Telework, Intelligent Transportation Systems, and Telecommunications Infrastructure 7

In addition to workplace technologies, there are other technologies that could have a significant impact on the spatial distribution of jobs and homes. This chapter examines three such technology systems: telework, intelligent transportation systems, and telecommunications infrastructure. Telework, which lets people work in distributed locations, including at home, is expected to increase, with potentially large impacts on where employed people live. Intelligent Transportation Systems (applying information technologies to surface transportation) could reduce congestion on metropolitan highways and improve traffic flow, similarly allowing people to live in outlying locations without spending more time commuting. Advanced telecommunication infrastructure is becoming highly dispersed across the country, enabling industrial development elsewhere than the largest metropolitan areas.

TELEWORK AND ITS EFFECT ON METROPOLITAN AREAS

The terms "telework," "telecommuting," "distributed work," and "teleprocesses" all refer to the substitution of transportation by the use of telecommunications and other information technologies, but these terms are often used to mean different things. The terms "telecommute" and "telework" were coined in 1973[1] and are better known than the other terms, but the distinctions are blurring.

[1] Jack M. Nilles, "Telecommunications and Organizational Decentralization," *IEEE Transactions on Communications*, vol. COM-23, No. 10, October 1975, pp. 1142-1147.

Telecommuting means the partial or complete substitution of an employee's normal working hours in a traditional office or other workplace by the home or alternative workplace such as a neighborhood telework center. Telecommuting reduces commuting time and is accomplished through information technologies.

Telework includes telecommuting, but also includes some self-employed people who work at home and mobile workers who use information technologies and telecommunications to do their jobs.[2] A teleworker may use a laptop and modem at the customer's site to conduct business; a telephone, fax, computer, and/or modem to work out of a permanent office located in the home; or a cellular telephone to conduct business while in a vehicle. As the broader concept, telework is more relevant to the overall study.

"Hoteling" is often a component of telework, and refers to two or more mobile workers sharing office space in a traditional office or telework center. Hoteling saves office costs but requires special workspace arrangements, as well as sophisticated telephone and computer networking tools. The offices should offer temporary or portable storage by the rotating workers, and should be able to route calls and electronic transactions to the worker, wherever he or she may be.

"Distributed work" is the use of telecommunications and other information technologies to perform work at a distance *but not necessarily outside of an office.*[3] In particular, distributed work specifically includes group activities—such as videoconferencing and networked information resources—that allow people from distant locations to work together. Distributed work can cut travel costs, and perhaps more importantly, permits work to be done that previously could not have been done at all, or only at great expense or inconvenience. In contrast, telework emphasizes the *substitution* of a home or other remote or mobile environment for the traditional office, although the difference is often difficult to distinguish and may eventually become meaningless.

Finally, a teleprocess is defined as an arrangement in which a remote transaction is performed by anyone (not just a worker) and is facilitated through the use of telecommunications (see figure 7-1).[4]

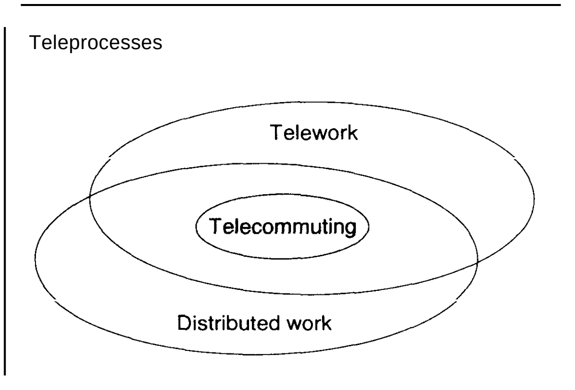
---

[2] "Home work" or "home-based" work refers to any form of work at home—whether using information technologies or not. "Mobile work" or "nomadic work" may occasionally use a home or traditional office, but the primary focus of the work is to be in transit between locations (such as taxi drivers and truckers), on the customer's site (such as case workers, field service representatives, construction workers, etc.), or in other variable locations (such as reporters, video crews, police, etc.). "Remote work" can be defined as "work done by an individual while at a different location than the person(s) directly supervising it," and includes most types of mobile work and home work, including telecommuting. "Flexiplace" is part of a terminology that accounts for flexibility in time and space. That is, traditional work arrangements concern a relatively fixed time and place. "Flex-time" arrangements use the traditional work location, but allow the worker to be present at different times to reduce traffic congestion, etc. Flexiplace involves traditional working hours but flexible work location—thus, remote or mobile work. Finally, "flexwork" allows both time and location to be flexible.

[3] See Charles E. Grantham and Larry D. Nichols, "Distributed Work: Learning to Manage at a Distance," *The Public Manager* (Winter 1994-1995), pp. 31-34; Lee Sproull and Sara Kiesler, "Computers, Networks and Work," *Scientific American*, September 1991, pp. 116-123; National Research Council, *Research Recommendations to Facilitate Distributed Work* (Washington, DC: National Academy Press, 1994).

[4] Teleprocesses include telework and distributed work (moving the workers), but also teleservices, which uses telecommunications to change the location of customers. The set of teleprocesses includes such activities as electronic funds transfers, electronic data interchange (EDI), remote sensing, distance education, telemedicine, and the use of on-line and recorded information (see chapter 4). Teleprocesses could be extended to include perhaps all but personal telecommunications transactions. U.S. Department of Energy, Office of Energy Research, *Beyond Telecommuting: A New Paradigm for the Effect of Telecommunications on Travel* (Springfield, VA: National Technical Information Service, September 1994).

FIGURE 7-1: Diagram Showing Overlapping Terminology



SOURCE Office of Technology Assessment, 1995

■ Motivations for Telework

There are several reasons for the adoption of telework.[5] First, the worker can benefit, through reduced commuting time, a more flexible work schedule, more time with family, lower fuel costs, and possibly more freedom of choice in where to live. Telework can also increase opportunities for disabled workers and others who are limited in mobility.

Second, organizations can also benefit. Proponents claim that telework brings many immediate benefits to organizations, such as improving individual productivity, improving employee morale, reducing employee turnover, and reducing office space. However, some of the productivity increases noted in pilot studies have not considered the overall productivity of the organization. For example, an individual worker may greatly improve his or her own productivity by working at home, in part because many of the interruptions—e.g., telephone queries—are offloaded to fellow employees who remain in the office. Also, in the case of long-term, full-time telework, the employee may become isolated from the organization and his fellow workers, and his productivity may drop.

Third, proponents argue that metropolitan regions and society at large benefit from widespread telework because of reductions in traffic congestion, pollution, and energy use. To the extent that travel is reduced, accidents may also be reduced. Not all of these benefits can be demonstrated, however, and others note that businesses will adopt telework based on its merits for business, not on its broad social impacts.

Some commentators fear that telework will create a growing group of itinerate information workers who work on limited-term contracts without the benefits and security that accompany full-time employment. In exchange for flexibility, they may be less able to negotiate favorable terms, since each contract could be negotiated individually by the employer. The concern is that ultimately such contract-based telework may become imperative rather than optional for many workers, leading to increasing instability for workers, and decreased loyalty and institutional memory for employers.

■ Tasks Amenable to Telework

As this report uses the term, three categories of jobs are appropriate for telework: routine information-handling tasks, mobile activities, and professional and other knowledge-related tasks. One estimate suggests that 40 percent of the workforce in the United States could telework at least some of the time, but of these workers, many may not prefer or be suited for telework, or their managers may not encourage telework.[6]

- ■ **Routine information-handling tasks.** Workers in these positions perform well-defined

[5] See, for example, Mitchell L. Moss and John Carey, "Information Technologies, Telecommuting, and Cities," *Cities in Competition: Productive and Sustainable Cilies for the 21st Century,* John Brotchie, Mike Batty, Ed Blakely, Peter Hall, and Peter Newton (Eds.) (Sydney, Australia: Longman Australia, 1995).

[6] Jack Nines, personal communication, Aug. 8, 1995.

tasks using telephones, facsimile machines, or computers with modems in such a way that their tasks are not tied to a physical location. Thus, a customer service worker who uses a computer to answer telephone queries or input information into a computer from toll-free telephone calls may be a candidate for telework. Directory assistance, dispatching, and data entry may also be suited for telework. On the other hand, if specific paper or other resources tied to a central location are necessary to complete the tasks (e.g., many library tasks), telework is not appropriate.

- **Mobile activities.** Field service representatives, delivery personnel, field salespersons, and others perform their duties at the customers' or vendors' site and may not require an office environment except for occasional meetings or to use shared resources. Many employers use telework arrangements for such workers to encourage more direct contact with customers and to save on the costs of unoccupied offices while the workers are offsite (hoteling).
- **Professional and other knowledge-related tasks. "**Knowledge workers" manipulate, analyze, or otherwise process information in a nonroutine manner and may spend many hours with telephone, facsimile, computer equipment, and/or paper documents. Thus, consultants, translators, marketing personnel, authors and editors, software engineers, executives, and others may telework from home or while traveling. This set of tasks overlaps with the other categories. For example, a consultant can work both at home and at a customer site, making that worker both a professional and a mobile worker. Likewise, many tasks are not clearly routine or non-routine, such as translation services and some customer service tasks.

Technologies Necessary for Telework

The technologies required for home-based telework are relatively commonplace. For most teleworkers, a laptop or personal computer with a modem, electronic mail software, facsimile equipment, and traditional telephone service are enough. For the employer, current computer networking and/or call distribution equipment is often adequate. Some applications, however, benefit from or require faster data transmission for file transfers or videoconferencing. In such cases, current digital telephony services, including ISDN (Integrated Services Digital Network) service, is generally adequate, although such services are not necessarily available or affordable to homes or in certain areas. Desktop videoconferencing equipment is becoming less expensive, but the demand for video communications is not yet clear. While these advanced technologies may facilitate the further adoption of telecommuting, they may or may not become widespread, even if costs continue to decrease.[7]

More advanced telework applications are possible, including advanced technologies for high-performance computing and networking. For example, a scientist may wish to process data entered from a collaborator at another location using software resident on a computer at a third location, and display the results at his or her computer. Such applications use the most advanced information technologies available today.[8] Ultimately, the widest range of information technologies could be applied to telework, just as they are currently applied to the wider set of teleprocesses, including:

[7] Some argue that videoconferencing will have the appeal of the telephone and the television, and will therefore eventually become pervasive. On the other hand, many videoconferencing efforts have failed, and the technology could have a general appeal more like quadraphonic stereo. Also, the telephone provides privacy and mobility that the videophone does not. Finally, it is not clear over what period its adoption will occur, since to some extent an established infrastructure of equipment is necessary to make video calls.

[8] See, for example, C.E. Thomas, J.S. Cavallini, G.R. Seweryniak, R.J. Aiken, T.A. Kitchens, D.A. Hitchcock, M.A. Scott, and L.C. Welch, "Virtual Laboratories: Collaborative Environments and Facilities On-line," paper presented at the IEEE 1995 Conference on Real-Time Computer Applications in Nuclear and Plasma Physics, East Lansing, MI, May 22, 1995.

cryptographic tools; advanced data transmission protocols for special applications; satellites for distance education, remote sensing, or geographic positioning; and virtual reality tools.

The shift from paper-based to computer-based document systems within industry facilities telework (see chapter 5). For example, electronic file management systems that rely on electronic imaging allow an increasing share of back office workers to review customer and other files, make comments and changes, and send the files to another worker for the next step in processing, all on desktop computers. Similarly, "groupware" programs facilitate the sharing of electronic resources for workers who collaborate on projects. Transforming the work itself so that an increasing share can be conducted using personal computers increases the mobility of the work and makes telework cheaper.

The widespread application of the most advanced technologies for telework is uncertain, however, since the current cost of high-speed digital transmission and advanced computer networking equipment is out of range for most telework applications. Moreover, a great deal of telework arrangements use only basic information technologies that are currently available; existing technology is sufficient to sustain substantial growth in telework for the next several years.

Telework and Management

Telework is only one component of a larger movement to change the way organizations operate—often referred to as "reengineering" and "reinvention." Organizations may reorganize, relocate offices, redefine their markets, create new types of relationships with customers and vendors, eliminate workers and middle management, incorporate information technologies in new ways,[9] as well as implement telework.

Telework ultimately will affect not just measures of individual productivity, but the performance of an enterprise in ways that are impossible to attribute to telework alone. For example, a hoteling arrangement may force salespeople to meet more directly with customers, increasing sales. Or, more flexible working arrangements may lead to improved employee morale and therefore better service, a better reputation, and more business. In particular, telework requires that organizations manage by results instead of physical presence in the office, which may lead to better worker performance, even for those workers who are not teleworking. Thus, attempts to measure the positive effects of telework on individual productivity are useful, but the business case for telework does not necessarily succeed or fail based on individual results.

Many hoteling arrangements design office space to promote "water cooler" discussions and interactions among employees who may visit the shared office only one or two days per week. Employees who are absent from the traditional office will need contact with their coworkers that may only partially be accommodated by videoconferencing, electronic mail, and other new media. It is not clear to what extent these media can substitute for direct human contact.[10]

Many commentators claim that managers are slow to implement telework, but management practices are nevertheless changing. However, management must make a much greater change to accommodate full-time, rather than part-time, telework. Each organization must therefore discover its own balance between those activities that

[9] See, for example, Thomas J. Allen, and Michael S. Scott Morton, *Information Technology and the Corporation of the 1990s* (New York, NY: Oxford University Press, 1994).

[10] It was once predicted that if computer programmers used terminals instead of punch cards, some socialization would be lost since the programmers had to carry the cards to a central location for processing. However, most programmers continued to work in shared locations and found other outlets for face-to-face interaction.

are appropriate for telework, and those more appropriate for a traditional office.

Telework Forecasts

Given the variety of definitions used in discussions of telework and related arrangements, and the difficulty of obtaining data on many of these activities, estimates of the number of existing arrangements and possible trends differ greatly. Forecasts fall into two main types. One type uses case studies, focus groups, and surveys to extrapolate findings to the nation at large. The other type estimates on a national scale the maximum number of jobs and workers that are suitable for telework and infers the level of adoption based on trends in the acceptance of telework by management and other factors. These different forecasts then reference each other. These analyses contain many assumptions, and any forecast must necessarily include a range of values for different scenarios.

The U.S. Department of Transportation (DOT) estimates that there were two million telecommuters (1.6 percent of the labor force) in 1992, telecommuting an average of 1-2 days per week and working mainly out of homes (99 percent).[11] DOT forecast that the number of telecommuters would increase to 7.5 to 15.0 million by 2002, telecommuting an average 3-4 days per week, with about one-half working from telework centers. This amounts to about 5 to 10 percent of the forecast labor force.

The assumption about the trend toward telework centers versus work at home is challenged by some telework experts. Given the option of managing workers in a telework center or in their homes, managers often initially choose the telework center as an intermediate or trial step so that certain issues (such as liability or socialization) can be managed in a traditional manner. Later, these organizations may wish to allow more workers to telework from home as management becomes more comfortable with telework. Also, many workers may have special reasons for teleworking from home. In any case, some forecast that home-based teleworkers will predominate over those in telework centers in the near and long term.

It is difficult to collect information on the number of workers in telework centers. In comparison, home-based telecommuting has been more easily and accurately monitored using census and other survey information, explaining why home-based telecommuting is more widely recognized than other activities.

A 1991 forecast estimated that the number of U.S. telecommuters would grow to between 12 and 25 million by 2002.[12] Importantly, this forecast portrays the growth as greatest in the early years when the number of teleworkers is relatively small, and as slowing to below 20 percent per year in the mid- to late-1990s. The high estimate is contingent on many factors, including:

- relatively rapid and complete acceptance by management of telework practices;
- relatively rapid adoption of technologies that may facilitate telework arrangements, such as ISDN and desktop videoconferencing;
- adoption of federal, state, or local policies that promote telework arrangements; and/or
- unpredictable local or global events, such as an earthquake or a fuel crisis.[13]

Effect of Telework on Urban Areas

Much of the discussion about the effects of telework on metro areas has focused on the possibility of reducing traffic congestion, pollution, and energy consumption. The major focus of this report

[11] U.S. Department of Transportation, *Transportation Implications of Telecommuting* (Washington, DC: U.S. Department of Transportation, April 1993).

[12] Jack Nilles, JALA International, Inc., "Telecommuting Forecasts," Los Angeles, CA, 1991.

[13] When the Northridge earthquake struck Los Angeles in January 1994, for example, federally sponsored telework projects were quickly adopted and continued for some time after the local infrastructure was repaired.

is on the spatial redistribution of workers and residents as a result of telework, and the consequent changes in travel patterns (rather than just on reduction of peak-hour congestion). However, very little is understood about these changes, in part because telework is a relatively new phenomenon. Most analyses of telework have focused on direct effects (e.g., reduced commuting), rather than on indirect effects such as reduced office space demand, relocation by telecommuters to outer suburban or exurban locations, and stimulation effects on travel.

Savings in Office Space

Proponents of telework suggest that telework arrangements that share office space—hoteling arrangements—can save on office space costs for the employer.[14] As discussed earlier, management acceptance of telework hinges on its business case, and this cost savings provides a strong, but not necessarily sufficient, motivation to adopt telework.

Hoteling is successful in many applications where field service technicians, sales representatives, or consultants are in the field much of the day. Such employees have similar needs for information technologies and can therefore share office equipment. An example is the accounting firm Ernst & Young, which, through hoteling, reduced its office space needs in Chicago's Sears Tower by over 10 percent.[15] Other employees require dedicated space and equipment to perform their work, even if they are not in their offices for the entire workday. If only a few employees in an office can practice hoteling, management may not perceive sufficient savings to implement it, and in any case, real estate cost savings would be marginal. Work practices, software, and office design may evolve sufficiently to accommodate many workers and managers who are uncomfortable with hoteling at present, but the penetration of hoteling into the workplace will continue to be low for the immediate future.

Residential Land Use Patterns

Some studies suggest that widespread adoption of telework would lead to more decentralized land use patterns, as residents choose to live farther from dense metropolitan centers in exchange for lower real estate costs, lower property taxes, and more rural settings.[16] However, little empirical work has been conducted regarding this consequence of telework.

An early pilot project in California found that in the first two years, there was no significant difference in household move patterns as a result of telework arrangements.[17] However, long-term effects are likely to be more pronounced than results measured over the short term. Also, the telecommuters in that pilot study lived, on average, farther from the traditional workplace than the workers in the control group. Thus, the telecommuters may have already relocated, and were using telecommuting to reduce their inconvenience.

It is not surprising that the first employees of a firm to sign on to telecommuting programs may be those who have the most to gain because they live far from their jobs and have a long commute.

---

[14] See, for example, U.S. General Services Administration, Office of Workplace Initiatives, "Interim Report: Federal Interagency Telecommuting Centers," report to the House Appropriations Subcommittee on Treasury, Postal Service, and General Government, March 1995.

[15] Interview with officials at Ernst & Young, October 1994. See also Michael Bagley, J. Mannering, and P. Mokhtarian, University of California at Davis, Institute of Transportation Studies, "Telecommuting Centers and Related Concepts," research report UCD-ITS-RR-94-4 prepared for the U.S. Federal Highway Administration and the California Department of Transportation, March 1994. According to the UC Davis study, Ernst & Young expects eventually to shrink its office space nationwide by 2 million square feet, for a savings of $40 million per year.

[16] See, for example, Ajay Kumar, "Impact of Technological Developments of Urban Form and Travel Behavior," *Regional Studies*, vol. 24, No. 2 (1990), pp. 137-148.

[17] California Department of General Services, "The California Telecommuting Pilot Project Final Report," report prepared by JALA Associates, Inc., June 1990.

Later, people who do not live so far from their jobs may begin to telework as accommodations become available to them, or when the benefits are perceived to outweigh the costs.

Changing residential locations and land use should not be viewed only in terms of decentralization, since the character of urban life is also changing. While telework is most often promoted as an antidote to the traditional suburb-to-center-city commute, metropolitan residents increasingly work in and commute between suburbs, which have urban sub-centers of their own. Also, as discussed earlier, workers are not only applying telework in their work, but employers are applying telecommunications in more of their operations, and residents are using teleprocesses for more than just work.

The impact of telework on residential location also depends on whether the household has one earner or two. Single-earner households are more free to move to a new location than those with two-earners, since not all workers will telework full-time. Residents will also prefer to remain in metropolitan areas for other reasons in the short and long term, such as to keep children in a particular school or to be near family and friends.

Most importantly, the degree of decentralization depends on whether telecommuting continues to be part-time for most participants, or whether it becomes predominantly full-time. In the former case, participants could still live within commuting distance of metropolitan areas, although this distance could be considerable for some people. In the latter case, participants could live almost anywhere, leading to a much wider decentralization of activities and a much larger impact on residential location.[18]

Those who think of telecommuters living in idyllic, remote locations are generally thinking of the full-time telecommuter. Most of the experts with whom OTA spoke expect that full-time telework will remain a small fraction of overall telework, suggesting that telework is unlikely to result in a widespread shift of households to rural locations.

Changes in Travel Patterns

Perhaps the most comprehensive documents surveying telecommuting and telework are a series of reports from DOT and the U.S. Department of Energy (DOE). DOT estimates that, by 2002, telecommuting could save 2.3 to 4.5 percent of annual passenger-vehicle *commuting* miles traveled, or about 0.7 to 1.4 percent of *total* annual passenger-vehicle miles traveled.[19] The estimated number of miles saved from telecommuting is nominally large (17.6 to 35.1 billion miles per year or 1.3 to 2.5 billion trips in 2002). However, the total number of vehicle miles that Americans drive each year is also increasing as women, young adults, and immigrant populations incorporate more driving into their lifestyles. The share saved from telecommuting is therefore smaller than it would be if current driving levels were fixed.

Even though the net effect of telecommuting on traffic congestion appears relatively small compared to the total vehicle miles traveled, small reductions in the number of vehicles on highways can have a great effect on congestion when traffic is at saturation. That is, although greatly reducing the number of vehicles on a nearly empty highway has little or no effect on travel time, reducing the number of vehicles on a crowded highway by only a small amount can significantly improve travel time. Thus, the adoption of telework will have the greatest effect in metro areas with the biggest traffic problems. The 10 largest cities could account for perhaps one-half of the benefits in delay reduc-

[18] Jack M. Nilles, "Telecommuting and Urban Sprawl: Mitigator or Inciter?," *Transportation*, vol. 18, 1991, pp. 411-432.

[19] U.S. Department of Transportation, op. cit., footnote 11.

tion, and the 75 largest cities for 90 percent of the benefits.[20]

Furthermore, though telework may have a relatively small impact on the total number of trips, it may redistribute the trips in time and location and therefore reduce peak-hour traffic congestion more than appears at first glance. Thus, traffic in suburban areas and off-peak hours may increase, but peak-hour congestion could decrease. The effect of telework could be to average traffic over space and time.

Also, the effect of telework on peak-hour congestion, even if small, is nevertheless significant if its cost is much less than the alternatives.[21]

DOE complemented the DOT study by examining the indirect effects of telecommuting, and found that perhaps one-half of the forecast reduction may be negated by the indirect effect of latent demand.[22] That is, as telecommuters avoid vehicle use by staying at home or commuting to neighborhood telework centers, others who previously avoided driving because of excessive traffic congestion will begin driving. Thus, if reduction of traffic congestion is an objective, telework arrangements should be part of a larger effort that focuses on demand management, intelligent transportation technologies, and public and alternative transportation. Demand management efforts—such as congestion pricing of peak hour traffic—could in turn increase the migration to telework arrangements as traditional commuting becomes more expensive.

More importantly, little is known about the much larger stimulation effect of telework on transportation, as noted in a later DOE study.[23] Substitution effects are inherently easier to estimate than stimulation effects, since the substitutional behavior patterns can be identified, tracked, and tested in pilot studies. On the other hand, stimulation effects arise from innovations that have not yet occurred. The following stimulation effects from teleprocesses—including some telework applications—have been suggested, or are already in progress.

- Demand for "just-in-time" (JIT) delivery will generate more trips for homes and businesses, which may be more geographically dispersed than before; JIT is facilitated by teleprocesses such as electronic data interchange and wireless dispatching.
- Teleworkers who spend more time at home may generate trips for services such as home delivery of fast food, goods purchased through home shopping, and trips to neighborhood stores that would have otherwise been integrated into a commute or walk near the central office.
- To the extent that telework enables increased residential mobility, residences could become more geographically decentralized. Thus, postal service, infrastructure maintenance, and other services could become less efficient (see chapter 8). Moreover, decentralized residents require longer trips when a commute is necessary, potentially driving more miles overall.

Telework Centers in Distressed Neighborhoods

Most telework efforts are directed at workers who live in suburban neighborhoods and who commute into the central city or to other suburbs. Little effort has been directed toward arrange-

[20] DOE ranked the following cities according to accumulated annual traffic delay reduction in 2010: Los Angeles (including Long Beach, Pompano, and Ontario, CA), New York and Northeastern New Jersey, Chicago, Dallas-Fort Worth, San Francisco-Oakland, Detroit, Atlanta, Houston, Washington, DC, San Diego, Philadelphia, and Boston. U.S. Department of Energy, Office of Policy, Planning, and Program Evaluation, *Energy, Emissions, and Social Consequences of Telecommuting* (Springfield, VA: National Technical Information Service, June 1994).

[21] See, for example, Jack M. Nilles and Walter Siembab, JALA International, Inc., "Telecommuting and Vanpooling: Cost and Benefit Comparisons," Los Angeles, CA, August 1992.

[22] U.S. Department of Energy, *Energy, Emissions, and Social Consequences of Telecommuting,* op. cit., footnote 20.

[23] U.S. Department of Energy, *Beyond Telecommuting: A New Paradigm for the Effect of Telecommunications on Travel,* op. cit., footnote 4.

ments that allow workers in urban neighborhoods to work at a distance with employers in the outer suburbs, or to promote telework in distressed urban and suburban neighborhoods.

The Los Angeles County Metropolitan Transit Authority has plans to operate two workstations in its "Blue Line Televillage" to serve potential teleworkers in the South Central Los Angeles area. The center currently provides a variety of services to residents of distressed neighborhoods in that area. The telework stations are viewed as an experimental project, with the intent of testing the application before dedicating additional resources.

The Clinton Administration in its National Information Infrastructure program made brief mention of such alternative telework arrangements. One suggestion was to establish "smart Metro stops" that could serve as telework centers, a center for public services, and an educational center for residents.[24] The U.S. General Services Administration (GSA) is working with the National Housing Program to establish telework centers for federal and other employees in public housing complexes, beginning in the Washington, D.C., area, but no formal plans are yet in place.[25]

Federal Programs and Policies Affecting Telework

Federal policies and programs related to telework fall into three categories: 1) pilot programs and research directed at promoting telework for federal employees, or more broadly; 2) federal and other policies that indirectly impact telework; and 3) funding for state and local governments that can be used for telework programs. Despite the fact that the federal government is devoting resources to promote telework, there is still no clear understanding of the costs and benefits of telework to business, workers, and society, including impacts on urban form.

Cost and Benefits of Telework

The various federal policies, programs, and statements on telework implicitly favor suburban and rural areas.[26] While there has been some discussion of teleworking from urban homes and centers to suburban offices, most interest is predominantly in the other direction, and such discussions often implicitly assume that dispersion of residents to more suburban and rural locations is universally beneficial. In practice, the allocation of the benefits may or may not match the allocation of costs for the various stakeholders.

Suburban and rural residents clearly stand to gain the most from telecommuting arrangements as they exist today. Workers who live well out of metro areas typically benefit from lower housing costs, reduced taxes, reduced crime, better schools, and other amenities. If these workers also can telecommute they save in fuel costs, tolls, and commuting time (which in turn may save in such items as day care expenses). In exchange, these workers may pay some of the costs (through donated personal space,[27] computer equipment, telecommunications charges, or extra hours maintaining computer equipment). However, if they work from a telecommuting center and still occupy their old office space, then their employer is paying more for total office space costs. Center city residents can also telecommute, but the benefits to those residents may not be as great.

---

[24] U.S. Department of Commerce, National Institute of Standards and Technology, *The Information Infrastructure: Reaching Society's Goals—Report of the Information Infrastructure Task Force Committee on Applications and Technology,* NIST Special Publication 868 (Washington, DC: U.S. Government Printing Office, September 1994).

[25] Warren Master, U.S. General Services Administration, personal communication, Aug. 24, 1995.

[26] This also appears to be the case in Europe, see European Commission, Directorate General XIII, "Europe and the Global Information Society—Recommendations to the European Council," Brussels, May 26, 1994. See also Bagley, Mannering, and Mokhtarian, op. cit., footnote 15.

[27] If the personal space is in addition to traditional office space, however, the total cost also goes up by the amount of the donated personal space.

On a larger scale, the metropolitan area itself may gain if widespread telework arrangements attract new businesses and residents because of improvements in quality of life, or if telework enhances the competitive advantage of local businesses. Alternatively, if telework becomes widely adopted, residential and business real estate in many center city locations could become less valuable, and urban governments could lose tax revenue. None of this is at present well understood.

Some of the costs could be reallocated to reduce subsidies. A telecommuter who works out of a telework center, for example, could pay some of the expenses of the center. Such a scheme might encourage employers to implement telework. On the other hand, one survey has indicated that workers would be strongly deterred from teleworking if their salary is cut (equivalent to being charged additional costs).[28]

Further examination of the costs and benefits of telework to stakeholders would allow policymakers to make better decisions.

Federal Telework Efforts

The federal government has a number of telework-related programs.[29] The motivation for the federal government includes energy conservation (DOE), traffic management (DOT), pollution control (Environmental Protection Agency—EPA), facilities management and the federal work environment (GSA), and personnel management (Office of Personnel Management—OPM). The general strategy has been to overlap these missions where common goals exist. In particular, the federal government has promoted telework in its own agencies as a means to manage its own resources better, as well as to set an example and to promote telework more broadly. Thus, the central federal activity has been the funding and implementation of pilot and other projects.

GSA and OPM have experimented with flexible workplace arrangements for over five years, including a pilot project that was completed in 1992 and included more than 1,000 federal employees nationwide. Congress later appropriated $6 million to GSA to establish pilot telecommuting centers around Washington, D.C., through partnerships with local governments and industry, to be completed in 1996.[30] For example, in Hagerstown, Maryland, GSA worked with the city of Hagerstown and Hagerstown Junior College, while in Fredricksburg, Virginia, GSA worked with the Rappahannock Area Development Commission. Following the 1994 earthquake in Northridge, California, GSA established three emergency telecommuting centers in the Los Angeles region. More recently, GSA established telecommuting arrangements in Oklahoma City following the bombing of the federal building in April 1995.

GSA is also the lead agency implementing the Federal Employee Clean Air Initiatives Act, intended to reduce federal employee reliance on single-occupancy vehicles, including measures to promote telecommuting. The Administration's National Performance Review also recommended that OPM and GSA work with agencies to expand flexible work arrangements for federal employees.[31] The President's Management Council

[28] The reverse was not true; that is, increasing salaries for workers who were willing to participate did not seem to be a strong motivation to telework. These hypotheses were based on survey questions and not actual program results. Adriana Bernardino and Moshe E. Ben-Akiva, "Employer's Perspective on Adoption of Telecommuting," paper presented at the 1995 Annual Meeting of the Transportation Research Board, National Academy of Sciences, session 163, Washington, D.C., January 1995.

[29] Since this report considers federal policies that impact telework for its own or for other employees, this chapter does not explicitly describe private sector efforts in telework. For an overview of private sector efforts, see U.S. General Services Administration, op. cit., footnote 14.

[30] Ibid., U.S. General Services Administration.

[31] Vice President Albert Gore, Jr., *Creating a Government that Works Better and Costs Less: Report of the National Performance Review* (Washington, DC: U.S. Government Printing Office, September 1993).

is currently reviewing a proposal for a National Telecommuting Project to be led by DOT and GSA that would span three years and 30 metropolitan areas.[32]

DOE has sponsored several studies on telework and related activities because of its interest in energy efficiency.[33] In 1993, DOE asked the National Research Council to conduct a study on the technological issues related to telework, broadening the focus to include distributed work and high-performance computing applications.[34]

Finally, the Clinton Administration's Climate Change Action Plan directs the EPA and DOT to work together to promote telecommuting. Actions include: encouraging states to use the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) to fund telecommuting programs (see below), pilot projects for federal employees, and issuing guidance to states wishing to establish telecommuting measures.[35]

Federal and Other Policies Affecting Telework

- **Telecom policy reform.** Several experts noted in interviews with OTA that perhaps the most significant federal policy affecting telework is the current telecommunications legislation. Proponents suggest that—to the extent that affordable technology is important—telecom policy reform could facilitate telework by making new technologies and services cheaper and more widely available.
- **Tax policies.** Expenses for home computers, telecommunications equipment, and other information technologies are allowed as tax deductions for home businesses, but for those teleworkers who do not work primarily at home the deduction may not be valid. Employers could also receive tax deductions or credits for telework programs that meet specified criteria. However, in both cases it is not clear why teleworkers should receive preferential tax treatment relative to employees that live closer to work and do not telecommute.
- **Fair Labor Standards Act.** Relatively few occupations are restricted on work at home because of federal labor laws, although many states have restrictions on certain types of work or the hours that an employee can work without compensation. In many telework cases, such provisions may be difficult to enforce.
- **Labor union concerns.** Labor unions have been generally supportive of telework efforts, but are concerned about several issues. First, widespread teleworking could reduce the ability of unions to effectively represent workers who telework outside a traditional workplace. Second, employers may exhibit preferences to allow some workers to telework, affecting equity. Third, electronic monitoring and other techniques may increasingly be used to supervise employees, increasing stress and reducing privacy. Fourth, employers may attempt to convert workers from career employment to contract work, reducing benefits and job security. Finally, for some workers, telework could mean a return to micro-management and the assignment of piecework, thus reducing the quality of work and upward mobility.
- **Zoning.** Some localities have restrictions on the location of businesses in residential areas—

[32] U.S. Department of Commerce, *The Information Infrastructure: Reaching Society's Goals—Report of the Information Infrastructure Task Force Committee on Applications and Technology,* op. cit., footnote 24.

[33] Two studies were prepared in response to a requirement in the Energy Policy Act of 1992, in conjunction with the Department of Transportation: U.S. Department of Transportation, op. cit., footnote 11; and U.S. Department of Energy, *Energy, Emissions, and Social Consequences of Telecommuting,* op. cit., footnote 20. DOE later contracted for a study on policy and other implications teleprocesses, looking beyond the narrower applications of telecommuting and telework. U.S. Department of Energy, *Beyond Telecommuting: A New Paradigm for the Effect of Telecommunications on Travel,* op. cit., footnote 4.

[34] National Research Council, op. cit., footnote 3.

[35] President William J. Clinton and Vice President Albert Gore, Jr., *The Climate Change Action Plan,* 1993.

restrictions that technically include many telework arrangements.[36] Many teleworkers sidestep these restrictions by working discreetly from their homes, and local authorities generally overlook such violations.

- **Congestion pricing of transportation.** Tolls for use of highways during rush hours could indirectly motivate workers to adopt telework. Such policies could be instituted as part of a regional transportation plan not specifically oriented toward telework itself, and directed at recovering some of the social costs of traffic congestion from those who generate the traffic. However, if congestion pricing significantly reduced congestion, it would also make commuting more attractive. (See next section.)
- **Demand management of energy.** Policies that encourage the pricing of energy use according to demand could reduce costs for residents while not at home, but increase costs for workers who telework from home. These increased costs could reduce the motivation for teleworkers to work from home (if they are paying their own energy costs), but also increasing the motivation for employers to reduce office energy costs.[37]
- **Liability.** Official telecommuting programs normally require a formal agreement between employer and employee that puts responsibility for a safe workplace on the telecommuter, and permits employer inspection with prior notice. Such an agreement may also limit the employer's liability for workman's compensation to specific work hours and to specific areas of the home. In cases lacking formal agreements, however, the assignment of liability for a safe workplace is less clear.

ISTEA Funding

Using Federal Highway Administration funds, DOT can fund telecommuting projects through the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). ISTEA funds can be applied to support compliance of the Clean Air Act and to improve the efficiency of local transportation infrastructures. Telecommuting programs qualify as travel demand management, and funds can be used to plan, develop, and market regional telework strategies. An example is an effort launched by the California Department of Transportation to create several telecommuting centers across the state through partnerships with local governments and the private sector.[38] Local governments have claimed, however, that the funds are not effective as currently allocated, and that the local governments should be able to apply the funds toward other telework-related expenses, e.g., toward construction and operating costs.

METROPOLITAN IMPLICATIONS OF INTELLIGENT TRANSPORTATION SYSTEMS

The form of cities is the result of many economic and social forces interacting in complicated ways—the transportation system is not necessarily the primary driver of change.[39] However, technological advances in transportation have had and will continue to have profound implications for cities and societal institutions in general. Dramatic changes in the shape of cities, in manufacturing and service industries, and in societal opportunities occurred during the past century as transportation technology changed from horse-drawn carriages to electric street cars to high-capacity

[36] See, for example, JALA International, Inc., "Village One Telecommunications Feasibility Study," report prepared for the City of Modesto, CA, October 1994.

[37] Robert J. Aiken, John S. Cavallini, and Mary Ann Scott, "Energy Utilities and the Internet: Users or Providers?," paper presented at the Fifth Annual Conference of the Internet Society, Honolulu, Hawaii, June 27, 1995.

[38] Bagley, Mannering, and Mokhtarian, op. cit., footnote 15.

[39] This section is based on a report prepared for the Office of Technology Assessment on Intelligent Transportation Systems. David C. Hodge and Richard Morrill, "Metropolitan Form Implications of Intelligent Transportation Systems," July 1995.

mass transit systems, and finally to automobiles, trucks, and other motor vehicles.

The next major change in metropolitan transportation systems will come from the application of information and automation technologies, rather than from fundamental changes in vehicle form or the infrastructure. Enhancing transportation infrastructure capacity, travel decisions, and vehicle safety through sensors, communications, computers, and electro/mechanical control technologies is referred to as *intelligent transportation systems* (ITS). ITS encompasses a wide range of applications and services, from synchronized traffic lights to computerized road maps. Some of these technologies have been deployed, some are now being tested, and some are still only concepts. Most of the near-term (next 10 to 15 years) applications of ITS aim to enhance or automate existing transportation functions and services, rather than provide radically new operational characteristics. These applications include automated transactions (e.g., paying tolls), traffic management and control, information for trip planning and navigation, and improving vehicle and driver performance.[40]

Chronic traffic congestion problems have been the primary motivation for ITS programs. ITS technologies offer two basic approaches for mitigating congestion: 1) increasing the effective capacity of road and highway infrastructure; and 2) changing the demand for travel mode and time through better information for ridesharing, transit, and other trip decisions; new forms of transit services; and practical and cost-effective direct pricing of transportation infrastructure (e.g., congestion pricing). If either aspect of ITS is successful in significantly changing the real or perceived costs of transportation, it could have implications for future metropolitan development.

Key ITS Technologies

Of primary interest to this study are the elements of ITS that could affect mobility and accessibility in the near-term, and could consequently affect metropolitan form. These ITS technologies and services can be put into three groups: 1) automated transactions, 2) traffic system management and control, and 3) traveler information services.[41] Advances in information management technologies—sensors; information processing; data networks; location and identification systems; and data entry and display devices—underpin ITS. The functions, technologies, and operational implications of these three ITS groups are described briefly below:

Automated Transactions

Automated transactions can reduce the time and costs for such tasks as toll and fare collections and, especially for commercial vehicles, regulatory, administrative and enforcement processes. Electronic payment technologies now allow drivers to pay tolls without stopping or slowing from cruising speed. On transit systems, such technologies mean passengers don't have to provide exact change; this speeds boarding times, and reduces cash handling costs for transit operators. Development of digital cash systems[42] should protect individual anonymity, often a concern with current electronic payment methods that maintain data on transaction location and time.

---

[40] The "Automated Highway System" concept—hands-off, high-speed, high-density trips by automobile—would offer dramatically different operational characteristics than current highways.

[41] A fourth area is "automated vehicle controls and sensors." Automated vehicle control systems are not assessed because in the near- to mid-term, they are unlikely to affect congestion, travel times, or mobility/accessibility. Certain safety, environmental, and energy-related systems are, however, discussed.

[42] Digital cash is based on public key cryptography that allows a buyer and seller in electronic commerce to transact business without necessarily identifying themselves to one another. Secure electronic payment with high levels of anonymity (and low cost) is expected to be essential for commerce on the Internet, and has received a great deal of recent attention.

For commercial vehicles, roadside weight and credential checks can be done automatically without stopping vehicles, and administrative processes such as obtaining permits and paying registration and roadway fees can be accomplished electronically, thus reducing costs for motor carriers and state regulatory agencies.

Traffic System Management and Control

Surveillance and communications technologies can improve the management of surface traffic. Surveillance is achieved by widespread traffic sensors such as induction loops, computer vision, and vehicle transponders. Traffic management centers process the information from sensors and other sources, including vehicles in the system acting as probes. The information is then used to regulate traffic flow through signal timing and freeway ramp controls, and to respond to accidents and other incidents. Vehicles need no new equipment for these ITS applications.

Traveler Information Services

These systems acquire, analyze, communicate, and present information to travelers, vehicle operators, and fleet managers on traffic conditions, routes, and schedules. In conjunction with advanced traffic management, traveler information systems could advise people while en-route about traffic conditions, how to avoid blockages, and where to find parking and other services.

Users will need special equipment to receive this ITS service. Systems might include electronic maps and electronic tourist guides supplied via equipment in vehicles, homes, businesses, and sidewalk kiosks. The more advanced en-route services will require wireless communication and information processing systems. Many commercial truck fleets and public transit systems have installed travel information technologies such as routing and dispatching systems and automatic vehicle location equipment. There is a growing consumer market for global positioning system-based navigation for private automobiles. However, with the exception of broadcast radio and some cellular phone services, there is not yet an operational deployment of commercial technologies for route guidance based on real-time traffic conditions.

Spatial Location Implications of ITS

It is highly unlikely that ITS will “cause” changes in urban form. Since good transportation is widely available at a relatively low cost, new facilities or changes in transportation technology have less impact than they once did. Other forces are restructuring the physical form and organization of cities, such as new technologies in industry, the reorganization of business, and demographic changes. ITS is not so much a new transportation technology as it is an extension, albeit potentially a significant one, of motor vehicle operations. As such, it may have a major role to play as an enabler, i.e., a technology which enables the other forces to change metropolitan form.

Transportation Capacity and Land Use

ITS can have some impacts on land use by increasing the average, and in some cases the maximum, vehicle-throughput capacity at certain bottlenecks and routes. ITS does this by speeding toll collection, optimizing flow through and across signalized routes, and allowing road officials to detect and resolve accident-causing delays more quickly. These technologies are likely to facilitate residential and commercial dispersion. Almost all theoretical formulations of the impact of transportation investment assert that better transportation in an area will attract business and people, and will spread out development because a greater distance can be covered in the same amount of time. The stability of metropolitan commuting times in recent decades provides evidence that this relationship holds and that time is the ultimate constraint on how people commute.[43]

A better transportation system may increase the concentration of businesses in the center, but it will almost certainly contribute to commutes over longer distances by workers. Signal preemption for buses, in combination with reserved lanes, can significantly improve public transportation by reducing travel times; however, it seems very unlikely that these improvements will cause many more people to switch to buses. Similarly, better transportation will be supportive of more dense development, but will not stimulate such developments.

Because metropolitan areas are not likely to be outfitted with many more traffic signals and integrated traffic control systems in the foreseeable future, gains in regional mobility will depend on ITS information systems. The deployment of driver information systems would support the decentralization of urban areas and a decline in public transit. Such systems would enable trip times to become more predictable, and allow drivers to avoid unexpected traffic jams.[44] Already heavily congested places would find little relief, however, because of the lack of viable alternate routes. Thus, the prospects for increasing maximum highway capacity through information systems are minimal. The benefits from information about non-recurrent congestion would be more noteworthy, but would depend on the context. Medium-sized metropolitan areas with moderate congestion and relatively good highway infrastructure are most likely to experience pressure for decentralization through driver information systems.

Transportation Demand and Land Use

ITS technologies for electronic payment, location, and identification enable two categories of pricing policies intended to allocate the costs of transportation more efficiently.[45] One option is to charge vehicles directly for the amount of public and private infrastructure they use, and possibly for the environmental and other costs that transportation imposes on society at large, if the latter can be quantified. The other option is to charge users for the congestion costs they impose on one another, with the goal of directly influencing individual behavior and choices to allocate more efficiently the scarce resource of road and highway access at peak periods. Reducing travel delays through congestion pricing would lower the overall costs of those who value their time highly, and raise total costs for others.

Transportation Infrastructure Pricing

Currently, the costs of public infrastructure for transportation are not efficiently priced.[46] That is, the payment mechanism, such as gasoline tax, does not necessarily correspond to the value of the "infrastructure consumed," which depends on vehicle weight, distance traveled, type of road, and other factors (see chapter 8). There are also costs that transportation users do not directly pay for, but often do account for in their travel decisions. The prime example is parking.

---

[43] Geurt Hupkes, "The Law of Constant Travel Time and Trip Rates," *Futures*, vol. 14, 1992, pp. 38-46; and P. Gordon, H. Richardson, and M. Jun, "The Commuting Paradox: Evidence From the Top Twenty," *Journal of the American Planning Association*, vol. 57, 1991, pp. 416-420.

[44] Non-recurring congestion stems from random, unpredictable incidents such as traffic accidents, stalled vehicles, or weather conditions that create temporary bottlenecks (capacity shortfalls).

[45] ITS technologies may have a dramatic effect on the quality and efficiency of both fixed route mass transit and paratransit that could lead to increased ridership. However, public transportation in most metropolitan areas, indeed in all but some of the largest historic urban centers, accounts for only a small fraction of urban travel, even commuter travel. While increased transit ridership should reduce the rate of congestion growth, there is little expectation that ITS technologies alone could make transit so attractive as to *reduce* automobile congestion in metropolitan areas. Alternate transportation options, such as high-quality transit, would be an important element of any congestion pricing policy.

[46] U.S. Congress, Office of Technology Assessment, *Saving Energy in U.S. Transportation*, OTA-ETI-589 (Washington, DC: U.S. Government Printing Office, July 1994), p. 12.

In a previous study, OTA concluded that "these costs could be fully recovered and/or more fairly allocated among users. If subsidies were withdrawn, externalities 'internalized,' and hidden costs brought out into the open and directly charged to motor vehicle users, the perceived price of motor vehicle use would increase substantially and people would drive less."[47] Consequently, infrastructure cost pricing would encourage more concentrated development and in-fill, favoring locations with established transit systems and road networks. Expansion at metropolitan peripheries would be more market driven, as is the case for the few private toll roads currently planned or under construction in the United States.[48]

Congestion Pricing

The impacts of a congestion pricing scheme on land use depend on the geographic patterns within a metropolitan area, the current patterns of travel and congestion, and the nature of the scheme. In places with very dense urban cores, congestion pricing would probably reduce travel time to the center. This would help sustain development in such central business districts, but it would also encourage dispersion of wealthier workers, business suppliers, and anyone willing to pay for the privilege of traveling on otherwise congested roads. In the short run, those whose time is less valuable (e.g., the poor) would shift their travel time or mode in response to the extra costs. Over longer periods, congestion pricing would lead to more concentrated residential development for those with lower incomes, while higher-income residents would be dispersed. Moreover, congestion pricing could lead to a movement of activities, such as retail, away from congested areas because the cost of doing business may be too high.

In conclusion, it is important to remember the complexity of the role of transportation within metropolitan areas and the tremendous amount of heterogeneity that exists in metro areas. No one knows what the long-term effects of congestion pricing on urban form would be. And the reality is that it is extremely unpopular politically.

TELECOMMUNICATIONS INFRASTRUCTURE AND ECONOMIC DEVELOPMENT

As more economic functions are conducted electronically, being able to transmit and receive large amounts of information rapidly will be critical in the competition for jobs and industry.[49] Just as the spatial distribution of the electrical power infrastructure helped shape urban development, so too does the spatial distribution of the telecommunications infrastructure shape development today. Moreover, like electrical power networks, advanced telecom infrastructure is rapidly diffusing across the country, minimizing competitive differences based on infrastructure alone. This section examines the spatial distribution of the telecom infrastructure and analyzes claims that an advanced infrastructure is critical for local growth.

■ Defining Telecom Infrastructure

The physical component of the telecom infrastructure is particularly relevant to this assessment, since much of the information economy is oriented toward the transmission of information, particularly the technology that delivers informa-

[47] Ibid., p. 109

[48] For example, the Dulles Greenway, a privately financed tollroad in Northern Virginia, is scheduled to open in fall 1995.

[49] See Mitchell L. Moss, "Telecommunications: Shaping the Future," in *America's New Market Geography,* George Sternlieb and James W. Hughes (Eds.), 1987, pp. 255-275; and Mitchell L. Moss, "Telecommunications, World Cities, and Urban Policy," *Urban Policy,* vol. 24, No. 6, December 1987, pp. 534-546. See also Mark E. Hepworth, *Geography of the Information Economy* (New York, NY: The Guilford Press, 1990); and Aharon Kellerman, *Telecommunications and Geography* (New York, NY: Halsted Press, 1993). OTA completed an earlier work on telecommunications and rural America in U.S. Congress, Office of Technology Assessment, *Rural America at the Crossroads: Networking for the Future*, OTA-TCT-471 (Washington, DC: U.S. Government Printing Office, 1991).

tion in the so-called last mile to the customer. The provider may string cables (e.g., fiberoptic, coaxial, or twisted wire pair) to the customer, it may transmit a focused beam (e.g., ground-to-ground microwave, or earth-to-satellite microwave), or it may transmit its information openly or in code (e.g., cellular telephone, broadcast radio and television, satellite television). Each technology has advantages and disadvantages. The marginal cost per user of satellite transmission is low and it may be optimal to reach remote or mobile users, for example, but its initial cost is high and some transmissions can be subject to atmospheric disturbances. Cable transmission may be less expensive initially, but the marginal cost per user is higher and the infrastructure can be damaged in floods or earthquakes.

Switching equipment at central offices is equally important. The central offices transfer traffic among residents and businesses, and through the providers' large-capacity trunk lines to other central offices. Special-purpose computer switches route transmissions from one user to another, whether that transmission is a telephone call, an electronic mail message, or a video channel. Switching capability adds capacity and flexibility, but also complexity and cost.[50] Table 7-1 displays some examples of transmission and switching technologies. Point-to-point communication, for example, has traditionally required central switching and cable transmission in the last mile. The cabled arrangement was well suited for densely populated areas, while radio telephones achieved the same purpose in remote rural areas. Cellular telephones use switching and coded radio broadcast to localized cells, offering mobility in densely populated areas.[51] The low-earth-orbit satellite systems now in development will use switching and satellite broadcast, expanding mobility to remote areas of the world.

TABLE 7-1: Examples of Switching and Wiring Combinations in the Last Mile to the User

	Switched	Unstitched
Wireline	Traditional telephone, Electronic mail	Cable television
Wireless	Cellular telephone radio telephone, paging	Broadcast radio/TV, Satellite TV

The telecommunications infrastructure has advanced well beyond the traditional set of telephone wires and over-the-air broadcast. The different transmission and switching technologies allow each user to tailor the technology to the application. A user may prefer satellite transmission for distance learning, for example, and wireline systems for videoconferencing. In many cases, a user may employ two complementary technologies to insure against downtime. Traditional voice transmissions—which also include facsimile and data transmissions using modems—are now completely digital or converted to digital form before being switched.

Also important in the information infrastructure is a confusing and overlapping variety of service providers and equipment manufacturers. Many of these providers resell to other providers, sometimes through several intermediaries. There are also numerous types of providers who own or lease the physical infrastructure and provide enhanced services, including value-added services, Internet features, and dial-up network services.

[50] The importance of switching is demonstrated by comparing the costs of two systems. The coaxial cable that carries cable television delivers many more orders of magnitude bandwidth (capacity) to the user (about 500 MHz) than do the twisted wires used to deliver basic telephone service (as low as 4 kHz for analog voice service). This tremendous capacity is necessary in order to deliver many channels of video programming. However, the basic cost of delivery of traditional (wired) telephone service and cable television service are comparable. The difference is that telephone service requires dynamic switching and billing services not used in basic cable programming.

[51] See U.S. Congress, Office of Technology Assessment, *Wireless Technologies and the National Information Infrastructure, OTA-ITC-622* (Washington, DC: U.S. Government Printing Office, 1995).

Measuring Urban Telecom Infrastructures

Little work has been done to characterize and compare telecommunications infrastructure across the United States at the metropolitan area level.[52] The publicly available information is usually only compiled at the regional or state levels, and private-sector information is often scanty or hard to get.[53] Moreover, it is difficult to define and measure the quality of the infrastructure, especially as the technologies become more arcane and speculative. For example, the widespread availability of Integrated Services Digital Network (ISDN)[54] services in a particular region may be viewed as progressive by some and as irrelevant by others. Several parameters, however, may be (or have been) used to measure infrastructures.

The most immediate measure of an infrastructure is the tangible investment in transmission media, including the number of miles per capita of fiberoptic cable that connects central office switches or customers,[55] the miles of microwave bypass routes, and the number of cellular telephone channels per capita. The installation of advanced equipment internal to the providers' networks is also important, such as the percentage of switches that use electronic, particularly digital, technology,[56] the percentage of central office switches with Signaling System 7 (SS7) software, and the percentage penetration of advanced intelligent network (AIN) features.[57]

Measuring only the advanced components of the infrastructure obscures, however, the value of the older infrastructure such as traditional twisted-wire cables or analog switches. Much of the established infrastructure is quite robust for modern applications, or can be used in innovative ways to squeeze more performance out of the sunk investment. Fiberoptic cable, for example, is the technology of choice for carrying traffic between telephone company central offices, but a custom installation may be expensive overkill in an application where its full capacity is not used. Also, measuring the number of households using the copper wire or radiotelephone infrastructure is a measure of universal access.[58]

The installed investment internal to the users' local networks is also important, since many sophisticated users buy bulk services and do much of the switching themselves, becoming providers

[52] A recent Department of Commerce report notes that current indicators from the Federal Communications Commission do not show the geographical distribution of basic telephone service, nor do they go beyond basic telephone service to include, for example, personal computers and modems. U.S. Department of Commerce, National Telecommunications and Information Administration, "Falling Through the Net: A Survey of the 'Have Nots' in Rural and Urban America," July 1995

[53] Firms exist that sell information about installed fiberoptic cables, microwave paths, and wireless licenses in various metros. This information is gathered from publicly available information and news releases, and may overlook many private installations, or information about features and applications associated with the installations.

[54] ISDN is a feature that allows more flexibility and faster data transmission than allowed by conventional analog telephone and modem equipment. ISDN can use existing copper wire but requires digital equipment at the user's and provider's ends.

[55] Several U.S. cities now claim to have the most miles of installed fiberoptic cable or cable per capita. These claims are difficult to verify and subject to change, and demonstrate the importance of using a variety of parameters to measure the physical infrastructure.

[56] Observers agree that the replacement of electromechanical switches with electronic switches is particularly important for modern services. Electronic switches can be based on analog or digital technology. Of these, digital switches are programmable and provide the most modern features.

[57] The advanced intelligent network takes the programmability of digital switching one step further by allowing the provider to program new features for the entire network from central points, avoiding costly and time-consuming installation of features at each switch.

[58] See U.S. Department of Commerce, National Telecommunications and Information Administration, *The NTIA Infrastructure Report: Telecommunications in the Age of Information* (Washington, DC: National Technical Information Service, 1991). See also *Wireless Technologies and the National Information Infrastructure,* op. cit., footnote 51.

and sometimes reselling that capacity elsewhere.[59] Measures of the users' installed infrastructure might include the number or percentage penetration of digital private branch exchange (PBX) equipment[60] and the total subscription to advanced telecom features.

Industry also makes investment and location decisions based on factors relating to the *market* for telecom services that go beyond the nominal availability of physical infrastructure. For example, a diverse selection of providers and services may indicate a more sophisticated or innovative market. Diversity may be crudely measured by the number of locally available providers in various markets such as long-distance and local telephony, cable television, cellular, value-added services, new personal communication services (PCS), and satellite uplink services. Other market-related factors that figure into investment decisions include: the price structure of the services, and the quality of service by the providers (e.g., the time delay for the installation of new features by a particular provider).

General State of Urban Telecom Infrastructures

Lacking data, in its interviews OTA found a consensus that the level of quality of telecom infrastructures in metropolitan areas across the United States is not only relatively high, but also relatively uniform. While variations in the physical infrastructure and the markets clearly exist across the country—and a more detailed analysis could highlight the variations—these differences appear to be relatively small compared to differences between, for example, some rural communities.

For example, most (if not all) U.S. metropolitan areas have local access to the Internet and online computer services such as Compuserve, America Online, and Prodigy. Competitive access providers (CAPs)[61] such as Metropolitan Fiber Systems, Teleport Communications Group, and MCI Metro are expanding into an increasing number of metros and competing with the traditional local providers. For example, while the CAPs initially served the most crowded markets such as New York and Chicago, they have expanded to smaller metros such as Omaha, Nebraska, and Wilmington, Delaware. Telephone and cable companies are competing to serve the video entertainment market wherever the new services are allowed and the residents are willing to pay.

A nominal review of news releases and maps detailing the location of fiberoptic cable and advanced services across the United States indicates a relatively uniform distribution from coast to coast. All the major telephone companies have their central offices substantially or completely interconnected by fiberoptic cable. But, microwave or satellite transmissions are indistinguishable from fiberoptic transmission for many common applications and the lack of fiberoptic cable in an areas does not necessarily mean a lack of quality infrastructure.[62] Also, the long-distance

[59] Some argue that such private investment should not be included in the infrastructure since its private nature precludes the leveraging aspects of public infrastructures such as roads, canals, or electrical power systems. The difficulty lies in the complex ownership of the telecom infrastructure, which is provided by an array of mostly private corporations, of which some have common carrier provisions and some do not. The tradeoff between managing telecom operations internally or contracting-out the services from providers varies by company and with time as the technology changes. Such internalization of the infrastructure, however, is more difficult for smaller, less-sophisticated businesses.

[60] PBX equipment allows a customer to lease high-capacity circuits and perform some or all of its switching on premises.

[61] Competitive access providers (CAPs) install all-fiber networks to connect customers to each other or to long-distance providers, bypassing the traditional local telephone company. A CAP may switch circuits for the customer, or it may simply interconnect locations and allow the customer to switch circuits in-house. CAPs were established in the 1980s as fiberoptic cable transmission became competitive with microwave transmission.

[62] Microwave and satellite transmissions are particularly appropriate for mobile or other flexible applications, while fiberoptic transmission is particularly appropriate for high-quality applications (such as commercial television feeds). Satellite transmission is also appropriate for broadcasting.

companies must pass voice, video, and data messages back and forth with the local telephone and other providers. In some cases, these inter-company connections pose technical problems since different companies use different equipment and provide different services. These differences limit the accessibility of some services, despite the presence of extensive fiberoptic cabling.

Furthermore, not all organizations need advanced telecom services and of those that do, some of the largest customers may be able to receive whatever they wish regardless of the local infrastructure. Large users may make special arrangements with the local providers. Companies may also construct private telecom networks by leasing channels wholesale from satellite or other providers. Internalization of much of their telecom operations makes large users less dependent on the local features of the public-switched network. The global nature of multinational corporations tends to make differences in the local public infrastructure less relevant. Thus, snapshots of the public infrastructure do not reveal much about its flexibility.

The difference between the collective urban and rural telecom infrastructures can be large, however, depending on what is measured and when. For example, in a 1993 survey only 55 percent of central offices in rural areas provided equal access[63] to competing long-distance providers—an indication of the level of diversity of carriers—compared to 97 percent of urban central offices.[64] This parameter ranged from zero (in rural Maryland, Wyoming, and Utah) to 100 percent in rural Connecticut. In that survey, digital switching was relatively widespread, however, with an average 91 percent penetration in rural central offices (the lowest being rural Arizona with 56 percent). The average interconnection of central offices with fiberoptic cable was 42 percent (with zero percent in rural Massachusetts, Maryland, and Vermont), and the penetration of SS7 software in rural central office switches averaged only 15 percent. However, these penetration rates are increasing as telephone companies modernize their networks.

Telecom Infrastructure and Local Economic Growth

Correlations Between Investment and Growth

Because of the perceived importance of the telecom infrastructure to local economic growth, there has been considerable interest in statistically demonstrating this relationship. It is often not possible, however, to find a statistical correlation between local investment in telecom infrastructure and local economic development. That is, the relationship may exist, but it cannot necessarily be mathematically demonstrated with the information provided.[65] Statistical correlations are difficult to demonstrate because economic development and investment are both affected by many interrelated factors—the relationship itself is not well-defined, even in principle. Also, effects may be obscured by other factors in the regional economy, by various delays before a cause results in an effect, and by incomplete measures of the use or quality of the infrastructure or of economic development.

[63] In order to have access to different long-distance providers, the providers' central offices must provide "equal access" for its users. Equal access allows a caller to dial a five-digit code to access a particular long-distance provider, or to request that the local provider make a particular long-distance provider their primary provider. The penetration of equal access in central offices is therefore an indicator of the availability of alternatives to the traditional carrier.

[64] The differences in these figures have decreased since this data was collected. National Exchange Carrier Association, "Building the Telecommunications Infrastructure in Rural America," 1993.

[65] Such an analysis might begin by stating a hypothesis, and then testing the hypothesis by applying statistical methods to the available data. The hypothesis may be said to be valid if the analysis indicates it is valid to a chosen degree of confidence. Not demonstrating that correlation, however, is not the same as statistically demonstrating the negation of the hypothesis, which must pass the same test. Therefore, demonstrating the negation of the hypothesis may be equally difficult.

Investment in infrastructure and economic growth may each be driven, in part, by population density, complicating the analysis. One study of metros in Indiana found no statistically significant difference between large and small metros in the overall use of telecommunications and information technologies, possibly indicating that the telecom infrastructure and metro population are *not* correlated.[66] Likewise, a study of rural counties in Washington and Oregon demonstrated that a correlation exists between telecom infrastructure (particularly single-party service and electronic switches) and economic performance in a manner *not* explained by population density alone.[67] However, the relationship of large to small cities may be complex. Large metropolitan areas, for example, may attract more information-intensive industries and, consequently, build more infrastructure (indicating a correlation), but the technology itself also serves to spread economic activity over a wider area (reducing the correlation).

One study of the variations among the different regions served by the seven "Baby Bells" across the United States did show that the regions were statistically different from each other in terms of the diffusion of new technologies.[68] The study evaluated several parameters including the growth rates of kilometers per capita of fiberoptic cable, basic and primary ISDN channels per capita, digital business lines per capita, and revenue and employment growth in various information-related industrial sectors. The study suggests that the greatest number of positive correlations of new technology diffusion and sectoral economic growth are in the NYNEX and Bell Atlantic regions, possibly due to the concentration and growth of financial and information-intensive activities in the northeastern U.S. Several factors complicate such correlations at the regional level, however, including the averaging of growth rates over entire regions.

These correlations do not prove that technology investment necessarily causes economic development, or vice versa, but simply that investment and development are found together in certain areas. Other studies have tested for causality in either or both directions: economic development causing investment in telecom infrastructure, and vice versa, with mixed results.[69] Also, while the uniformity of the telecom infrastructure across metropolitan areas in the U.S. makes correlations difficult at the local and regional levels, correlations have been clearly established between access to basic telephone service and economic growth on the national scale, particularly in developing countries.[70]

Despite the difficulty in demonstrating statistical correlations between telecom investment and

---

[66] Patrick Alles, Adrian Esparza, and Susan Lucas, "Telecommunications and the Large City-Small City Divide: Evidence from Indiana Cities," *The Professional Geographer,* vol. 46, No. 3, 1994, pp. 307-315.

[67] That is, increasing population density did not seem to cause independent improvements in the telecom infrastructure and in economic activity, with no direct correlation between the latter two. See E. Parker and H. Hudson, *Electronic Byways: State Policies for Rural Development through Telecommunications* (Boulder, CO: Westview Press, 1992).

[68] Mark Welsh, Department of Geography, Florida State University, "Economic Restructuring and Divestiture: An Examination of Analog and Digital Capital Development for the Regional Bell Operating Companies," Mar. 21, 1995.

[69] One study of two counties in Pennsylvania measured correlations between economic activity and two types of telecom infrastructure investment (central office equipment and outside plant—cable and wire) by sampling data over two, three, and four years to observe a cause-effect relationship. Francis J. Cronin, Edwin B. Parker, Elisabeth K. Colleran, and Mark A. Gold, "Telecommunications Infrastructure Investment and Economic Development," *Telecommunications Policy,* August 1993, pp. 415-430. Another study taken from 45 nations over 13 years presented evidence to demonstrate both the effects of economic growth leading to telecom investment and the converse. Andrew Hardy, "The Role of the Telephone in Economic Development," *Telecommunications Policy,* vol. 5, No. 4, December 1980, pp. 278-286.

[70] Robert J. Saunders, Jeremy J. Warford, and Bjorn Wellenius, *Telecommunications and Economic Development, 2nd Edition* (Baltimore, MD: Johns Hopkins University Press, 1994).

economic growth, observers nevertheless believe that the relationship exists, but the improvement of a local telecom infrastructure to a minimum level (particularly the installation of digital switching) may be necessary for economic development but not sufficient. That is, the widespread notion that "if you build it, they will come" is not necessarily true.

First, factors determining local economic growth are complex and not dependent only on investment in telecom infrastructure. Second, there is an effect of diminishing returns; investment in basic infrastructure in less-developed communities or regions will naturally show the greatest returns, while additional investment in relatively advanced areas may produce only marginal returns.[71] Third, as more localities reach the threshold of investment to spur economic development, that threshold provides less of an advantage for each. Fourth, minimum thresholds of telecom investment—if they exist—may be difficult to discern and may change over time. Statistical correlations demonstrated today may not apply tomorrow. Purchasers of advanced services are often required to commit to a particular technology that may become quickly obsolete or overinvested, causing uncertainty.

Finally, businesses are often mobile and free to relocate when conditions elsewhere become more favorable. One expert told OTA that telecom-related back office jobs are "easy come, easy go," unlike heavy industry, medical centers, deep-water ports, or natural tourist attractions that are more difficult or impossible to move. Thus, municipalities who see telecom as a tool for economic development must gain a large enough competitive advantage to attract some key businesses, and then transform the economic growth into a more permanent or diversified economy.

Importance of the Business Climate

As the telecom infrastructure becomes more evenly distributed, the behavior of providers, users, and regulators becomes more important than the differences among urban infrastructures—it is not "what is there" but also "how it is used" that is important. Some regions and regional providers are more responsive to business needs than others, and businesses may make location decisions accordingly. In particular, if local public policy or the private sector does not recognize the importance of stimulating user demand for new and advanced services, supply-side approaches alone are likely doomed to fail.[72] That is, by generating and augmenting demand for services rather than generating infrastructure per se, "the deployment pattern for the infrastructure will be rationalized and its utility will be maximized." [73]

These three parties—the users, providers, and regulators—are interdependent. The providers buy and sell each others' services, and many large businesses and institutions exchange extra telecom capacity with providers. The corporate decisions of large telecom providers reflect not only specific market demands, but also the corporate vision of its role in the evolving industry. For example, anticipating more competition, the large telephone companies have been reorganizing (from functional lines to lines of business) in part to be more responsive to customer needs.[74] Regulatory pressure, in turn, may be applied to balance the short-term interests of providers with the long-term interests of the region. For example, regula-

---

71 Andrew Hardy, op. cit., footnote 69.

72 David Gibbs, "Telematics and Urban Development Policies," *Telecommunications Policy*, May/June 1993, pp. 250-256.

73 Gail Garfield Schwartz, "Telecommunications and Economic Development Policy," *Economic Development Quarterly*, vol 4., No. 2, May 1990, pp. 88.

74 Other official and unofficial reasons include realignment toward new regulatory regimes, an appearance of responsivity to the financial markets, and as a means to relocate workers and cut costs.

tors may encourage the providers to interconnect their networks and unbundle their services in order to provide more choices for users. Finally, innovative corporate and institutional "early adopters" create demand for new and quality services. Also, special events such as Olympic Games or a political convention force the infrastructure to a higher priority.

Telecom Investment and Distressed Neighborhoods

Investment in telecom infrastructure is also relevant to economic growth at the neighborhood level, particularly as information technologies disperse organizations and workers throughout metropolitan areas. Some claim that telecom providers neglect low-income neighborhoods as they upgrade the infrastructure, leading to lower levels of economic growth in those areas.[75] They argue that regulators should pressure telephone companies to provide the same services to wealthy and lower-income neighborhoods alike, in exchange for the continuing use of public property as right-of-way, or regulatory relief.

.From the provider's perspective, some difference in investment among neighborhoods and regions is inevitable as providers first invest in the areas with greater demand or most capable of returning profits, and invest in lower-income areas as the technologies become more mature and less risky. Since advanced technologies such as ISDN and other switched digital services are not standard and require new investment, providers have held off on installation of such services to residential and low-income areas. Providers must constantly make business decisions and take risks based on the anticipated revenue potential of new services and future competition, the current and estimated operating and construction costs, and public relations.

Moreover, much of the gap in investment in distressed neighborhoods is irrelevant to growth because basic phone service is usually available and can be installed relatively quickly.[76] Also, a variety of technical solutions can often accommodate users who lack advanced services. For example, high-speed modems can transfer data over traditional telephone lines at speeds acceptable (and more affordable) for most business users, if advanced services are not available. Likewise, residents of distressed neighborhoods in metropolitan areas are not excluded from local Internet access, unlike many rural users who must access the Internet through long-distance calls.

Also, the income and expertise of residents of disadvantaged neighborhoods is often the limiting factor rather than availability of telecom service.[77,78] Contrary to the perception that personal computing is widely accessible, innovative applications and computer networking require training and resources that are not necessarily available in or relevant to the needs of distressed communi-

[75] A 1995 Department of Commerce study found that the lowest telephone penetration levels were measured for households with incomes under $10,000 annually, households under 25 years old, and households with less than a high school education. Central city households generally fared worse in all of these comparisons with respect to rural and urban households; however, comparisons across income, age, and educational levels each generally demonstrate larger differences in telephone penetration than location. See U.S. Department of Commerce, "Falling Through the Net," op. cit., footnote 52.

[76] Wiring new cables in older buildings can sometimes be prohibitively expensive, however.

[77] A Rutgers University study sponsored by Bell Atlantic suggests that low-income urban areas consume a disproportionately high amount of premium features from the telephone company, but may not be able to afford them; and that inner-city residents may lose phone service because of the unlimited and unpredictable cost of long-distance service and other usage-related calls, not because of the access cost of local service itself. Milton Mueller and Jorge Reina Schement, Rutgers University, "Universal Service from the Bottom Up: A Profile of Telecommunications Access in Camden, New Jersey," report prepared for Bell Atlantic, January 1995.

[78] The average penetration of telephones in 1990 was estimated at 93.3 percent—about 6 million households are *not* connected at any given time—but another large and unknown number lose and regain service throughout the year. U.S. Department of Commerce, *The NTIA Infrastructure Report*, op. cit., footnote 58.

ties. In a similar fashion, school classrooms commonly do not have installed telephones, ready access to copiers, computers with user-friendly software, and Internet access, even though telephone service, copiers, software and Internet services are nominally available.

The main obstacles for residents and businesses in distressed neighborhoods are the capital equipment costs and technical expertise to establish and maintain telecom applications, and to some extent the ongoing expenses of standard telephone service, rather than the access to basic and advanced services per se. This does not mean that investment in the physical infrastructure is irrelevant, but other factors should be recognized and addressed as well, including education in computer skills, business assistance, and increasing neighborhood security.

Public Policy and Urban Telecom Infrastructure

Public policy is vulnerable to proposals that are technological fixes to complex problems but that cannot adapt to technological and regulatory change. Many proponents of early cable television, in particular, hoped for a decentralized, interactive medium that would solve many urban problems. Instead it became a commercial success only by imitating broadcast television. The early claims for cable television, however, were not unlike claims made today for the Internet or for a fiberoptic infrastructure.[79,80]

There are many examples of state and federal governments working to improve telecom infrastructure in order to promote economic development—successfully or not. For example, the state of Iowa contracted to lay fiberoptic cables in the ground to create its own high-capacity network for public services such as distance education and public administration. The state of North Carolina worked through universities, industry, and telecom providers to expand its "information superhighway" for advanced applications. The Canadian province of New Brunswick supported an effort to install fiberoptic cable and modern equipment to attract back office and other activities that operate remotely via telecommunications. State public service commissions and related bodies are also reconsidering telecom regulation to promote investment in their regions, balancing the interests of consumers and providers. The Clinton Administration has addressed telecom and other information technology applications through its National Information Infrastructure (NII) program, and other countries have been promoting similar efforts.

[79] The concepts of "wired cities" and "electronic highways" based on the advent of cable television date back to this period. What has changed is that the technologies are different, the market forces are recognized to have a greater role, and the field of stakeholders has widened. The visions, however, are not necessarily less utopian. For example, in the 1970s it was hoped that cable television would provide more independent and diverse sources of content—promising over 100 channels, local home shopping, high-bandwidth information retrieval, interactivity, and more political participation. Instead, cable television became mainly a medium for commercial entertainment. See William H. Dutton, Jay G. Blumler, and Kenneth L. Kraemer, *Wired Cities: Shaping the Future of Communications* (Boston, MA: G.K. Hall & Co., 1986); and "Ralph Lee Smith, "The Wired Nation," *The Nation*, May 18, 1970, pp. 582-606.

[80] An early predecessor to today's NII initiative was an interagency study on urban communications published in 1971. The study suggested pilot applications including telemedicine, distance education, intelligent transportation systems, electronic delivery of public services, video surveillance for public safety, and so forth. These applications are still relevant today, even though the specific technologies used to implement them have changed over the 25 years since the report. The impact of telecom on economic activity in general, however, was not directly discussed. National Academy of Engineering, "Communications Technology for Urban Improvement," report to the Department of Housing and Urban Development (Washington, DC: National Academy of Engineering, June 1971. See Peter C. Goldmark, "Communication and the Community," *Scientific American*, 1972, pp. 143-150

Local governments have had a less pivotal role as enablers of local economic growth through investment in telecommunications.[81] As with other public and private organizations and the telecom industry itself, telecom was traditionally viewed as a relatively static infrastructure. The local government role was generally limited to internal procurements; and negotiation with cable television providers over rights-of-way, franchise fees, zoning regulations, institutional networks,[82] and channels set aside for public, education, or government (PEG) use.[83]

During the 1980s, some municipalities looked to teleports as a parallel to airports and maritime ports to spur economic and real estate development. A teleport is essentially a user or provider that consolidates communications to and from satellites. Unlike airports and maritime ports, however, proximity to a teleport is usually irrelevant if the local terrestrial telecom infrastructure can move information from the customer to the teleport and back.[84] Also, teleport providers resemble other telecom providers and services; thus, U.S. teleport providers have not greatly involved the public sector except to meet zoning or other land use restrictions. Finally, terrestrial fiberoptic cable eventually became competitive with satellite communication for many business applications, changing the strategic importance of teleports.

For example, New York City supported the Staten Island teleport to retain back office jobs in the New York metro. The teleport developed real estate in conjunction with the installation of satellite earth stations for data transmission, connected to Manhattan by fiberoptic cable and microwave links.[85] The cooperative effort eventually split off its fiberoptic transmission functions into what is today Teleport Communications Group (TCG—a competitive access provider), and continued the "dish farm" operations as a real estate development. One observer claimed, however, that the Staten Island teleport was appropriate for its time, and survived, but would not succeed if it were created today, largely due to competition from providers of fiberoptic transmission.

The Washington International Teleport, in contrast, did not play a role in real estate development. It evolved at first as a local microwave interconnect company and soon began to operate facilities to serve broadcasters and video programmers. It continues to serve as an intermediary or gateway to move mostly video information from earth to satellite and back. Because of its mid-Atlantic coast location, its gateway function now serves countries on the "Atlantic Rim."

---

[81] "Despite the central role of cities as 'hubs' of the burgeoning information economy, the nature, location and quality of urban telecommunications infrastructure was shaped entirely by telephone companies working within regulatory frameworks. This was in sharp contrast to the central role often played by cities in the development of urban transport, water and public health infrastructure." Stephen D.N. Graham, "The Role of Cities in Telecommunications Development," *Telecommunications Policy*, April 1992, pp. 187-193.

[82] Institutional networks are arrangements with cable television providers for free access to private video and data channels for internal use in exchange for franchise privileges and rights-of-way.

[83] Some municipalities have custom-made telecom plans to their particular needs. For example, Boston minimized the repeated repair of its congested city streets by planning and negotiating for extra capacity when first installing cabling. Los Angeles has a strong interest in accommodating telecommuting efforts to reduce congestion and pollution from commuter traffic. See Jurgen Schmandt, Frederick Williams, Robert H. Wilson, and Sharon Strover, *The New Urban Infrastructure: Cities and Telecommunications* (New York, NY: Praeger, 1990).

[84] European and Asian teleports are often modeled around real estate development, and integrate the teleport more completely with public sector planning and development. This integration is in part due to the need to bring the entire local infrastructure up to international quality. In the United States, in contrast, a stronger separation between public and private sector involvement is associated with a more competitive local infrastructure, and consequent difficulty for some teleports in the new industry to show a profit. Karen J.P. Howes, "Teleports—Satellites, Fiber and Compression," *Via Satellite*, August 1993, pp. 26-34.

[85] Gayle M. Horwitz, "New York's Port of the Future: The Staten Island Teleport," *The Journal of Urban Technology*, Fall 1992, pp. 69-86.

Today, many U.S. municipalities are forming telecom plans that at least recognize the significance of telecom to local development,[86] and some are particularly innovative in their attempts to craft a local infrastructure that meets their interests. For example, the town of Blacksburg, Virginia, in conjunction with Bell Atlantic and Virginia Polytechnic Institute and State University, created the Blacksburg Electronic Village to extend the university network to the residents of the town and to the municipal government. Many cities have arranged with cable television providers to install high-capacity institutional networks in partial exchange for rights of way within the city boundaries.[87] Many cities have established planning committees or policies to promote the local telecommunications infrastructure.[88] Seattle, Washington, has debated a public role in financing and installing its local telecom infrastructure, as has New Orleans. Omaha is well-known as a capital of telemarketing and data processing, not because of a planned strategy but in part because of labor expertise that spilled over from the Strategic Air Command facilities, and also because of state telecom policy reform.[89]

Most of the over 19,000 municipalities in the United States do not have explicit policies, however. A survey conducted by the International City/County Management Association of over 1,000 U.S. local governments found that only 5 percent had written telecommunications plans. On the other hand, about 72 percent felt that the "information superhighway" will have a positive effect on economic development in their community, while only about 2 percent felt it would have a negative effect.[90]

There are no federal telecom policies that are directed explicitly toward urban areas. However, Congress has recently considered legislation that could pre-empt or limit local government control over negotiating rights-of-way and franchises with telecom providers. Local officials have expressed strong opposition to any further limitation over local control, on the grounds that local governments should have maximum flexibility to negotiate terms that best fit their needs.[91] Local governments argue that the use of public rights-of-way should merit compensation, as with the use of any property, particularly since the use of a right-of-way sometimes requires public expense to repair cumulative damage to streets. They have also argued that the local community should be able to require access to public, educational, and government (PEG) programming that providers may not otherwise deliver. Thus, some argue that local governments should be able to charge franchise fees to direct-to-home satellite providers and telephone companies that provide television services via telephone lines, even if they are not currently using or paying for public rights-of-way. Franchise fees are important to local governments both

[86] See Robert H. Wilson and Paul E. Teske, "Telecommunications and Economic Development: The State and Local Role," *Economic Development Quarterly*, vol. 4, No. 2, May 1990, pp. 158-174.

[87] For example, see City of New York, Department of Telecommunications and Energy, "Institutional Network Master Plan: Report to the Mayor's Telecommunications Productivity and Planning Committee," October 1993.

[88] For example, see San Diego State University, International Center for Communications, "San Diego: City of the Future—the Role of Telecommunications," March 1994.

[89] "Omaha's telemarketing industry developed there because its geographic location in the center of the country gave it a cost advantage in the days of banded, WATS service." It also had low labor costs and residents with mainstream dialects. "As it became a center of telemarketing, the infrastructure in and around the city became more capacious and sophisticated." Milton Mueller, listserv communication, Dec. 16, 1994.

[90] Less than 2 percent of communities with populations under 10,000 had such plans. Lisa Huffman and Woody Talcove, International City/County Management Association, "Local Governments Not Ready for the Information Superhighway," *Government Technology*, vol. 8, No. 2, February 1995, p.1.

[91] See National League of Cities, "1994 National Municipal Policy: Transportation and Communications," Washington DC, December 1993.

as a source of revenue and as a means of local control over their infrastructure.

Others have argued that while some communities have negotiated very favorable agreements, others have not, and the federal government is in a better position to mandate a standard that all providers must meet. Providers claim that the establishment of a single nationwide standard may minimize costs for providers that serve several communities, as well as the collective costs for local governments. Telephone companies argue that their delivery of "video dial-tone" is different from cable television provision, and should be exempt from the PEG requirements.

Federal policy could also pre-empt local control over antennas for wireless communications.[92] Local governments prefer to maintain control over zoning and other arrangements that specify how and where towers for cellular telephone and other communications can be constructed. The industry contends that making these arrangements with each community raises their costs and delays implementation of the wireless infrastructure.

Several programs are not part of an urban policy but are nevertheless relevant to urban municipalities (as well as rural communities) that are seeking to promote local infrastructure. Through its Telecommunications and Information Infrastructure Assistance Program (TIIAP), the National Telecommunications and Information Administration (NTIA) in the Department of Commerce provides matching funds for state and local applications that enhance the local information infrastructure.[93] These projects do not necessarily improve the local physical infrastructure per se, but rather improve access to government services and demonstrate innovative applications in, for example, distance education, health care, and digital libraries.[94] NTIA also provides funds through its Public Telecommunications Facilities Program (PTFP) for public radio and television broadcasting facilities, and the Department of Education provides funds to school districts for projects in distance education.

[92] See *Wireless Technologies and the National Information Infrastructure*, op. cit., footnote 51.

[93] The 1994 appropriation for TIIAP was $25 million, increasing to $62 million for 1995. The current Congress reduced that appropriation to $45 million in the rescission package.

[94] OTA examined the use of information technology to improve federal government services in U.S. Congress, Office of Technology Assessment, *Making Government Work: Electronic Delivery of Federal Services,* OTA-TCT-578 (Washington DC: U.S. Government Printing Office, September 1993); and William H. Dutton, University of Southern California, "Electronic Service Delivery and the Inner City: Community Workshop Summary," contractor paper prepared for the Office of Technology Assessment, National Technical Information Service, December 1992. See also Organization for Economic Cooperation and Development, *Information Systems for Urban Management*, 1993. For information on community free-nets see Richard Civille, Miles Fidelman, and John Altobello, Center for Civic Networking, "A National Strategy for Civic Networks," Washington D.C.