# Mobility and the Implications of Wireless Technologies

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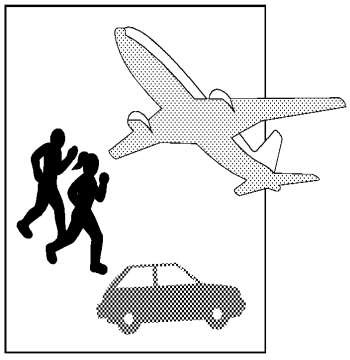
The need for mobility underlies many applications of wireless technology.[1] It is the single feature of wireless systems that other telecommunications technologies cannot replicate. Wireless technologies permit users to access communications networks while they are "on the go," and also make it easier for individuals to stay connected as they move around. However, the concept of "mobility" and its implications for the deployment of wireless technologies are poorly understood.

Individuals and businesses already use a number of wireless technologies, including cellular telephones, pagers, and various wireless data services, but over the next five to 10 years, a variety of new mobile communication systems—personal communications service (PCS), enhanced specialized mobile radio (ESMR), satellite-based telephony, and higher-bandwidth wireless data communications systems—will begin operation (see chapters 3, 4, and 5). To consider the potential success or failure of these new technologies and the implications of their widespread use, it is critical to understand the underlying forces that might motivate people and businesses to use them. Is society becoming more mobile? How does a technology deployed at scale challenge policymaking in this area? What are the potential social implications of widespread deployment of wireless telecommunications? An analytic framework used to address these issues places mobility,



[1] Some of the material in this chapter is based on Philip Aspden and James Katz, Bell Communications Research, Morristown, NJ, "Mobility and Communications: Analytical Trends and Conceptual Models," contractor report prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, Jan. 20, 1995.

the unique property of wireless, at the center. This chapter attempts to anticipate the answers to some of these questions.

## FINDINGS

- **The concept of *mobility* is rudimentary and unfocused. Although some information and statistics have been collected, there is little hard data that allow a thorough understanding of the various characteristics of personal and professional mobility and their implications for the implementation and use of wireless services.** Mobility is an enduring social quality that affects people in both their personal and business lives. People move about in their private lives every day to shop, visit friends or relatives, or run errands. Understanding the patterns of what they do, how they do it, and what information they could use in the process will be crucial to understanding how wireless technologies may play a role in peoples' lives.
- Worker mobility is particularly significant because businesses tend to lead the way in the use of telecommunications technologies, and are expected to be the earliest and heaviest users of wireless technologies as well. Considering the ways in which a job can be "mobile," **OTA conservatively estimates that nearly 50 million workers (44 percent of the workforce) are mobile in some way today and the percentage of the workforce that can be classified as mobile is increasing.**
- From the technology side, research on how people use or would use wireless devices is sketchy. Some marketing surveys have been conducted, but they do not offer a very compelling or complete picture of how the average consumer might use communication or information resources in a mobile or portable setting. Prospectively, it is difficult to ask people to evaluate a technology or service they have never used and may not completely understand. A better grasp of mobility will improve product development and inform policymaking regarding new wireless technologies and systems.
- Academic researchers have been studying "mobility" for years, but they tend to concentrate on one particular element only—work patterns, time spent commuting, or time management, for example. Researchers in different disciplines do not generally collaborate or communicate, and it appears difficult for them to conceptualize how their work may fit together. Little work has been done to bring together the disparate elements that define mobility, and no theoretical framework exists for studying mobility as a unified concept. **More research on all aspects of mobility—and their relation to telecommunications technologies, including wireless—is needed.**
- Because mobility is so poorly understood and the wireless technologies that will enhance the mobility of both people and machines are not yet widely used—even the penetration rate for cellular telephones is less than 10 percent—assessing the implications of this widespread use is difficult. **The impacts of wireless technologies on individuals, organizations, and society are only now emerging; they are likely to involve increased personal and business efficiency, as well as increased stress and concern about monitoring and privacy. Wireless technologies are likely to play a role in the continuing evolution of new organizational and social forms, potentially reinforcing geographic dispersion and functional dissolution.**

## SELECTED EXAMPLES OF MOBILE WIRELESS SERVICES

Other than using wireless telecommunications for traditional telephony, what might people do with wireless? People or organizations often use new technologies to perform old functions. Over time, however, a technology deployed for one purpose may be used for something quite different than its designers intended. Many new applications of wireless technologies are still only at the developmental stage, and have yet to pervade the public's consciousness. A brief description of some of the current and projected uses of mobile communica-

tions may provide an idea of the broad scope and scale of their potential applications. The following examples are drawn from existing commercial or demonstration projects.[2]

## Inventory Management

The emphasis on lowering costs and increasing efficiency in business operations has focused on improving inventory management, total quality management, and just-in-time manufacturing. Wireless technologies can help where mobility is a key feature of the process. For example, in warehouses, knowing more about the location of specific items can greatly reduce costs. Equipment to track inventory is becoming more popular. For example, Rexham, a box manufacturer in Charlotte, North Carolina, has revamped its quality control function with a wireless bar code system that provides up-to-the-minute information about job status and product information. Sensors can be attached to items so they can be tracked and found when needed. Using such a system, one chemical company experienced a 100 percent payback in six months and reduced its accounting personnel for this function from 12 to one.

## Electronic Newspapers

Newspapers have been one of the most transportable sources of information. A few companies are now developing the capability to deliver newspapers via wireless systems directly to customer's laptop computers. One publisher has developed a prototype electronic newspaper whose screen resembles the front page of a newspaper. The user can touch a picture or headline to receive additional information in any form: video, sound, or text. Designed to overcome some of the shortcomings of traditional print newspapers—bulkiness and limited circulation—newspapers distributed using wireless could use digital cellular networks or new PCS systems to reach readers efficiently, wherever they are. Prospective users might include travelers who want to read hometown newspapers or business executives who want to purchase electronic publications while aboard trains or airplanes.

## Classroom Networking

Duke University recently participated in an experiment using a wireless local area network (LAN) to connect engineering students' laptop computers to one another and to the instructor's computer.[3] The system consists of an infrared transceiver attached to each student's computer that sends and receives messages to and from every other computer. Transmitting at 230 kbps, the infrared system is completely transportable, and an ad hoc network can be established in about 20 minutes in the library, lab, or dormitory.

Tying together the computers allowed the comparing of notes, facilitated collaboration on group projects, and allowed the professor to project one student's computer screen onto a large screen in front of the entire class for discussion. In addition to allowing students to work easily with one another, the system also sends the instructor's comments directly to every student's computer, perhaps communicating ideas more effectively. Based on this experiment, Duke University is considering implementing similar systems in other classes.

## Real Estate Marketing

In the last few decades, real estate agents have come to rely heavily on computerized databases such as the Multiple Listing Service. However, while on the road, agents are out of touch with these databases, and must make frequent trips back to their offices to use them. To help agents save time and eliminate unproductive travel, sev-

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[2] For a broader set of examples, and an analysis of the emerging uses of wireless technology, see Virginia Polytechnic Institute and State University, Center for Wireless Telecommunications, Blacksburg, VA, "A Survey of Emerging Applications of Wireless Technologies," contractor report prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, Sept. 15, 1994.

[3] Gary Hughes, "Wireless Network Goes to School," *Wireless for the Corporate User*, vol. 3, No. 3, 1994.

eral wireless services have been developed. For example, a low-power FM transmitter can be placed on a property for sale which will broadcast messages that identify key characteristics of the property. An agent driving past the house can tune in to hear the details. Another system uses a personal digital assistant (PDA) and a cellular digital packet data (CDPD) radio modem to provide real estate agents access to a multimedia database of homes. The data consist of pictures of houses, maps of residential areas, and detailed statistics that can be searched by price, location, number of rooms, etc. Rather than having to return to the office to search the listings again, a revised list of appropriate offerings could be accessed from any location.

## Field Service

To handle more calls, provide faster and more accurate inventory control, and reduce the time spent sending dispatch instructions, Coast Plumbing of Solana Beach, CA, implemented a data communications system that integrated dispatch, billing, and inventory functions.[4] The system connects a portable computer in each of the company's 20 trucks to a host computer in the office. The system delivers text dispatches to the plumber's portable computer, which displays the customer's name, address, and the reason for the call. The system also allows the technicians to check on part availability, access prior service history, and look up prices. Once a job is finished, the system automatically transmits billing and inventory information back to the host computer, which then updates parts lists and customer accounts. Coast also uses specialized mobile radio for voice and data communications.

After implementing the system, Coast Plumbing increased the number of calls per day handled by each plumber, dramatically reduced the amount of time spent on physical inventory, improved customer satisfaction, and streamlined administrative processes. The company estimates that the system saves it more than $10,000 per month in total costs.

## Disaster Recovery and Assistance

The success of emergency relief and recovery efforts relies on the ability of workers to communicate effectively, efficiently, and securely. Wireless is uniquely suited to these applications because: 1) disasters typically do not affect wireless communications links, especially satellite links, and 2) the rapid deployment of a communications system for mobile field workers is more efficacious with a wireless system. The users of these systems include insurance companies; emergency relief workers; federal, state and municipal disaster agencies; emergency medical personnel; and other suppliers of necessary services. They will typically need communications in the field to report assessments of damage, call for reallocation of resources, predict additional consequences, and file insurance claims or pay such claims electronically. For example, one company provided Iowa's 99 counties with backup protection during the flood of 1993 with a portable 18 GHz digital microwave system. The system was engineered, manufactured, delivered, and installed in just four days.

## Intelligent Transportation Systems

Intelligent Transportation Systems (ITSs)[5] apply information and communication technologies to surface transportation systems to reduce traffic

[4] Deborah Kirtland, *Wireless for the Corporate User,* vol. 3, No. 2, 1994, p. 53.

[5] ITS was formerly called Intelligent Vehicle Highway Systems (IVHS), but was changed to ITS to include public transit and other transportation modes.

congestion, improve safety, make public transit options more attractive to commuters, and decrease transportation-related environmental impacts.[6] Interest in ITS stems from the realization on the part of transportation experts that building more roads and/or expanding existing ones is often too costly and only marginally effective in reducing congestion, and does little to alleviate safety and environmental problems. ITS could make more efficient use of the current transportation infrastructure, improve safety, and allow public transportation to be more responsive to passenger demands. To transmit information to mobile units (automobiles, buses, and trains, etc.) from a fixed location, and vice versa, wireless technology of some kind is necessary.

In 1991, Congress passed the Intermodal Surface Transportation Efficiency Act (ISTEA[7]), which committed $659 million over six years for ITS projects. ISTEA also mandated the U.S. Department of Transportation (DOT) to establish the ITS Architecture Development Program. This program brings together DOT, a public/private consortium called ITS America, and various private transportation and communication companies for the purpose of forming a framework to develop an integrated, interoperable ITS in the United States.[8] More recently, the Federal Communications Commission (FCC) has allocated 26 MHz in the 902-928 MHz band for what it terms Transportation Infrastructure Radio Service, or TIRS.

Among the areas being developed are advanced traveler information systems that will inform people on the best way to get to their destinations; advanced traffic management systems that will gather and distribute data on traffic congestion and alter the timing of control signals to move traffic more efficiently; automatic toll collection; parking and security applications; and automated vehicle control. To date, most ITS efforts have focused on providing route guidance to travelers and fleet monitoring and control to transportation companies. Systems in Japan, Europe, and the United States rely on the Global Positioning System (GPS) for vehicle location, often used in conjunction with dead reckoning.[9] Some systems also employ terrestrial-based wireless data systems to relay traffic conditions to travelers in their cars. Both scenarios involve sophisticated mobile units for the users that can cost as much as $8,000.[10] One system marketed by Oldsmobile offers drivers stored information about local points of interest, such as restaurants, with the option to receive updated traffic, weather, and special event information via a wireless link.

More complex ITS proposals will require more sophisticated technology, both in-vehicle and in the public transportation infrastructure, than existing systems now offer. For example, some plans call for a radar-equipped vehicle that will sense the distance between it and the car in front and automatically apply the brakes if the gap is too small. Some plans for these Advanced Vehicle Control Systems (AVCS) may also incorporate sophisticated sensing equipment in the roadway, which would work in conjunction with systems in the ve-

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[6] National Research Council, "Primer on Intelligent Vehicle Highway Systems," Transportation Research Circular 412, Washington, DC, August 1994. See also U.S. Congress, Office of Technology Assessment, *Intelligent Transportation Systems for Metropolitan America—Background Paper*, background paper for OTA's Project on the Technological Shaping of Metropolitan America (in progress).

[7] Public Law 102-240; Dec. 18, 1991.

[8] U.S. Department of Transportation and ITS America, ITS Architecture Development Program; Phase I, Summary Report, Washington, DC, November 1994.

[9] Dead reckoning is a technique by which vehicle location can be calculated and matched to on-board maps by calculating the distance traveled from a specific starting point.

[10] W. Clay Collier and Richard J. Weiland, "Smart Cars, Smart Highways," *IEEE Spectrum*, Apr. 4, 1994, pp. 27-33.

hicles to automatically track the vehicle down the road at a constant speed toward the driver's destination.

## CHARACTERISTICS OF MOBILITY

At the root of interest in wireless telecommunications is its ability to accommodate the physical mobility of people and things. However, our understanding of mobility is intuitive and poorly characterized analytically.[11] Some of the broad outlines of mobility are sketched here to provide a sounder basis for analyzing mobility and its implications. Key questions are: Why are people mobile? What are the features and forces that have shaped people's mobility patterns? What are the key trends in mobility? How do wireless technologies fit with mobile activities? What are the consequences of mobility?

Mobility has a number of dimensions that give it different meanings for different people. For example, some mobility is local, as in a hospital where nurses and doctors are constantly on the move, but within well-defined boundaries. Some mobility is long-distance, as with cross-country trucking or cellular roaming to cities outside the home service area. Some people are mobile but do not communicate en route, such as executives travelling to meetings in distant cities. Others communicate en route over long distances, such as salesmen who need to get up-to-date information before meeting their next prospect. While each is mobile, the wireless telecommunications technologies each would likely use may be quite different. Using the single term "mobility" masks its multiple dimensions and deprives it of analytic precision. Data on mobility characteristics, as described below, do not exist at present.

From the examples of applications given above and data on past and projected demand, the following characteristics or drivers of mobile access can be inferred:

- **People want to be mobile because they can increase their control and reduce uncertainty** in the conduct of their business or personal affairs. People move to see and do things remotely so that they can control their activities or gather information that reduces their uncertainty.
- **People want to communicate while moving**, or while in transit. They want flexibility in deploying and redeploying assets, services, etc. In many situations, people cannot predict their communications requirements, either for type of service or its location. All of these needs are met by a variety of wireless technologies, at a low cost, depending on the application, the data rate, and security requirements.
- **People want to communicate and get information *immediately.*** When they are traveling or away from wired telecommunications links, the urge to be connected is strong. Although one can usually travel to a place that has communications resources, the time pressures of today's society and business world dictate that those who have easiest access to communications resources have a competitive advantage.

Typologies like those in table 2-1 could be used to develop research programs and data sources on mobility and communications that could assist both policymakers and business planners. In particular, this framework could help determine the potential scale of wireless communications. Decisionmakers would then know whether particular public wireless communications systems are likely to be confined to small populations of workers or users, or are likely to be applicable to large segments of society. They could also provide information on the impact these technologies may have on individuals, organizations, and society at large.

[11] One attempt is that of the Cross-Industry Working Team, Corporation for National Research Initiatives, "Nomadicity: Characteristics, Issues and Applications," March 1995.

TABLE 2-1: Typology of Mobility and Comm...

**Mobility characteristics:**

- ***mobility extensiveness*** (how far: global, national, regional, local, or home/office)
- ***mobility intensiveness*** (how much mobility is required for an activity)
- ***mode of transport***
  self-propulsion (walking or biking)
  limited occupancy vehicle (private automobile, truck, small boat, or small airplane)
  public transport (bus, airplane, or ship)
- ***variety of routes undertaken***
  standardized
  externally directed (defined by third party)
  spontaneous

**Activities or information might be categorized by:**

- ***function***
  data-gathering and entry
  data analysis
  execution or control of activity or function
- ***time factors***
  real time
  asynchronous
- ***information type***
  symbols
  audio
  text images
  still picture images
  moving picture images
- ***delivery paths***
  point-to-point
  point-to-multipoint
  dispatch
- ***location***
  information obtained while in transit
  information obtained by visiting many locations
  information unrelated to location

SOURCE: Office of Technology Assessment, 1995.

## JOBS AND MOBILITY

Although the use of wireless technologies is likely to be pervasive, their greatest impacts may be in working environments and on jobs. Jobs previously fixed may become mobile with new technologies, altering a wide range of business practices. Unfortunately, no government or private agency collects data on mobility in employment, nor are there measures on the degree of mobility typically associated with particular job classifications. Private studies tend to focus on particular market segments, such as white-collar office workers and executives on the road.

OTA made a preliminary estimate of high and low degrees of mobility in the work force to illustrate the argument made here. Based on Bureau of Labor Statistics data, and using rough estimates of the mobility requirements of jobs across the whole U.S. economy, OTA estimates that 34 million people are somewhat mobile and 15 million are highly mobile for significant parts of their working day, for a total of about 44 percent of the **U.S.**

TABLE 2-2: Occupations and Mobility Classification, 1994

| Occupation | Total employed (millions) | High mobility workers | Moderate mobility workers | Percent mobile |
|---|---|---|---|---|
| **Executive, administrative, and managerial** | **15.4** | **0.8** | **3.8** | **25.8** |
| **Service deliverers** | **12.2** | **5.7** | **5.5** | **51.3** |
| Engineers, architects, surveyors | 1.9 | | 0.9 | |
| Social, recreation, religious workers | 1.1 | 0.5 | 0.5 | |
| Sales representatives, financial and business services | 2,3 | 1.2 | 1.2 | |
| Sales representatives, except retail | 1.5 | 0.8 | 0.8 | |
| Adjusters and investigators | 1.4 | 0.7 | 0.7 | |
| Protective services | 2.2 | 1.6 | 0.5 | |
| Mechanics, appliances, equipment | 1.8 | 0.9 | 0.9 | |
| **Campus/building-wide workers** | 8.8 | 0.0 | 8.0 | 91.3 |
| Health diagnosing occupations | 0.9 | | 0.9 | |
| Health assessment and treating occupations | 2.6 | | 2.6 | |
| Teachers, college and university | 0.8 | | 0.8 | |
| Health technologists and technicians | 1.5 | | 0.8 | |
| Cleaning/building service occupations | 3.0 | | 3.0 | |
| **Workers who move people or goods** | 6.0 | 4.2 | 1.7 | 33.2 |
| Mail and message distributing | 1.0 | 0.5 | 0.5 | |
| Transportation, material moving occupations | 5.0 | 3.8 | 1.3 | |
| **Outdoor workers** | 8.3 | 4.2 | 4.2 | 54.2 |
| Construction trades | 5.0 | 2,5 | 2,5 | |
| Farming, forestry and fishing | 3.3 | 1.7 | 1.7 | |
| **Others** | 68.7 | 0.4 | **11.0** | **16.4** |
| Total | **119.3** | **15.2** | **34.3** | **44.0** |

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, "Employment and Earnings," January 1994. and Office of Technology Assessment, 1995.

work force (see table 2-2). Workers may be grouped in five clusters, as indicated in the table. Because the criteria used in arriving at these estimates were extremely conservative, it seems likely this is an under- rather than over-estimate of the true amount of mobility in the work force.[12]

There is also some evidence that the number of mobile workers is increasing as a proportion of total workers. Using the classifications above-and past, current, and projected employment levels in each subcomponent—the pool from which the future mobile workforce will be drawn can be illustrated (see table 2-3). Such estimates show that these job clusters will increase 51 percent over the 1983-2005 period, somewhat faster than the projected growth rate for all jobs, which is 42 percent. Executive and managerial jobs are projected to increase fastest (73 percent), followed by campus/ building-wide workers (60 percent), and service deliverers to homes and businesses (54 percent). Finally, recent projections of occupational employment levels suggest that many of the fastest-growing job categories are mobile, further supporting the argument that mobility is likely to

[12] DYG, Inc., "The Growing Emergence of Mobile Workers," report prepared for Cowles Business Media, 1994, p. 2.

TABLE 2-3: Estimated Total Number Of Workers In Mobile Occupations, 1983-2005 (millions)

| Occupations | 1983 | 1994 | 2005 |
|---|---|---|---|
| Executive, administrative and managerial workers | 10.8 | 15.4 | 18.6 |
| Service deliverers to homes and businesses | 9.9 | 12.2 | 15,1 |
| Campus/building-wide workers | 7.1 | 8.8 | 11.4 |
| Workers who move people or goods | 5.0 | 6.0 | 6.9 |
| Outdoor workers | 8.0 | 8.3 | 9.4 |
| **Total** | **40.8** | **50.7** | **61.4** |

SOURCE: Office of Technology Assessment and Bureau of Labor Statistics, 1995.

be more important in the future.[13] Several other more limited studies have come to similar conclusions.[14]

## IMPLICATIONS OF INCREASED MOBILITY

Having established that wireless telecommunications are here to stay, though still not ubiquitous in business and society, what are the implications of increased mobility for individuals, organizations, and society? How will wireless telecommunications affect peoples' personal and business lives? Much remains unknown, and issues are just beginning to be identified.

### Implications for Individuals

Increasingly, communication will be made to a person, not a place. The potential for more complete integration of people with each other and information sources may be increased considerably with widespread deployment of wireless telecommunications. Networks may center on people rather than on physical connections, which could have both positive and negative effects on individuals.

#### *Increased Contactability*

The most striking impact of wireless communications systems may be the ability to make and receive phone calls from any location at any time, enabling users to be constantly "in touch." A recent Bellcore survey on telephone use asked people their opinions on their need to be reachable (see table 2-4). Nearly 50 percent agreed with the statement that "my responsibilities require me to be 'easily reachable,'" even on holidays. About 20 percent of those surveyed disagreed with the idea that they need to be readily contactable.

TABLE 2-4: Opinions on the Need To Be Reachable

| | Strongly agree | Agree | Neutral | Disagree | Strongly disagree | No answer |
|---|---|---|---|---|---|---|
| My responsibilities require me to be "easily" reachable | 13.4 | 35.4 | 26 | 18.9 | 2.9 | 3.5 |
| People need to contact me about important matters | 12.5 | 35.9 | 27,7 | 17,5 | 3.3 | 3.1 |
| There are often times when I urgently need to get through to another person | 8.3 | 36,5 | 29,7 | 20.0 | 2.2 | 3.3 |
| I "stay in touch" even when I am on holiday | 8.9 | 40 | 21,3 | 20.8 | 5.9 | 3.1 |

SOURCE: Bell Communications Research, "The Telephone: Making It Work Better For You," Bellcore national postal survey, 1993.

[13] Bureau of Labor Statistics, *Monthly Labor Review,* November 1993, cited in Peter Francese, "Cellular Customers," *American Demographics,* vol. 16, No. 8, August 1994, p. 56.

[14] William F. Ablondi and Thomas R. Elliott, "Mobile Professional Market Segmentation Study," BIS Strategic Decisions, Norwell, MA, pp. 1-3, and Alison L. Sprout, "Moving Into the Virtual *Office,''Forfune,* May 2, 1994, p. 103.

TABLE 2-5: Personal Life Improvement Due to Cellular Telephone Use

| | Percent of cellular telephone users agreeing strongly or agreeing somewhat in: | |
|---|---|---|
| **Cellular telephones have:** | **1991** | **1993** |
| Increased your flexibility | 86 | 94 |
| Increased your efficiency | 79 | 75 |
| Helped you make the most of your personal time | 76 | 81 |
| Added a significant amount of time to your day | 68 | 62 |

Interviewing for the Motorola survey was conducted by telephone between December 1990 and January 1991, and between March and April 1993. In 1991, the nationally representative sample size was 650, and in 1993 it was 660 people. In the 1993 survey, 63 percent of the sample was male, 37 percent was female.

SOURCE: The Gallup Organization, "The Motorola Cellular Impact Survey: Evaluating 10 Years of Cellular Ownership in America, " Princeton, NJ, 1993.

Thus, wireless may enable people to remain in continuous contact. In some cases, this higher level of connectedness could reduce the sense of alienation that plagues many people who are out of physical contact with others. People may feel secure in dense networks of communications with people they can rely on, and be able to conduct many activities with considerable remote control. Survey research on current cellular users shows that cellular telephone users feel positive about the technology with respect to its ability to help them maintain contacts in both business and private life. A survey of users in 1991 and 1993 yielded the results in table 2-5.

In general, this survey reports that users believe that cellular phones help them make better use of their personal time. About half of respondents said they feel better connected to their families because of their cellular telephones. A significant fraction said they couldn't do without their cellular telephone (46 percent), and most believe that the phone has been a good value for the money (85 percent). Clearly, this data should be viewed with some skepticism. Respondents were all paying cellular customers who may justify their purchase of cellular services by alleging benefits. People who had tried and ultimately rejected cellular services were not polled as to their attitudes.

Although many users clearly value the ability to communicate more easily, there are drawbacks. The same device that allows users to call out enables other people to call in—potentially reducing privacy and control over one's time.[15]

> Paradoxically, the most important aspect of the mobile telephone may be the ability to reach others with it and to be reachable anywhere, which implies both absolute mobility *and* the opposite of mobility as traditionally understood! The owner of a mobile telephone maybe highly mobile, but is always "at home," always "there," as long as he or she carries a [personal phone], thus making simultaneously possible a freely floating, highly mobile society and a very traditional, immobile social and spatial structure.[16]

The tension between accessibility and privacy is easy to underestimate, because people may choose to use communications technologies that help them perform certain tasks, but that may also bind them in unwanted ways. People generally seek wide communications access to others, and they want to be able to receive messages quickly and reliably. Yet people seldom want to be universally accessible to others; they want to limit access by certain people, they want control over when they receive calls, and they want to choose with

[15] It should be noted that the same concerns were also raised when telephones were first introduced almost 100 years ago. It may take some years before new social/business protocols regarding mobile telephone use are internalized by society. For users who are bothered by this prospect, the phone can always be turned off-unless an employer expects it to be on.

[16] J.P. Roos, "300,000 Yuppies? Mobile Telephones in Finland," *Telecommunications Policy,* August 1993, p. 458.

whom they communicate.[17] There also may be disadvantages of greater accessibility to others. While it may be possible to reach a specific person, wherever he or she is, that person may be reached in an unexpected context. Thus, a call to an office worker may reach him or her away from desk and files—in the company cafeteria or in the bathroom, for example. The physical context of communication is important to the business that can be conducted, a context that previously was provided by the knowledge that calls reach people in fixed places.

The inability to control incoming calls, which may come at inconvenient times, may also be resented.[18] There may be no easy way to avoid such demands: if wireless telecommunications use becomes the norm, then turning a phone off completely may signal to a caller "This person is purposefully limiting availability." For some people, increased personal psychological stress could result from loss of control over when and where people can contact you.[19]

### *Personal Monitoring and Privacy*

Another implication of increased contactability—when coupled with remote sensing equipment and databases—is the potential for personal passive monitoring. Both benefits and threats to personal freedoms could occur. The benefits include systems that offer remote monitoring of health care delivery devices and those that protect personal security. Large firms and government agencies have used such dedicated systems for years; however, due to their expense and size, they have been unavailable to private users or small firms until relatively recently. The Advanced Research Projects Agency (ARPA), for example, has been funding wireless telecommunications research for several years; one of its main interests is in equipping soldiers with battlefield personal monitors to relay vital signs and injury information to medical centers to provide timely and accurate responses to the wounded.[20] Similar systems are now being developed for consumer use. "Electronic house arrest" has been enforced with electronic monitoring devices that signal when a convict leaves his or her home.[21] Marathons runners have recently been issued shoelaces with wireless microchips embedded in them to prevent them from deviating from the prescribed course.[22]

Information about movement and activities also could be obtained and used in ways that violate privacy. Relations between employers and employees could deteriorate if some employees feel burdened or controlled by employer or job requirements. Their supervisors, however, may welcome the ability to monitor activities even during off hours. People may feel that there is no way to escape the control of others if they have no choice but to be equipped with wireless technologies as part of their jobs.[23] Chapter 10 discusses the privacy of location information in more detail.

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[17] James E. Katz, "Caller ID, Privacy and Social Processes," *Telecommunications Policy*, vol. 14, No. 5, October 1990, pp. 372-411, and James E. Katz, "Controlling Access: Demographic Characteristics of Unlisted/Nonpublished Subscribers," Bellcore Technical Memorandum, Morristown, NJ, 1993.

[18] Ibid.

[19] Michael Ventura, "Trapped In the Time Machine," *The Washington Post*, Feb. 12, 1995, pp. C1, C4, excerpted from "The Age of Interruption," *The Family Therapy Networker*, vol. 19, No. 1, Jan. 1, 1995, pp. 18-25, 28-31.

[20] Randy Katz, wireless project manager, Advanced Research Projects Agency, interview, June 9, 1994.

[21] Joseph Hoshen, Jim Sennott, and Max Winkler, "Keeping Tabs on Criminals," *IEEE Spectrum*, February 1995, pp. 26-32, details location monitoring technologies in use and under development for nonincarceration alternatives to imprisonment. All the techniques use wireless systems, and newer systems provide highly accurate and continuous monitoring of location. Future systems are envisioned that will be able to actively restrain people who violate their conditions of parole, such as sounding an alarm or causing an electric shock or other restraining action.

[22] Shiv Sharma, "Sports Diary," *Manchester Guardian Weekly*, Mar. 5, 1995, p. 31.

[23] For literary treatment of these ideas, see George Orwell's *1984* (San Diego: Harcourt, Brace, Jovanovich, 1984), and Jerzy Kosinski's *The Painted Bird* (Boston: Houghton Mifflin, 1976).

The specter of gradually ceding the right to be left alone is of great concern to many. The time people spend alone in their automobiles is increasingly a thing of the past as commuters now conduct business with cellular telephones, car faxes, laptop computers, and books, journals and office materials on tape.[24] The feeling of personal solitude may well be eroded when a person can make a cellular or satellite phone call from every area of the planet, or know where someone is located to within 10 meters.

William Safire, the *New York Times* columnist and former speechwriter for President Richard Nixon, has commented:

> I have fended off the threat of intrusive wireless communication almost from its inception. At the Moscow Summit in 1972, President Nixon's chief of staff, H. R. Haldeman, introduced us to the new "beeperphone." Through this amazing paging device, worn on the hip, the nation's chief executive could instantly track down any of his score of assistants anywhere in the capital of the rival superpower at any moment.
>
> Being on the end of an electronic leash did not appeal to me; indeed, its big-brother aspect struck me as more representative of the Soviet society than our own...
>
> Think again about the rush to total intouchedness. The telecommunications that produced telemarketing can produce telefugitives. No slack can be cut in the wireless wire; a society with no place to hide produces people with no secrets worth keeping and individuals with no minds of their own.[25]

### *Personal Safety*

Widespread deployment of wireless telecommunications systems may also lead to an increased sense of personal safety and security, because people can call for help regardless of where they are, and can report accidents and other incidents in situations where assistance may be required. In a Gallup survey, a total of 91 percent of respondents believed that having a cellular telephone made them safer and more secure, and 90 percent said they would be more willing to lend a helping hand to a stranger because they can call for help (table 2-6).[26] Accidents along major roadways in big cities result in an average of eight calls to 911.[27]

Using communications technology for safety purposes may be a double-edged sword, however. Mobile communications are extensively used by criminals as well as law-abiding citizens, and mobility can make criminals more effective and threatening.[28] Indeed, the demand for altered phones is fueled in large part by people who want to use cellular telephones to commit crimes.

## Implications for Organizations

Wireless telecommunications technologies will find a significant role in the workplace and in organizations. Strategies to deal with the new possibilities of wireless work are being experimented

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[24] Rajiv Chadrasekaran, "For Some Area Commuters, Work Begins Behind the Wheel," *The Washington Post*, Aug. 9, 1994, pp. 1, 10.

[25] William Safire, "Stay Out of Touch," *The New York Times*, Nov. 1, 1993, p. A1.

[26] The Gallup Organization, "The Motorola Cellular Impact Survey: Evaluating 10 Years of Cellular Ownership in America," Princeton, NJ, 1993, p. 11.

[27] This common use of cellular telephones has driven much of the secondary growth in cellular subscriptions. Cellular companies have recognized this and offer payment plans targeted to this segment of the market. However, easy accident reporting sometimes creates problems, because police must decide which of the calls gives the correct information, location, etc. People vary widely in the accuracy of their reporting.

[28] "Chicago Council Considers Measure Limiting Pay Phones," *Telecommunications Reports*, Sept. 19, 1994, pp. 7-8.

TABLE 2-6: Cellular Telephone Use and Personal Safety

| Have you ever used your cellular telephone to call: | Percent responding "yes" | |
|---|---|---|
| | 1991 | 1993 |
| For roadside assistance for your own disabled vehicle | 31 | 38 |
| For roadside assistance for someone else's disabled vehicle | 7 | 13 |
| For assistance for your own medical or health emergency | 7 | 13 |
| For assistance for someone else's medical or health emergency | 23 | 28 |
| The police to warn of hazardous road conditions (e.g., collapsed roadway, downed trees, weaving driver, or icy road) | 24 | 28 |

SOURCE: The Gallup Organization, "The Motorola Cellular Impact Survey: Evaluating 10 Years of Cellular Ownership in America," Princeton, NJ, 1993,p.11.

with by a small number of early adopters .29 Interest is growing among policymakers as well; the National Research Council recently released areport addressing some of these issues.[30]

New telecommunications technologies, principally computer networks, but also mobile computing and wireless telecommunications systems, make it easier to decentralize or reconcentrate central office operations and introduce new spatial relationships among workers. These changes are still not widespread, but there is some evidence that new organizational relationships-such as subcontracting, teaming and contingent organizational forms, and greater demands for flexible response to changing market conditions—are facilitated by use of new telecommunications technologies.[31] These are not solely due to wireless telecommunications technologies, but it seems certain that these technologies will play a role in such restructuring.

Another force driving the restructuring of physical organizations is the cost of space and facilities. Firms with large numbers of mobile employees see the cost of a private office as a drain on company revenues and some are experimenting with alternative arrangements that take advantage of mobile technologies. In occupations where workers spend a lot of time out of the office, such

[29]Early adopters were different from later adopters. Researchers are careful not to extrapolate protected usage Patterns too far from this early adopter group. See DYG, Inc., op. cit., footnote 12, p. 5.

[30]National Research Council, *Research Recommend.aliens To Facilitate Distributed Work* (Washington, DC: National Academy Press, 1994), p. 37. The study was requested by the Department of Energy in 1993.

[31]There is a growing literature in this area. Aspects of this development were addressed in U.S. Congress, Office of Technology Assessment, *Electronic Enterprises: Looking to the Future,* TCT-600 (Washington, DC: U.S. Government Printing Office, May 1994). See also Robert G. Eccles and Richard L. Nolan, "A Framework for the Design of the Emerging Global Organizational Structure," in *Globalization, Technology, and Competition: The Fusion of Computers and Telecommunications in the 1990s,* Stephen P. Bradley, Jerry A. Hausman and Richard L. Nolan (eds.) (Boston, MA: Harvard Business School Press, 1993), pp. 57-80; Tom Malone, J. Yates, and R. I. Benjamin, "Electronic Markets and Electronic Hierarchies: Effects of Information Technology on Market Structure and Corporate Strategies," *Communications of the ACM,* vol. *30, No. 6,* June 1987, pp. 484-497; Ajit Kambil, "Information Technology and Vertical Integration: Evidence from the Manufacturing Sector," in Steve S. Wildman and Margaret Guerin-Calvert, *Electronic Services Networks:A Business and Public Policy Challenge (New* York, NY: Praeger, 1991); Stuart Smith, David Transfield, Hohn Gbessant, Paul Levy, and Clive Ley, "Factory 2000: Design for the Factory of the Future," *International Studies of Management and Organization,* vol. 22, No. 4, pp. 61-68. Examples focusing on wireless include: Mel Mandell, "Office of the Future?'' Across *the Board,* October 1994, pp. 45-47; Alison L. Sprout, "Moving into the Virtual *Office,''Fortune,* May 2, 1994, p. 103; Kirk Johnson, "Evolution of the Workplace Alters Office Relationships," New *York Times,* Oct. 5, 1994, pp. Bl, B3.

as insurance adjusters or management consultants, alternatives could produce cost savings.[32] Nonterritorial or just-in-time offices are organized as shared facilities; work stations are allocated on a first-come, first-served basis or are shared with specific people. Moving to these newer organizational forms reduces the importance of place and increases the importance of communications links and networks. Further deconcentration may be facilitated by the widespread availability of wireless telecommunications. Long-term productivity benefits are as yet unknown because the short-term real estate savings, which can be significant,[33] may mask the effect of mobile office designs on work performance and employee development.[34]

Mobile work may result in more individual autonomy for workers because they will increasingly be able to work outside of traditional office settings.[35] Managers will have less visual assurance of job performance, and will have to rely more on other, perhaps performance-based, measures of job fulfillment.[36] Many supervisors ask how they can be sure their employees are working when they are not in the office.

On the other hand, such wireless-facilitated mobile work may also increase workers' isolation. They may have less face-to-face contact with co-workers and spend significant amounts of time away from their families.[37] Employee stress and burnout may increase in companies that adopt mobile office concepts. In some cases, employees are responsible for some of the costs associated with working on the road and for their home base; having to pay these costs themselves could undermine morale. Mobile workers typically work longer and harder than their office-located counterparts. Reconciling the desire to get more work out of employees with the need to keep morale high poses some dilemmas for firms.

### *Productivity and Efficiency*

In business, the ability to be in touch with others through wireless telecommunications may be a real benefit to those who spend time away from telecommunications systems unwillingly, such as road-bound sales representatives, nurses on the move, or soldiers in the field. There is growing evidence that wireless devices drastically cut the time required to locate people in offices and hospitals.[38] Stockbrokers find it increasingly difficult to be out of touch with the global securities and financial markets because a gap in their trading day can mean large shifts in market positions and

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[32] IBM has cut real estate costs by 50 percent for its marketing and sales costs in the New York-New Jersey area by moving to a converted warehouse in Cranford, New Jersey. Office space decreased by 75 percent, and only 200 of the 700 employees have permanent desks. Ira Sager, "The Few, the True, the Blue," *Business Week*, May 30, 1994, pp. 124-126. In one comparative study of such new office facilities, consulting firms Anderson Consulting in San Francisco and Ernst & Young in London reduced their need for space by 68 and 32 percent, respectively, saving $137,000 and $383,000 per year in gross space costs for 70 and 96 people. Franklin Becker, Bethany Davis, and William Sims, "Using the Performance Profile To Assess Shared Offices," *Facilities Management Journal*, May/June, 1991, pp. 13-29.

[33] Mel Mandell, "Office of the Future?" *Across the Board*, October 1994, pp. 45-47.

[34] Sue Shellenbarger, "Overwork, Low Morale Vex the Mobile Office," *The Wall Street Journal*, Aug. 19, 1994, pp. B-1, B-4.

[35] DYG, Inc., op. cit., footnote 12, lays out many of the characteristics of this type of worker, often called the untethered worker, the mobile worker or the self-contained worker. See also Mark Weiser, citation in National Research Council, op. cit., footnote 30.

[36] For example, see National Research Council, op., cit., footnote 30, pp. 12-13. This point is echoed frequently in the business press and wireless telecommunications trade press.

[37] Kirk Johnson, "New Breed of High-Tech Nomads: Mobile Computer Carrying Workers Transform Companies," *The New York Times*, Feb. 8, 1994, pp. B1, B5.

[38] One study found that the time: 1) required to locate a nurse fell from 28 minutes to 20 seconds with a wireless, office-based telephone system, 2) a nurse waited by a phone for a returned page fell from 52 minutes to less than 2 minutes, and 3) callers were put on hold fell from 62 minutes to 36 minutes. "Effects of Communication Delays on Hospitals: SpectraLink Workflow Study Results, August 1993," SpectraLink Company document, n.d.

TABLE 2-7: Business Performance Due to Cellular Telephone Use

| | Percent of cellular telephone users agreeing strongly or agreeing somewhat in: | |
|---|---|---|
| **Cellular telephones have:** | **1991** | **1993** |
| Increased your flexibility | 91 | 97 |
| Increased your efficiency | 87 | 91 |
| Enhanced communications which has made your life less stressful | 83 | 82 |
| Made you more productive at work | 81 | 84 |
| Made you more competitive | 67 | 73 |
| Added a significant amount of time to your day | 78 | 80 |
| Made you more successful in business | 70 | 74 |

SOURCE: The Gallup Organization, "The Motorola Cellular Impact Survey: Evaluating 10 Years of Cellular Ownership in America," Princeton, NJ, 1993,

values. Stock quote devices such as QuoTrek, Quotam, and Metriplex deliver up-to-date information via digital broadcasting facilities or FM side bands generated by radio stations .39 Users, at least, believe that wireless technologies improve their performance (table 2-7).

Wireless telecommunications may increase productivity for workers who can perform parts of their jobs in the "dead time" while in transit between places, as noted above. One study assessed employees' ability to recapture time spent away from the office by using cellular telephones.[40] Table 2-8 gives the annual productivity gains for broad job categories.[41]

Larger amounts of time recaptured in this model yield greater productivity gains. Thus, if a sales

TABLE 2-8: Annual Productivity Gains Attributable to Cellular Telephone Use

| Occupation | Annual income (dollars) | Average hours lost per week away from office | Time spent making cellular calls, hours per week | Annual productivity gains per employee,* (dollars per year) |
|---|---|---|---|---|
| President or chief executive officer | 100,000 | 12.4 | 1.2 | 2,220 |
| Sales or other revenue-generating employee | 65,000 | 18.8 | 1.6 | 1,200 |
| Middle management/director/ supervisor | 65,000 | 9.6 | 1.2 | 780 |
| Field service person/technician | 60,000 | 15,5 | 1,3 | 680 |
| Technical/R&D | 45,000 | 7.4 | 1,1 | -60 |
| Administrative/secretarial | 30,000 | 3.3 | 0.7 | -550 |
| Entry level | 25,000 | 3.7 | 0.7 | -680 |

SOURCE: "Cellular Use and Cost Management in Business," study prepared for PacTel Cellular by Yankelovich Partners, Newport Beach, CA, 1993, pp. 15-18,

[39] Jay Mathews, "Getting a Grip on the Markets," *Washington Post,* May 20, 1994, pp. Fl, F3.

[40] "Cellular Use and Cost Management in Business," study prepared for PacTel Cellular by Yankelovich Partners, Newport Beach, CA, 1993.

[41] Senior executives in the large-sample survey reported they were away from their offices 149 minutes per day, and that they used cellular telephones about 10 percent of this time. The study then calculated the annual productivity gain by multiplying time recaptured by the average wage rates for various job classifications.

TABLE 2-9: Survey Respondents' Estimates of Time Added Per Day Due To Cellular Telephone Use

| Time added per day | 1991 (percent) | 1993 (percent) |
|---|---|---|
| A half-hour or less | 31 | 38 |
| Between a half-hour and an hour | 16 | 17 |
| 1 hour | 23 | 24 |
| 2 hours | 17 | 11 |
| 3 hours | 4 | 3 |
| 4 hours or more | 3 | 1 |
| Don't know/not sure | 6 | 3 |
| Lost time/very little | NA | 3 |
| Mean average (hours) | 1,06 | 0.92 |

SOURCE: The Gallup Organization, "The Motorola Cellular Impact Survey: Evaluating 10 Years of Cellular Ownership in America," Princeton, NJ, 1993.

TABLE 2-10: Survey Respondents' Estimates of Productivity Increases Due To Cellular Telephone Use

| Productivity improvement | 1991 (percent) | 1993 (percent) |
|---|---|---|
| Zero | 9 | 16 |
| 10 | 17 | 11 |
| 20 | 15 | 18 |
| 30 | 15 | 12 |
| 40 | 6 | 6 |
| 50 | 10 | 11 |
| 60 | 4 | 3 |
| 70 | 6 | 6 |
| 80 | 6 | 9 |
| 90 | 2 | 3 |
| 100 | 4 | 1 |
| Don't know/not sure | 6 | 4 |
| Mean (percent) | 36 | 34 |

SOURCE: The Gallup Organization, "The Motorola Cellular Impact Survey devaluating 10 Years of Cellular Ownership in America, " Princeton, NJ, 1993.

representative recaptured 20 percent of time away from the office, the productivity gain would be about $3,540. The negative figures for technical, R&D, administrative, and entry level categories indicate that the productivity gain due to recaptured time does not cover the cost of wireless service and equipment.

Another survey reported on the time added to a person's day, which averages about one hour, and on productivity, which averages about 35 percent (tables 2-9 and 2-10).[42]

Although these numbers are suggestive of the positive effects mobile wireless technologies could have on productivity and efficiency, few studies of the deployment of these technologies have been undertaken. The National Research Council report on distributed work notes that such work can enhance productivity, but it also suggests that sociological and organizational studies of distributed work will be needed to ensure that distributed work can be carried out to serve the needs of individuals and organizations effectively.[43] In addition, productivity improvements due to communications and computing technologies are difficult to measure.[44] Quantitative research is needed to determine the effects of wireless telecommunications on productivity.

## Implications for Society

### *Universal Service*

One of the promises of wireless systems is that they can provide communication and information services to citizens who cannot access them via wireline models or who cannot afford them. While about 94 percent (240 million) of the U.S. population currently have telephone service, 6 percent (15.3 million) do not. A number of underserved populations could benefit from the use of wireless technologies (see chapter 9).

For example, there are four to five million migrant farmworkers without a permanent residence

[42] The Gallup Organization, op. cit., footnote 26. These figures have declined from 1991 to 1993, probably because more cost-conscious users, the so-called "second-tier" users, have subscribed.

[43] National Research Council, op. cit, footnote 30, p. 37.

[44] U.S. Congress, op. cit., footnote 31, pp. 51-52. See also, Richard A. Kuehn, "Enhanced Technology Doesn't Always Enhance Productivity," *Business Communications Review,* vol. 24, No. 4, April 1994, p. 83.

living and working in the United States,[45] and possibly two million homeless people living in shelters or on the street.[46] These people are inherently mobile, and thus have the most difficult time gaining access to reliable and affordable communications services.[47] There is currently no effort at the federal level to address their need for telecommunications access.

Recently, social agencies have begun to provide homeless people with voicemail boxes to facilitate their efforts to find employment, and to stay in touch with support services, families, and others.[48] Advocates for the homeless say that optimally, people should have access to immediate communications, such as might be provided by wireless, which would help assure better safety, services and employment prospects, all key concerns for the homeless. Failing personal telephone service, voicemail is an attractive alternative.

### *Land Use and Transportation Effects*

Regional sprawl may also be associated with wireless telecommunications—easier mobile communications together with easy transportation may exacerbate travel patterns already in place due in part to earlier development of transportation and communications infrastructures.[49] Past telecommunications development facilitated (though probably did not cause) the growth and power of major cities and urban cores, while at the same time enabling production to be coordinated in factories located outside the cities. In many cases, the dispersal of production into outlying areas promoted the relocation of people to those areas as well. While this migration was not caused directly by either telecommunications or transportation system improvements, it is unlikely that such changes would have been so great without them.

The effect of wireless telecommunications on travel behavior and land use has not been widely studied, but preliminary work suggests that it may contribute to urban and suburban sprawl.[50] Already there is evidence that car offices are used increasingly by mobile professionals and services.[51] This minimizes the need for costly office overhead, but presumably increases the time

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[45] U.S. Department of Health and Human Services, Public Health Service, Health Resources and Services Administration, *An Atlas of State Profiles Which Estimate Number of Migrant and Seasonal Farmworkers and Members of Their Families* (Washington, DC: U.S. Government Printing Office, March 1990); National Advisory Council on Migrant Health, *1993 Recommendations of the National Advisory Council on Migrant Health*, (Rockville, MD: National Advisory Council on Migrant Health, May 1993). Migrant workers are difficult to identify, because of their mobility and language differences from the majority population. Various federal agencies have different definitions and counting methods. See Valerie A. Wilk, *The Occupational Health of Migrant and Seasonal Farmworkers in the United States*, (Washington, DC: Farmworker Justice Fund, Inc., 1986), pp. 11-12.

[46] National Coalition for the Homeless, "How Many People Are Homeless in the U.S. and Recent Increases in Homelessness," information sheet, issue no. 5 (Washington, DC: Homelessness Information Exchange, National Coalition for the Homeless, January 1994). The Census Bureau estimates, conservatively, that there are about 250,000 homeless people in the United States. U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1994* (Washington, DC: U.S. Government Printing Office, September 1994), table 84, p. 69.

[47] See Chantal de Gounay, "L'âge du citoyen nomade," *Esprit* Paris, France, no. 11, November 1992, pp. 113-126, for a discussion of contemporary nomadism and culture in advanced industrial societies.

[48] N.R. Kleinfield, "For Homeless, Free Voice Mail Can Be a Key to a Normal Life," *The New York Times*, Jan. 30, 1995, pp. B1, B6; "Hold My Calls," *Newsweek*, Mar. 30, 1992, p. 9; "No Home: Please Hold," *The Economist*, Dec. 18, 1993, p. 29.

[49] Ithiel de Sola Pool et al., "Foresight and Hindsight: The Case of the Telephone," in *The Social Impact of the Telephone*, Ithiel de Sola Pool (ed.), (Cambridge, MA: The MIT Press, 1977), pp. 127-158.

[50] Youngbin Yim, Institute of Transportation Studies, University of California, Berkeley, interview, Jan. 24, 1995. See also Youngbin Yim, Adib Kanafani, and Jean-Luc Ygnace, "Expanding Usage of Cellular Phones: User Profile and Transportation Issues," PATH Research Report, UCB-ITS-PRR-91-19, (Berkeley, CA: University of California, Institute of Transportation Studies, Program on Advanced Technology for the Highway, December 1991).

[51] See, for example, Sue Ellen Christian, "It's Not a Car, It's a Mobile Office," *The Washington Post*, Aug. 8, 1994, pp. 17, 21.

spent on the road, and enables greater deconcentration from central facilities. Much more work will be required to determine what factors account for urban form and land use, including sprawl, and what role wireless telecommunications technologies may play.[52]

[52] An ongoing OTA study is examining questions of information and other technologies and urban form. See U. S. Congress, Office of Technology Assessment, *Technological Reshaping of Metropolitan America*, (in progress).