	
Mauritius		Selected		NovAtel	Expected	
Morocco			Selected	Ericsson	Expected	
Nigeria		Selected		Ericsson	Expected	
Oman			Selected	Ericsson	Expected	
Saudi Arabia			Selected	Phillips/ Ericsson	Expected	
South Africa				Siemens (450-C)	Expected	
Tunisia			Selected	Ericsson	Expected	
Turkey			Selected	Mobira	Expected	
UAE		Selected		Ericsson	Selected	
Zaire	Selected			Motorola/ Plexsys		Expected
Zambia				Motorola		

Source: Pyramid Research, Inc., *Cellular Markets in Developing Countries*; "World Report '92," *Cellular Business*, May 1992; and USITC staff interviews with industry representatives.

Table F-1d
Cellular standards in Eastern Europe and the former Soviet Union and the analog equipment supplier(s)

Country	AMPS	TACS	NMT	Analog Equipment Supplier(s)	GSM	USA-D
Byelarus			Selected	n/a		
Czechoslovakia			Selected	Nokia	Expected	
Estonia			Selected	Ericsson		
Hungary			Selected	Ericsson	Selected	
Latvia			Selected	n/a		
Lithuania			Selected	Nokia		
Poland			Selected	Alcatel Nokia	Expected	
Romania			Selected	n/a		
Russia			Selected	Nokia/Ericsson Ericsson	Selected	
Ukraine			Selected	n/a	Expected	
Uzbekistan			Selected	n/a		
Yugoslavia			Selected	Ericsson	Expected	

Source: Pyramid Research, Inc., *Cellular Markets in Developing Countries*; "World Report '92," *Cellular Business*, May 1992; and USITC interviews with industry representatives.

APPENDIX G
WAIVERS ON INTER-LATA RESTRICTIONS

Table G-1
Cellular waiver requests on inter-LATA restrictions

Company	DOJ	Court	Disposition	Notes
AT&T	-	May 19, 1983	Nov. 1, 1983	Granted
US West	Aug. 23, 1984	Aug. 27, 1984	Dec. 14, 1984	Granted
Bell Atlantic	Nov. 9, 1984	Apr. 5, 1985	June 25, 1985	Granted
NYNEX	Feb. 8, 1985	Sept. 24, 1985	Jan. 28, 1987	Granted
Pacific Telesis	Mar. 21, 1985	Oct. 30, 1986	Feb. 24, 1987	Granted
Pacific Telesis	July 1, 1985	Dec. 9, 1985	Feb. 26, 1986	Granted in part
Bell Atlantic	Dec. 13, 1985	Aug. 12, 1988	Feb. 15, 1991	Granted
Southwestern Bell	June 30, 1986	Nov. 26, 1986	Sept. 22, 1987	Granted
Southwestern Bell	Aug. 28, 1986	Feb. 1, 1989	Sept. 28, 1990	Procedure established for granting waiver pending further information.
Bell Atlantic	Oct. 24, 1986	Feb. 23, 1988	Feb. 2, 1989	Granted
Bell Atlantic	Oct. 24, 1986	Aug. 15, 1988	Sept. 12, 1990	Granted
Ameritech	Nov. 12, 1986	June 15, 1988	Sept. 6, 1988	Granted
NYNEX	Nov. 25, 1986	May 9, 1988	Sept. 6, 1988	Granted
Southwestern Bell	Feb. 2, 1987	Dec. 23, 1987	Mar. 31, 1988	Granted
Pacific Telesis	Feb. 11, 1987	Aug. 12, 1988	Nov. 14, 1988	Granted
BellSouth	Feb. 29, 1987	Sept. 30, 1988	Feb. 2, 1989	Granted
BellSouth	Feb. 29, 1987	Sept. 30, 1988	Feb. 2, 1989	Granted
BellSouth	Apr. 10, 1987	June 15, 1988	Sept. 6, 1988	Granted
NYNEX	May 4, 1987	July 5, 1988	Sept. 12, 1990	Granted
NYNEX	May 4, 1987	Aug. 15, 1988	Sept. 6, 1988	Granted
NYNEX	May 29, 1987	Aug. 15, 1988	Feb. 15, 1991	Granted
NYNEX	June 4, 1987	Sept. 6, 1988	Sept. 20, 1988	Granted
Bell Atlantic	June 30, 1987	June 15, 1988	Sept. 12, 1990	Granted
BellSouth	July 21, 1987	Sept. 30, 1988	Feb. 2, 1989	Granted
Southwestern Bell	Aug. 7, 1987	Aug. 12, 1988	Sept. 12, 1990	1 Year Grant
BellSouth	Oct. 8, 1987	Jan. 16, 1990	Sept. 12, 1990	Granted
Ameritech	Oct. 20, 1987	July 5, 1988	Sept. 6, 1988	Granted
US West	-	July 29, 1988	Sept. 6, 1988	Granted
Ameritech	Oct. 20, 1987	Aug. 15, 1988	Sept. 12, 1990	Granted
Bell Atlantic	Nov. 19, 1987	Sept. 20, 1988	Sept. 12, 1990	Granted
US West	Nov. 20, 1987	June 15, 1988	Sept. 6, 1989	Granted
NYNEX	Dec. 29, 1987	Sept. 30, 1988	Sept. 12, 1990	Granted
US West	Jan. 11, 1988	Sept. 30, 1988	Feb. 2, 1990	Granted
Pacific Telesis	May 9, 1988	Aug. 12, 1988	Sept. 12, 1990	1 Year Grant
US West	June 3, 1988	Aug. 12, 1988	Sept. 12, 1990	1 Year Grant
BellSouth	June 8, 1988	Sept. 30, 1988	Sept. 12, 1990	Granted in part
US West	June 14, 1988	Sept. 30, 1988	Feb. 2, 1989	Granted
Southwestern Bell	July 21, 1988	Aug. 12, 1988	Sept. 12, 1990	1 Year Grant
BellSouth	Aug. 11, 1988	Sept. 19, 1988	Sept. 12, 1990	1 Year Grant
BellSouth	Aug. 11, 1988	Sept. 30, 1988	Sept. 12, 1990	Granted in part
Pacific Telesis	Aug. 12, 1988	Feb. 1, 1989	Sept. 28, 1990	Procedure established for granting waiver pending further information.
BellSouth	Sept. 13, 1988	Jan. 16, 1990	Sept. 12, 1990	Granted in part
Southwestern Bell	Sept. 21, 1988	Sept. 26, 1989	Apr. 10, 1990	Withdrawn by Southwestern Bell as moot

Table G-1—Continued
Cellular waiver requests on inter-LATA restrictions

Company	DOJ	Court	Disposition	Notes
Pacific Telesis	Sept. 26, 1988	Feb. 20, 1990	Sept. 12, 1990	Remand to Department of Justice
Pacific Telesis	Sept. 27, 1988	Feb. 20, 1990	Sept. 12, 1990	1 Year Grant
Pacific Telesis	Sept. 27, 1988	Feb. 20, 1990	Sept. 12, 1990	1 Year Grant
Pacific Telesis	Nov. 17, 1988	Feb. 20, 1990	Sept. 12, 1990	1 Year Grant
NYNEX	Dec. 6, 1988	Jan. 16, 1990	Sept. 12, 1990	Granted
Bell Atlantic	Dec. 12, 1988	Jan. 16, 1990	Sept. 12, 1990	Granted
Pacific Telesis	Jan. 5, 1989	Feb. 20, 1990	Sept. 12, 1990	1 Year Grant
Bell Atlantic	Feb. 17, 1989	Nov. 16, 1990	Feb. 15, 1991	Granted
NYNEX	Mar. 14, 1989	Jan. 16, 1990	Sept. 12, 1990	Granted
Southwestern Bell	Mar. 27, 1989	Nov. 16, 1990	Apr. 10, 1990	Withdrawn by Southwestern Bell as moot
Pacific Telesis	Aug. 29, 1989	Nov. 8, 1990	Dec. 8, 1990	Granted pursuant to court's 9/28/90 order
BellSouth	Sept. 15, 1989	Jan. 16, 1990	Sept. 12, 1990	Granted in part
Bell Atlantic	Dec. 15, 1989	Feb. 2, 1990	Apr. 6, 1990	Granted
BellSouth	-	June 18, 1990	Sept. 12, 1990	Remand to Department of Justice
RHCs	-	June 18, 1990	Sept. 12, 1990	1 Year Grant

Source: Report of the Bell Companies on Competition in Wireless Telecommunications Services, 1991, Oct. 31, 1991.

Table G-2
Pending waiver requests on inter-LATA restrictions

Requestor	DOJ	Court	Description
Pacific Telesis	Sept. 19, 1988		Resell interexchange services to GTE Mobilnet cellular customers.
Ameritech	Jan. 6, 1989		InterLATA 800 service for miliLATA paging.
NYNEX	Mar. 7, 1989	Mar. 15, 1991	InterLATA cellular service in six New Work RSAs.
Southwestern Bell	July 18, 1989	Mar. 15, 1991	InterLATA cellular service in RSAs.
Pacific Telesis	Oct. 3, 1989		InterLATA paging origination and access to VSR services.
Bell Atlantic	Oct. 6, 1989		Management and consulting services for other cellular systems.
Southwestern Bell	Dec. 21, 1989		Intersystem handoff and automatic call delivery between Massachusetts and Maine.
US West	Dec. 21, 1989	Mar. 15, 1991	InterLATA cellular service in RSAs.
Ameritech	Dec. 27, 1990		InterLATA service and automatic call delivery in Toledo.
NYNEX	Jan. 16, 1990		InterLATA cellular service between areas of New York and Massachusetts.
Southwestern Bell	Jan. 19, 1990		InterLATA cellular service in Texas.
Bell Atlantic	Jan. 30, 1990	Mar. 15, 1991	InterLATA cellular service in RSAs.
NYNEX	May 21, 1990		InterLATA cellular service between areas of Massachusetts and Connecticut.
Ameritech	July 26, 1990	Mar. 15, 1991	InterLATA integration of RSAs with existing cellular systems in Illinois and Indiana.
US West	Aug. 1, 1990		Cellular service in several Washington and Oregon LATAs and in Canadian cellular areas.
RHCs	Aug. 2, 1990	Mar. 15, 1991	RSA waivers for all RHCs.
NYNEX	Sept. 12, 1990		Resell cellular service in New York RSAs.
Pacific Telesis	Nov. 29, 1990	Apr. 4, 1991	InterLATA cellular service between several Ohio MSAs.
Southwestern Bell	Dec. 20, 1990		Automatic call delivery.
Bell Atlantic	Jan. 10, 1991		Automatic call delivery.
NYNEX	Jan. 28, 1991		Automatic call delivery.
BellSouth	Jan. 29, 1991		Automatic call delivery.
BellSouth	May 9, 1991		Integrated cellular service in California, Indiana, Virginia, Louisiana, and Florida.
BellSouth	May 9, 1991		Integrated cellular service over an expanded area in Indiana.

Source: Report of the Bell Companies on Competition in Wireless Telecommunications Services, 1991, Oct. 31, 1991.

APPENDIX H
FIRMS' PROPOSALS TO THE FCC PERTAINING TO REGULATION OF PERSONAL COMMUNICATIONS

Table H–1
Firms' proposals to the FCC pertaining to regulation of personal communications, through January 1993

Firm type/Firm	Number of Licenses	Spectrum Per Licensee	Licensing Areas	Licensing Procedure	Unlicensed Service	Cellular/LEC Eligibility
Personal Communications/Cable Firms						
American Personal Communications	2 + Reserve	40 MHz	Major Trading Areas[1]	Comparative Hearing	20 MHz	No/(2)
Associated PCN Corporation	2	40 MHz	(2)	Lottery	(2)	No/Yes
Cablevision Systems Corporation	3	30-40 MHz	LATAs[3]	Lottery	(2)	(2)
Cox Enterprises, Inc.	2	40 MHz	Major Trading Areas	Comparative Hearing	(2)	(2)/No
PCN America, Inc. (Millicom)	2	40 MHz	Major Trading Areas	Comparative Hearing	20 MHz	No/No
Personal Communications Services of N.Y., Inc. (LOCATE)	3	30 MHz	Major Trading Areas	Comparative Hearing	(2)	No/No
Pertel, Inc.	2-3	30-45 MHz	Major Trading Areas	Hearing/Lottery	20 MHz	No/Yes
Omnipoint Communications, Inc.	2	40-60 MHz	(2)	(2)	20 MHz	(2)
Tel/Logic	2-3	30-40 MHz	LATAs/National	Lottery	20 MHz	No/No
Time Warner Telecommunications, Inc.	2	40+ MHz	1 National, 1 MTA	Qualified Lottery	20 MHz	(2)
Viacom International, Inc.	2	25 MHz + "Pool"	Cellular Areas	Lottery	No	No/No
Cellular and SMR Firms						
ALLTEL Corporation	5	20 MHz	Cellular Areas	Lottery	(2)	Yes/Yes
Cellular Telecommunications Industry Association (CTIA)	5	20 MHz	Cellular Areas	Auction or Lottery	(2)	Yes/Yes
Centel Corporation	5-6	20-25 MHz	Cellular Areas	Lottery	20 MHz	Yes/Yes
Comsat PCS Communications, Inc.	4	20 MHz	LATAs	Lottery	(2)	No/No
Fleet Call	5	20 MHz	Cellular Areas	Auction	(2)	(2)
GTE Corporation	5	20 MHz	Cellular Areas	Comparative Hearing	(2)	Yes/Yes
McCaw Cellular Communications, Inc.	5-7	20 MHz	Cellular Areas	Auction/Lottery	20 MHz	Yes/Yes
Regional Bell Holding Companies (RHCs)						
Ameritech	4	2 x 20, 2 x 30 MHz	Basic Trading Areas[4]	Lottery	20 MHz	Yes/Yes
Bell Atlantic	5	18-20 MHz	2 National, 3 Cellular	Hearing and Lottery	20 MHz	Yes/Yes
BellSouth	5 + 1	5 x 20, 1 x 10 MHz	Cellular Areas	Lottery	(2)	(2)
NYNEX Corporation	5	(2)	Cellular Areas	Comparative Hearing	20 MHz	Yes/Yes
Pacific Telesis	3	25 MHz	Basic Trading Areas	Lottery	65 MHz	Yes/Yes
Southwestern Bell	2-3	20-25 MHz	Cellular Areas	(2)	No	Yes/Yes
U S West	4	25 MHz	3 MTA/ 1 Cellular	Lottery	40 MHz	Yes/Yes
Interexchange Carriers						
AT&T	5	20 MHz	Cellular Areas	Lottery	20 MHz	Yes/Yes
MCI	3	40 MHz	National	Comparative Hearing	(2)	No/No
Sprint	3	30 MHz	Cellular Areas	Lottery	(2)	Yes/Yes
Non-RHC Local Exchange Carriers (LECs)						
Cincinnati Bell Telephone Company	4	20 MHz	Cellular Areas	Lottery	20 MHz	Yes/Yes
National Telephone Cooperative Association	5	(2)	Cellular Areas	Lottery	(2)	(2)/Yes
OPASTCO	5	(2)	Cellular Areas	Lottery	(2)	(2)/Yes
Rochester Telephone Corporation	5	20 MHz	Cellular Areas	Comparative Hearing	(2)	Yes/Yes
United States Telephone Association	5	20 MHz	Cellular Areas	Lottery	(2)	Yes/Yes

See notes at end of table.

Table H-1—Continued
Firms' proposals to the FCC pertaining to regulation of personal communications, through January 1993

Firm type/Firm	Number of Licenses	Spectrum Per Licensee	Licensing Areas	Licensing Procedure	Unlicensed Service	Cellular/LEC Eligibility
Equipment Manufacturers/Data-PCS						
Apple Computer, Inc.	(2)	(2)	(2)	(2)	40-65 MHz	(2)
Ericsson Corporation	2	25 MHz	(2)	(2)	35+ MHz	(2)
Hughes Network System, Inc.	3	30 MHz	Cellular Areas	(2)	20 MHz	Yes/Yes
Motorola, Inc.	4+	2 x 40, 2 x 10 MHz	Basic Trading Areas	Lottery	20 MHz	(2)
Northern Telecom	3	30 MHz	(2)	(2)	35+ MHz	Yes/Yes
Qualcomm, Inc.	2 + Reserve	40 MHz	Major Trading Areas	Hearing or Lottery	20 MHz	(2)
ROLM	3	(2)	(2)	Lottery	35+ MHz	No/Yes
Wireless Information Network Forum (WINForum)	(2)	(2)	(2)	(2)	40-65 MHz	(2)
Government Entities						
Antitrust Division, Department of Justice	3	30 MHz	Cellular Areas	Auction or Lottery	20 MHz	No/Yes
National Telecommunications & Information Administration (NTIA)	3-5	+30 MHz	183 DOC Areas	Auction	(2)	No/Yes
Small Business Administration	5+	20 MHz	Cellular Areas	Lottery	Supports	Yes/Yes

[1] Licenses would be specific to one of 49 major trading areas, as defined by Rand-McNally.
[2] Not available.
[3] Licenses would be specific to one of 161 local access and transport areas.
[4] Licenses would be specific to one of 487 basic trading areas, as defined by Rand-McNally.

Source: FCC, General Docket 90-314.

APPENDIX I
LICENSE AWARDS IN EMERGING CELLULAR MARKETS

Table I-1
Foreign participation in cellular licenses, emerging cellular markets, 1993

Country/City	Partners	Ownership	Award Date	Comments
		(Percent)		
Argentina	*Communicaciones Radio Moviles (CRM)*		1989	November 1991: roaming agreement between
(Buenos Aires)	BellSouth (US)	38.0		Chile, Argentina, Uruguay, Mexico, and Peru
	Motorola (US)	25.0		established. $220 million to be invested over
	BGH (Argentina)	15.0		15 years.
	Socma (Argentina)	17.0		
	Astra (Argentina)	5.0		
Argentina	*StarTel*		1991	Wireline cellular licensee.
(Buenos Aires)	Telefonica de Espana (Spain)	40.0		
	Citibank (US)	n/a		
	Technit (Argentina)	n/a		
	France Telecom	20.0		
	STET (Italy)	20.0		
	J.P. Morgan (US)	n/a		
	Perex Compac (Argentina)	n/a		
Australia	*Optus Communications*		1991	GSM license.
	BellSouth (US)	24.5		
	Cable & Wireless (UK)	24.5		
	Four Australian firms	51.0		
Australia	*Arena GSM*		1993	GSM license. $96 million license fee paid to
	Vodafone (UK)	n/a		Government. On-line in mid-1993.
	MCI (US)	n/a		
	Exicom (New Zealand)	n/a		
Bangladesh	Hutchison Telephone Company (Hong Kong)	60.0	1991	Expected on-line by 1993.
	Bangladesh Government	40.0		
Bolivia	*Telefonica Cellular de Bolivia*		1991	
	Millicom International Cellular (Sweden/US)	69.0		
	Bolivian companies	31.0		
Byelarus	CommStruct International (US)	50.0	1991	
	Byelarus Government	50.0		
Chile	*CIDCOM*		1991	Competes with CTC, one of Chile's 2 dominant
Santiago, Valparaiso, Vina de Mar	BellSouth (US)	100.0		carriers. Purchased from Pacific Telecom (US) in 1991 for $17 million. $50 million capital investment over 2-3 year period.
Chile	*Compania de Telefonos Chile (CTC) Cellular*			CTC is a local and long-distance telephone
Santiago, Valparaiso, Vina del Mar	Telefonica de Espana (Spain)	50.2		company. In April 1992, the Chilean
	Chilean Investors	49.8		Government ruled that Telefonica must divest its holding in either CTC or ENTEL within 18 months.
Chile	*Telecom Chile*			ENTEL is Chile's long-distance and
Rural	Motorola (US)	66.0		international provider, is 20 percent-owned
	ENTEL (Chile)	34.0		by Telefonica de Espana, 10 percent-owned by Chase Manhattan (US).

Table I-1—Continued
Foreign participation in cellular licenses, emerging cellular markets, 1993

Country/City	Partners	Ownership	Award Date	Comments
		(Percent)		
Chile	*VTR Telecom*		n/a	Controls 60 percent of the cellular market outside Santiago
Rural	Millicom International Cellular (Sweden/US)	n/a		
	VTR Telecommunications (Chile)	n/a		
Costa Rica	*Movitel*		1988	
	Millicom International Cellular (Sweden/US)	85.0		
	Costa Rican investors	15.0		
Czechoslovakia	*Eurotel Prague/Eurotel Bratislava*		1990	Eurotel will invest $60 million over next ten years.
	US West (US)	24.5		
	Bell Atlantic (US)	24.5		
	Czech & Slovak Governments	51.0		
Dominican Republic	*Codetel*		1990	Codetel is the GTE-owned Dominican telephone company.
	GTE (US)	100.0		
El Salvador	*Telemovil*			
	Millicom International Cellular (Sweden/US)	70.0		
	Salvadoran investor	30.0		
Estonia	*Eesti Mobiil Telefon (EMT)*		1990	Baltic systems are inter-operable with the Scandinavian, Moscow, and St. Petersburg cellular networks.
	Telecom Finland	24.5		
	Swedish Telecom	24.5		
	Estonian Government	51.0		
Ghana	Millicom International Cellular (Sweden/US)	100.0	1987	
Guatemala	*Communicaciones Celulares*		1990	20-year license
	Millicom International Cellular (Sweden/US)	45.0		
	Local partner	55.0		
Honduras	Millicom International Cellular (Sweden/US)	n/a	1992	
	Motorola (US)	n/a		
Hong Kong	*Hutchison Telephone Company*		1985	Analog and digital networks.
	Hutchison Telecommunications (Hong Kong)	70.0		
	Motorola (US)	30.0		
Hong Kong	*Pacific Link*		1989	Millicom sold its 50 percent stake to First Pacific in 1991 for $150 million. Analog and digital network.
	First Pacific Corporation (Hong Kong)	70.0		
	Vodafone (UK)	30.0		
Hong Kong	*SmartCom*		1992	First digital license (GSM), fourth cellular license. Town Khan is a commercial subsidiary of China's Communications Ministry. $154 million to be invested by 1997. McCaw's share is less than $10 million. McCaw will provide technical expertise.
	McCaw Cellular Communications (US)	30.0		
	Sun Hung Kai Properties (Hong Kong)	40.0		
	ABC Communications (Hong Kong)	15.0		
	Town Kahn (People's Republic of China)	15.0		
Hungary	*WesTel*		1989	To date, US West has invested $13 million.
	US West (US)	49.0		
	Hungarian Telephone Company	51.0		

Table I-1—Continued
Foreign participation in cellular licenses, emerging cellular markets, 1993

Country/City	Partners	Ownership	Award Date	Comments
		(Percent)		
India				
Bombay	Bhaarati Cellular (India)	n/a	1992	2 GSM licenses in each city.
	SFR (France)	n/a		
	Compagnie Generale des Eaux (France)	n/a		
	BPL Systems & Projects Ltd. (India)	n/a	1992	
	France Telecom	n/a		
Delhi	India Telecom Pvt. Ltd.	n/a	1992	
	OTC Ltd. (Australia)	n/a		
	Tata Cellular Ltd. (India)	n/a	1992	
	BCE (Canada)	n/a		
Madras	Sterling Cellular Ltd. (India)	n/a	1992	
	Cellular Communications, Inc. (US)	n/a		
	Skycell Communications Pvt. Ltd. (India)	n/a	1992	
	BellSouth (US)	n/a		
Calcutta	Usha Martin Telecom Ltd. (India)	n/a	1992	
	Telekom Malaysia	n/a		
	Mobile Telecom Services Ltd. (India)	n/a	1992	
	Vodafone (UK)	n/a		
Korea	*Sunkyong Group*		1992	License returned to Government in late 1992 amidst allegations of corruption. Other foreign bidders included: NYNEX (US), BT (UK), Pacific Telesis (US) and Mannesmann Mobilfunk. Eliminated from final round of competition: Bell Atlantic (US), Swedish Telecom, Southwestern Bell (US) and US West (US). Foreign ownership limited to 33 percent.
	Sunkyong (Korea)	n/a		
	GTE (US)	n/a		
	Vodafone (UK)	n/a		
	Hutchison Telecom (Hong Kong)	n/a		
	Lucky Goldstar (Korea)	n/a		
	Korea Electric Corp.	n/a		
	Various Korean companies	n/a		
Latvia	*Latvian Mobile Telephone Company*		1991	
	Swedish Telecom	24.5		
	Telecom Finland	24.5		
	VEF (Latvia)	23.0		
	Latvian State Radio & Television Centre	23.0		
	Latvian Telecommunication Centre	5.0		
Lithuania	*Comliet*		1991	Comliet will also establish international satellite link.
	Millicom International Cellular (Sweden/US)	49.0		
	Vilnius Telephone Network (Lithuania)	41.0		
	UAB Antena (Lithuania)	10.0		
Mauritius	Millicom International Cellular (Sweden/US)	50.0		MIC's initial investment: $3.5 million.
	Local Partners (Mauritius)	50.0		

Table I-1—Continued
Foreign participation in cellular licenses, emerging cellular markets, 1993

Country/City	Partners	Ownership	Award Date	Comments
		(Percent)		
Mexico	*TELCEL*		1990	TELCEL, TELMEX's mobile subsidiary, is the wireline cellular operator in each of Mexico's 8 regions and Mexico City.
	Southwestern Bell (US)	10.0		
	France Telecom	10.0		
	Grupo Carso (Mexico)	29.0		
	Public Stock Offering	51.0		
Mexico (Region 2 Arizona border)	*Movitel del Noroeste*		1990	Contel is providing technological and operating expertise
	McCaw (US)	19.0		
	Contel Cellular (US)	19.0		
	Industrias Bachoco (Mexico)	24.0		
	Tubos de Acero (Mexico)	35.0		
	DBL Americas Fund (Mexico)	3.0		
Mexico (Region 3, New Mexico, West Texas border)	*Norcel*		1990	
	Motorola (US)	25.0		
	Centel (US)	20.0		
	Grupo Domod (Mexico)	51.0		
	Private Mexican investor	4.0		
Mexico (Region 4, Texas border, Monterrey)	*Cedetel*		1990	
	Millicom International Cellular (Sweden/US)	49.0		
	Protexa (Mexico)	51.0		
Mexico (Region 5, Guadalajara)	*Comcel*		1990	Nonwireline license consortia each paid the Government $55 million for the license and pay 6 percent of network revenues as operating fees. $41 million investment over 2-3 year period.
	BellSouth (US)	39.0		
	Grupo Hermes (Mexico)	45.0		
	Racal Telecom (UK)	10.0		
	Banamex (Mexico)	6.0		
Mexico (Region 6, central Mexico)	*Portacel*		1990	
	BCE Mobile (Canada)	30.0		
	Grupo Alarcon (Mexico)	70.0		
Mexico (Region 7, Acapulco)	*Telecommunicaciones del Golfo*		1990	
	BCE Mobile (Canada)	30.0		
	Grupo Industrio de Desarrollo (Mexico)	n/a		
	IUSA (Mexico)	n/a		
Mexico (Region 8, Yucatan Peninsula)	*Portatel del Sureste*		1990	
	Associated Communications (US)	24.0		
	LCC (US)	15.0		
	Mexican investors	61.0		
New Zealand	Bell Atlantic (US)	50.0	1990	49.9% of Telecom New Zealand to be sold on open market by September 1993.
	Ameritech (US)	50.0		
New Zealand	BellSouth (US)	100.0		
Nicaragua	Millicom International Cellular (Sweden/US)	n/a	1992	
	Motorola (US)	n/a		
	CTC Cellular (Spain/Chile)	n/a		

Table I-1—Continued
Foreign participation in cellular licenses, emerging cellular markets, 1993

Country/City	Partners	Ownership	Award Date	Comments
		(Percent)		
Nigeria	*Mobile Telecommunications Service (MTS)*		1993	Extended Total Access Communications (ETACs standard) $65 million wireless intrastructure for cellular, paging, trunked radio, voice mail and broadcast television services.
	Digital Communications (US)	55.0		
	Nigerian Telecommunications	44.0		
Pakistan	*Pakcom*		1989	
	Millicom International Cellular (Sweden/US)	50.0		
	Arfeen International (Pakistan)	50.0		
Pakistan	*Paktel*		1990	
	Cable & Wireless (UK)	80.0		
	Hasan Associates (Pakistan)	20.0		
Paraguay	*Telefonica Celular*		1991	
	Millicom International Cellular (Sweden/US)	51.0		
	Paraguayan partner	49.0		
Peru	*Telemovil*		1990	
	Panamericana de Television (Peru)	n/a		
	Cellular International (US)	n/a		
Philippines	*Extelcom*			
	Millicom International Cellular (Sweden/US)	50.0	1989	
	Express Telecommunications Company (Philippines)	50.0		
Poland	*Polska Telefonia Komorkowa*		1991	$50 million investment over 3-4 years. Reportedly, Ameritech and France Telecom paid $70-80 million for the license.
	Ameritech (US)	24.5		
	France Telecom	24.5		
	Polish Government	51.0		
Romania	Nationwide Cellular (US)	51.0	1991	
	Romanian Government	49.0		
Russia			1993	GSM licenses. Intertelecom provides intercity and international long distance service in Russia. VART is a group of Russian telecommunications equipment manufacturers.
Perm	US West (US)	n/a		
Novosibirsk	Intertelecom (Russia)	n/a		
Nizhny Novgorod				
Sochi	US West (US)	n/a		
Vladivostock	Intertelecom (Russia)	n/a		
Blagoveshensk	VART (Russia)	n/a		
Petropavlovsk				
Russia	*Moscow Cellular Communications*		1991	Initial investment: $7 million.
Moscow	US West (US)	22.0		
	Millicom International Cellular (Sweden/US)	20.0		
	Ministry of Posts and Telecommunications	50.0		
	Fyodorov Eye Microsurgery Science and Technology Complex of Moscow	8.0		

Table I-1—Continued
Foreign participation in cellular licenses, emerging cellular markets, 1993

Country/City	Partners	Ownership	Award Date	Comments
		(Percent)		
Russia	*Euronet*		1992	Awarded a test license by the Russian Government to operate an 800 MHz AMPS cellular system.
	Plexys International (US)	n/a		
	Information Transfer Technical System Center (Russian Ministry of Foreign Affairs)	n/a		
	Vimpel Corp. (Russian military electronics contractor)	n/a		
Moscow	BCE (Canada)	n/a	1993	GSM license
	Russian partners	n/a		
Russia	*Delta Telecom*		1991	Priority connection to international gateway switch. $7 million investment.
St. Petersburg	US West (US)	40.0		
	St. Petersburg City Telephone Network Production Association	55.0		
	St. Petersburg Station Technical Radio Control	5.0		
St. Petersburg	Telecom Finland	n/a	1993	GSM license
Sri Lanka	*Celltel Lanka*		1989	MIC paid $7 million for its rights rto the cellular concession.
	Millicom International Cellular (Sweden/US)	50.0		
	Local Partner (Sri Lanka)	50.0		
Tanzania	Cable & Wireless (UK)	100.0	1992	
Ukraine	*Ukrainian Mobile Company*		1992	The consortium is licensed to provide paging, analog cellular, GSM cellular and PCN services. Reportedly, PTT Netherlands has relinquished its stake to DBP Telekom.
	DBP Telekom (Germany)	16.3		
	PTT Telecom (Netherlands)	16.3		
	Telecom Denmark	16.3		
	Ukrainian Government	51.1		
Uruguay	*Abitar*		1991	$10 million to build the system
	BellSouth (US)	38.0		
	Motorola (US)	25.0		
	BGH (Argentina)	15.0		
	Socma (Argentina)	17.0		
	Astra (Argentina)	5.0		
Uzbekistan	*Uzbanrobita*		1992	ICG is providing hard currency and operating expertise.
	ICG (US)	45.0		
	Uzbek Government	55.0		
Venezuela	*CANTV*		1992	GTE-led consortium paid $83 million for ownership of the cellular concession. Government's 49% eventually to be sold on the open market.
	GTE (US)	20.0		
	AT&T (US)	5.0		
	Telefonica de Espana (Spain)	16.0		
	Venezuelan Government	49.0		
	CANTV workers	11.0		

Table I-1—Continued
Foreign participation in cellular licenses, emerging cellular markets, 1993

Country/City	Partners	Ownership	Award Date	Comments
		(Percent)		
Venezuela	TELCEL BellSouth (US) Racal Telecom (UK) Three Venezuelan concerns	 44.0 n/a n/a	1991	TELCEL is the non-wireline cellular concession. $45 million investment over 2-3 year period.
Brazil Sao Paolo			To be awarded	15–year license. Process suspended pending a decision on the constitutionality of private telecommunications service providers.
Colombia			To be awarded	In December 1993, government will award six cellular licenses.
Ecuador			To be awarded	2 licenses, both 100 percent private. Auction by Government. Bidders include MIC (Sweden/US), McCaw Cellular (US), Vanguard Cellular (US), Bell Canada, Entel (Spain/Chile), Motorola (US), and CTC Cellular (Spain/Chile).
Egypt			To be awarded in 1993	2nd Egyptian cellular system, GSM license. Bidders include Millicom International Cellular (Sweden/US) and Cable Wireless (UK).
Honduras			To be awarded in 1993	TDMA digital cellular network.
Hungary			To be awarded in 1993	2 nationwide, 15-year GSM licenses. One is reserved for HTC/foreign company joint venture; the other will be 100 percent private. Likely foreign bidders: WesTel for the HTC joint venture; BT (UK) Germany, France Telecom, DBP Telekom (Germany) consortium for the private license. Upfront $30 million fee and $1 million annual radio frequency usage fee.
Indonesia			To be awarded in 1993	State will retain 51 percent ownership.
Israel			To be awarded in 1993	2nd Israeli cellular system. Will supplement cellular network built and operated by Motorola on an exclusive basis until 1994.
South Africa			To be awarded	At least two licenses are to be granted.

Note.—n/a = not available.
Source: Compiled by USITC staff from information in Pyramid Research, *Cellular Markets in Developing Countries* and *Communications Week International, Telephony, Mobile Phone News,* and *FCC Report.*

APPENDIX J
STATISTICAL ANALYSIS OF COMPETITIVENESS IN CELLULAR COMMUNICATIONS

This appendix reports the results of statistical tests performed to evaluate how various factors affect global competitiveness in cellular communications. An effort was made to quantify the factors that chapters 3 and 5 identify as determinants of competitiveness in each of the three industry segments—cellular service providers, cellular network equipment manufacturers, and cellular phone manufacturers. Multivariate regression analysis was then used to measure the relationships between these determinants and the measures of competitiveness for each segment.

For each industry segment, the dependent variable was a market-share-related indicator of competitive success.[1] The dependent variable for the cellular service analysis was each service provider's success or failure in winning individual license awards. This analysis used individual awards as observations, rather than aggregate market share, because two of the independent variables pertain to specific awards. The dependent variable for network equipment manufacturers was the share of annual systems contracts received by each firm for each of the years 1987 through 1991. In the case of phone manufacturers, the dependent variable was the share of phone sales by each firm in each of three regional markets—the United States, Japan, and Europe—in 1990.

This analysis found that certain key variables had a statistically significant relationship with a firm's success in all three segments of the cellular industry — cellular services, cellular network equipment, and cellular phones. While all of the tested variables were significant in the analysis of cellular services, certain variables included in the analyses of network equipment and phones were not significant, possibly because the variables were imprecisely measured.

CELLULAR SERVICE PROVIDERS

Tested Hypothesis and Variables

The estimated equation for cellular service providers seeks to explain the success of service providers in winning participation in foreign service licenses during the period 1988-91.[2] Competition between established service providers within respective home markets is not examined.[3] The tested hypothesis is represented by the following equation (see also table J-1):

> Probability of winning foreign license =
> f (service experience, competitive home market, experience with local standard, regional marketing presence)

As chapter 5 notes, the skills that licensing authorities look for in service providers are not directly measurable, but it is possible to observe and quantify several aspects of the experience and policies that appear to produce such skills. First, firms gain experience simply through the number of subscribers they serve and the length of time they operate. Thus, the first variable, service experience, is measured by each firm's cumulative subscriber-years, i.e., the sum of subscribers in each previous year of service.[4] This variable is normalized as a percentage of the total for all firms, making the data comparable for each of the 4 years of the sample.[5] Second, it is hypothesized that service firms have a particular incentive to develop their technical and marketing skills when they have competitive home markets, a result of government licensing practices. This variable is binary (1/0) in form, reflecting whether competitive home market experience is present (1) or absent (0).

The third explanatory variable is experience with the technical standard being adopted, which also reflects a firm's technical expertise.[6] The fourth variable, marketing presence, controls for the effect of a firm's previous regional activity on its ability to win a license.[7] Both these variables are also binary in form.

The dependent variable takes a value of either one or zero depending on whether a firm succeeds (1) or

[1] Studies of competitiveness usually propose measuring competitiveness by market share and sometimes profitability. Since information is not available on the profitability of the cellular operations of most service and equipment firms, market share is the measure used in this study. For further discussion of the measurement of competitiveness see *Global Competitiveness of U.S. Advanced-Technology Industries: Communications Technology and Equipment*, USITC publication 2439, Oct. 1991, pp. 3-1 to 3-2, and *Global Competitiveness of U.S. Advanced-Technology Industries: Semiconductor Manufacturing and Testing Equipment*, USITC publication 2434, Sept. 1991, pp. 2-1 to 2-2.

[2] Very few service licenses had international participation before 1988.

[3] Because of data limitations, this analysis also does not address how multi-national service firms compete for participation in consortia that bid for service licenses.

[4] Data were taken from various sources, primarily from Shearson Lehman Brothers, *European Mobile Communications*, Dec. 2, 1991, and annual reports of U.S. corporations.

[5] A regression was also run using nonnormalized data. Indicators of goodness-of-fit had lower values for this regression, but results were similar in qualitative terms.

[6] In most but not all cases, local standards were determined before licenses were awarded. Data were drawn from a variety of sources, including U.S. Department of Commerce, *A Competitive Assessment of the U.S. Cellular Radiotelephone Industry: Partial Statistical Update*, March 1992.

[7] Data on regional marketing presence were drawn primarily from *RHCs' International Ventures* (Alexandria, VA: Telecom Publishing Group, 1992) and information supplied by AT&T.

Table J-1
Cellular service providers: Variables used in statistical analysis of global competitiveness

Dependent variable	*Independent variables*			
Success in winning licenses (1989-92)	*Service experience*	*Competitive home market*	*Experience with local standard*	*Regional marketing presence*
1 for winning a particular award; 0 for not winning	Cumulative subscriber-years	Binary condition	Binary condition	Binary condition

Source: USITC staff.

fails (0) to win a particular license award.[8] The data include observations for 29 license competitions and 24 firms,[9] a total of 696 observations. The dependent variable takes a value of "1" in 58 of these observations. This number is greater than 29 for two reasons: first, awards were sometimes given to consortia involving multiple multinational firms; second, in several cases, countries simultaneously awarded two or more licenses. All nonwinners of a license award are assigned a "0" whether or not they were active bidders. This is done largely because complete data on active bidders are usually not available.

For technical reasons, the regression was run using the logit functional form rather than the more common linear form.[10]

Results

Table J-2 presents results from the regression. All estimated coefficients have the theoretically expected sign and are statistically significant at confidence levels of at least 95 percent.

Because a logit regression uses a maximum-likelihood estimation method, standard R-square coefficients are not available to indicate goodness-of-fit. However, a measure designed to correspond to the standard R-square for logit regressions indicates that the regression accounts for approximately 22 percent of the variation in the data (table J-2). The relatively low value for R-square implies that the probability of winning awards also depends substantially on other factors. These may include such nonquantifiable factors as cost management skills, financial commitments, support from the firms' governments, and preferences of the license awarders.

Nevertheless, the regression results indicate that the selected variables have a systematic influence on the probability of winning a license award. The estimated coefficients of the logit regression itself (table J-2) indicate the effect of each variable on the logistic transformation of the dependent variable, i.e., ln (p/1-p), where "p" is the probability of winning the award. These coefficients indicate that each of these variables has a positive effect on the probability of winning, but they do not directly indicate the magnitude of the effects. The

[8] Data are from U.S. Department of Commerce and Pyramid Research Inc. Several small countries were omitted from the sample.

[9] The firms included are all service operators that have at least one foreign license, except Millicom International Cellular. As chapter 5 explains, Millicom's strategy makes it substantially different from other firms in the market.

[10] The "linear probability model," using the ordinary least squares (OLS) estimation method, assumes a linear functional relation between the independent and dependent variables. That is, it assumes that the probability p of an event occurring is given by the equation

$$p = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + \ldots + u,$$

where the x-terms are the independent variables, the b-terms are the estimated coefficients, and u is a random error term. The logit or "logistic probability model," by contrast, assumes that the model takes the logistic functional form,

$$\ln (p/[1-p]) = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + \ldots + u,$$

where ln represents the natural logarithm. Logit models are estimated using maximum-likelihood techniques.

One reason to prefer the logistic form is that it assures that the estimated value of p remains between 0 and 1 for all values of the independent variables. The linear form, by contrast, often yields results that imply probabilities of less than zero or greater than one for some values of the independent variables. A linear regression run with the data here, for example, yielded a negative constant term, implying that firms with no experience or regional marketing presence would be expected to win a negative number of contracts—an impossible result.

A second problem with the linear model, at least in conjunction with OLS estimation, is heteroskedasticity, or differing variances of error terms for different observations. The logit model does not have this problem because it is estimated with a maximum-likelihood method. For a discussion of both these issues, see Peter Kennedy, *A Guide to Econometrics*, 3rd ed. (Cambridge, MA: MIT Press, 1992), p. 229.

Table J-2
Estimates for cellular services model (t-statistics in parentheses)

Regression method:	Logit / maximum likelihood
Number of observations:	696
Degrees of freedom:	691
McFadden R-square[1]	.221
McFadden adjusted R-square[1]	.217

Variables	*Logit Estimates*	*Transformed Coefficients[2]*
Constant	-4.86 (-9.90)***	—
Service experience (percent of total subscriber-years)	0.107 (1.98)**	0.00468
Competitive home market (binary)	0.929 (2.16)**	0.0407
Experience with the standard (binary)	1.24 (3.89)***	0.0543
Regional marketing presence (binary)	2.46 (7.85)***	0.108

**Statistically significant at 95 percent confidence level in a two-sided test.

***Significant at 99 percent confidence level.

[1] Analogous to conventional R-square, but for logit regressions. See G.S. Maddala, *Limited-Dependent and Qualitative Variables in Econometrics* (Cambridge: Cambridge University Press, 1983), pp. 37-41.

[2] Transformed to reflect effect of variable on probability p of winning a license award. Logit estimates reflect effects of variables on ln (p/1-p). The transformation is done at the mean values of the variables.

Source: USITC staff.

second column of coefficients indicates this magnitude. For example, each percentage point of total service experience increases a firm's probability of winning a license award by approximately 0.468 percent.

CELLULAR NETWORK EQUIPMENT MANUFACTURERS

Tested Hypothesis and Variables

The estimated equation for network equipment manufacturers seeks to explain these firms' relative success in winning system contracts from foreign service providers. Data represent 103 contracts for sales of analog cellular systems[11] for the years 1987 through 1991.[12] Five firms received these contracts.[13]

The hypothesis being tested is represented by the following equation (see also table J-3):

Contract market share = f (radio experience, wireline switch experience, R&D)

[11] The data exclude several digital system contracts for 1991. The data also exclude contracts for a number of small systems sold to local U.S. service providers. Apart from these, there were very few new analog equipment contracts in equipment-producing countries during the period considered, because these countries had introduced service earlier.

[12] The data are arranged by the opening date of service, not the date that contracts were concluded. Dates of the contracts are not generally available.

[13] The firms are five of the six major firms discussed in chapter 5, Ericsson, Motorola, NEC, Nokia, and Northern Telecom. AT&T is excluded because it has focused almost exclusively on the North American market, which is excluded from the sample data. The data also exclude one sale by Siemens (using its proprietary C-450 system rather than an international standard) and several sales by two firms, NovAtel and Plexsys, that sell only small cellular systems.

Table J-3
Network equipment manufacturers: Variables used in statistical analysis of global competitiveness

Dependent variable	*Independent variables*		
Success in winning contracts (1987-91)	*Radio experience*	*Switch experience*	*Firm-level R&D (3-year average)*
Annual share of number of contracts	Number of standards	Sales (number of lines)	Total ($) or R&D/sales

Source: USITC staff.

The dependent variable, contract market share, is the firm's annual share of the number of new equipment contracts.[14] The first two independent variables cover major factors discussed in chapters 3 and 5: radio and wireline switch experience. Radio experience is measured by a closely related proxy, the number of system standards that each firm supports. As chapter 5 indicates, the ability to reconfigure network equipment for different system standards appears to depend on radio research, development, and manufacturing experience. The effect of this variable on sales is likely to be due partly to the greater sales opportunities that result from a larger number of standards supported. Wireline switch experience is measured by annual sales of central office switches in units of switch capacity (number of lines).[15]

The remaining variable is research and development (R&D) expenditures. R&D data pertaining solely to cellular equipment are not available, so data on firm-level R&D expenditures for all activities are used as a proxy.[16] Firm-level R&D is measured in two alternative ways: as a percentage of sales and as a total in U.S. dollars, in each case using an average of the previous 3 years. The percentage method gives the firm's overall R&D intensity, which may be correlated with its R&D spending on cellular equipment in particular. The second method is partly a reflection of the firm's overall size, but it may also indicate the sum total of in-house technical expertise.

Results

In a test of the model, the variables for radio and switch experience and R&D all proved statistically significant at the 99-percent level (table J-4).[17] However, the coefficient for R&D had a negative sign. This unexpected result appears to have been due to a single firm in the sample, NEC, which had large firm-level R&D expenditures and low network equipment sales during the sample period.[18]

Because firm-level R&D is an imprecise proxy for cellular R&D, the variable was excluded in a second test of the model. In this test also, both radio and switch experience were statistically significant at the 99-percent level (column II of table J-4).

The relative influence of each factor in affecting number of contracts is suggested by the beta weights, which indicate relative movements of the dependent variable in response to one-standard-deviation changes in the independent variables (table J-4).[19] By this measure, radio experience had a substantially larger effect than switch experience, 0.84 compared to 0.28 in version II of the regression.

Diagnostic tests for collinearity indicate that the highest condition number reported for either version is 12, well below the threshold value of 30. The regression method, pooled cross-section time-series, corrects for potential heteroskedasticity and serial correlation.

[14] Units rather than value are considered because data are not publicly available on the value of most contracts. Sources of data are the U.S. Department of Commerce, *A Competitive Assessment of the U.S. Cellular Radiotelephone Industry: Partial Statistical Update* (Washington, D.C., March 1992) and Pyramid Research Inc., *Cellular Markets in Developing Countries* (Cambridge, MA, 1991).

[15] Data for firms other than Motorola are from the U.S. Department of Commerce. They cover 1987, the most recent year available. Data for Motorola are USITC staff estimates of sales by DSC Communications Corp., the source of most of Motorola's switches during the sample period.

[16] Data are derived from company annual reports and from other sources.

[17] Results were similar measuring firm-level R&D in dollars and as a percentage of sales.

[18] In regressions, not reported here, that excluded observations for NEC or that measured R&D as a percentage of firm sales, the R&D variable had a positive estimated coefficient.

[19] In each case the other independent variables are assumed to stay constant. For a further discussion of beta weights, also known as standardized coefficients, see USITC, *Communications Technology and Equipment*, app. G.

Table J-4
Estimates for network equipment model
(t-statistics in parentheses) [beta weights in brackets]

	Version I	*Version II*
Regression method (both versions): pooled cross-section time-series		
Number of observations	25	25
Degrees of freedom	21	22
Buse R-square[1]	.554	.485
Variables	*Estimated coefficients*	
Constant	-.139 (-2.03)*	-.149 (-2.22)**
Radio experience (number of standards offered)	0.127 (4.91)*** [.85]	0.124 (4.44)*** [.84]
Wireline switch experience (billion U.S. dollars)	0.0329 (3.24)*** [.41]	0.0227 (2.83)*** [.28]
R&D (company total, billion U.S. dollars)	-0.132 (-3.92)*** [-.43]	—

*Statistically significant at 90 percent confidence level in a two-sided test.

**Significant at 95 percent confidence level.

***Significant at 99 percent confidence level.

[1] See A. Buse, "Goodness of Fit in Generalized Least Squares Estimation," *The American Statistician*, vol. 27, 1973, pp. 106-108.

Source: USITC staff.

Cellular Telephone Manufacturers

Tested Hypothesis and Variables

The estimated equation for cellular telephone manufacturers seeks to explain firm market shares in the three major regional markets, the United States, Europe, and Japan, for the year 1990.[20] The hypothesis being tested is represented by the following equation (see also table J-5):

> Market share = f (breadth of product line, integrated circuit sales, R&D, home market, years in market)

The dependent variable, market share, is measured in terms of unit sales, because data are better for units than for value of sales.[21] The first two independent variables are related to two of the factors that chapter 3 and 5 identify as determinants of competitiveness: radio manufacturing experience and integrated circuit expertise. Chapter 5 indicates that breadth of product line, measured by number of substantially different models sold in each regional market,[22] appears to depend in part on radio experience.[23] It may also reflect integrated circuit expertise, which enables firms to develop additional high-performance models. The second variable, integrated circuit (IC) sales, is a more direct measure of integrated circuit expertise. Data on IC sales cover all metal-oxide semiconductor (MOS) devices except memory devices.[24] It was not possible to include a variable for the other factor identified in chapters 3 and 5, advanced manufacturing techniques, because of the lack of comparable data for all firms.

[20] 1990 is the most recent year for which data are available for all three regions.

[21] Data on unit sales are still imprecise, particularly for Europe. Sources are Herschel Shosteck Associates, *Cellular Brand Sales*, and EGIS, "The Digital Cellular Equipment Market in Japan" (Washington, D.C., 1990).

[22] Data are derived by ITC staff from information supplied by Personal Technology Research, Inc.

[23] Data on more direct measures of radio manufacturing experience were unavailable.

[24] Data are from Integrated Circuit Engineering Corporation, *Status 1992: A Report on the Integrated Circuit Industry* (Scottsdale, AZ, 1992).

Table J-5
Cellular phone manufacturers: Variables used in statistical analysis of global competitiveness

Dependent variable	*Independent variables*				
Unit sales (1990)	*Product line breadth*	*Integrated circuit expertise*	*Firm R&D (3-year average)*	*Home market*	*Years in Market*
Market shares in 3 regions	Number of models	Sales ($)	Total or R&D/sales	Binary	Number

Source: USITC staff.

As was the case with network equipment, it is necessary to measure the third variable, R&D, at the firm level, using an average of the previous three years.[25] The fourth variable, home market, is a binary variable added to control for the possible advantage of home-market firms, whether due to market information, transport costs, nontariff trade barriers, or other factors. The final variable, the number of years each firm has participated in each regional market, controls for the possible advantage of established firms over newcomers.

With a sample of only 16 firms, it was necessary to get multiple observations per firm in order to obtain statistically meaningful results. As a result, the model was tested by combining data for each of the three regions in the same regression. Of the 16 firms, 13 had sales in the United States, 9 had sales in Europe, and 8 had sales in Japan, for a total of 30 observations.

Results

A test of the model shows that the two factors of greatest interest, breadth of product line and IC sales, are both statistically significant, at the 90- and 95-percent confidence levels, respectively (column I of table J-6). R&D is not statistically significant and has the theoretically wrong sign, possibly reflecting that this variable is imprecisely measured because of the lack of data for R&D expenditures for cellular phones specifically. The variables home market and years in the market have the expected sign, and the latter is statistically significant at the 90-percent confidence level.

Due to the imprecise measurement of R&D, that variable is removed in a second version of the regression. Results for the remaining variables are qualitatively similar, with the variable breadth of product line increasing substantially in statistical significance and the variable years in the market decreasing in significance (column II of table J-6).

[25] Data are from corporate annual reports and other sources.

Beta weights indicate that the two most influential variables affecting relative phone sales are breadth of product line and integrated circuit sales, with respective beta weights of .44 and .32 in version II of the regression.

Diagnostic tests for collinearity indicate that the highest condition numbers are 13 for version I and 9 for version II, both well below the threshold value of 30. Residual plots and estimated variances of error terms indicate that heteroskedasticity is not a problem.

Conclusion

Statistical tests for all three segments of the cellular communications industries support the hypotheses that several variables identified in chapters 3 and 5 are associated with competitiveness. These variables are, (1) for cellular service providers, customer service experience and competitive home market experience, (2) for cellular network equipment manufacturers, radio and switch experience, and (3) for cellular phone manufacturers, product line breadth (a reflection of radio experience) and integrated circuit expertise. For all three industry segments, therefore, experience emerges as a key factor for firm competitiveness. In cellular service, this experience is gained primarily through service in the home market. For the two manufacturing segments, this experience is gained in related technologies such as telecommunications switches, for network equipment; integrated circuits, for cellular phones; and radio, for both segments.

Other variables related to a firm's participation in specific regional markets also proved statistically significant in both the cellular service analysis and the cellular phones analysis. R&D was also tested as a factor in the network equipment and phones analyses, but the expected relationship could not be confirmed, possibly because R&D was measured at the firm level rather than for cellular products specifically.

Table J-6
Estimates for cellular phone model
(t-statistics in parentheses) [beta-weights in brackets]

	Version I	*Version II*
Regression method (both versions): ordinary least squares		
Number of observations:	30	30
Degrees of freedom:	24	25
R-square	.597	.556
Adjusted R-square	.514	.485
Variables	*Estimated Coefficients*	
Constant	-0.0588 (-1.22)	-0.101 (-2.46)**
Breadth of product line (number of models)	0.0240 (1.87)* [.32]	0.0324 (2.71)** [.44]
Integrated-circuit sales (billion U.S. dollars)	0.0450 (2.67)** [.48]	0.0305 (2.10)** [.32]
R&D (percent of company sales)	-0.805 (-1.57) [-.26]	—
Home market (binary)	0.0394 (1.63) [.23]	0.0368 (1.49) [.22]
Years in market	0.0124 (2.00)* [.31]	0.00870 (1.48) [.22]

*Statistically significant at 90 percent confidence level in a two-sided test.

**Significant at 95 percent confidence level.

Source: USITC staff.