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AN EXAMINATION OF TELEWORK AND THE PHYSICAL IMPACTS ON COMMUNITY AND REGIONAL DEVELOPMENT

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Robert Kelly Mulvihill
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DEDICATION

This thesis is dedicated to my wife, Linda, for her enduring support and love during this and all other endeavors.

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ABSTRACT

In this research, the practice of teleworking and the related physical impacts on communities and regions is examined. Telework is a relatively new form of work that substitutes information technology for travel to a regular place of work. As a result, there are potentially significant physical impacts on spatial development patterns, land use relationships, transportation systems, and environmental quality. This study first addresses the larger context of the telework phenomenon by characterizing the macroeconomic shift to an Information Economy. The body of the research focuses on home-based telecommuting and telecenter-based telecommuting, which are the two most prevalent forms of telework. In the United States, the current number of teleworkers is estimated at 20 million people, and long-term projections forecast a steady rate of adoption. The major forces facilitating the adoption of telework are identified and discussed. The findings regarding the physical impacts indicate a reduction in the number of commute trips and miles traveled, which result in lower auto emissions and potential reductions in traffic congestion. The indirect effects of telecommuting are latent demand for travel and an increased potential for dispersed development patterns. Future impacts of telework will largely be dictated by the frequency of telework activity among the growing population teleworkers projected, and the interplay of existing development factors which have generally led to the decentralization of metropolitan areas.

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CHAPTER 1

INTRODUCTION & METHODOLOGY

1.1 PURPOSE

The purpose of this study is present exploratory research about a new form of work in the emerging Information Economy[1], and the related physical impacts of this form of work on communities and regions. Telework is a rapidly emerging form of work enabled by information technology, and can be defined as substituting information technology for travel to a physical workplace.

This topic is important to communities and the planning profession. In particular, it is pertinent to several major issues including traffic congestion, suburban sprawl and growth management, and workforce availability. The research may serve to increase awareness among both academic and professional communities by framing some of the key issues facing planners. A better understanding of telework may also maintain and enhance the relevance of planning in this rapidly changing environment that is redefining fundamental social, economic and physical relationships.

Telework and the related physical impacts are studied in detail, given a general analysis and understanding of the larger context within which the teleworking phenomenon is occurring. This entails exploring the major social, economic and technological changes that have resulted in the present-day Information Economy. The

[1] The "Information Economy" is a term that characterizes the centrality of information and knowledge in most economic sector as strategic resources and value-added economic inputs. While information and knowledge have always had an economic function, physical resources and inputs tended to determine economic value in industrial or agricultural economies.

planning implications of telework will be presented in a discussion and conclusion, as derived from the observations, analyses, and findings. The above research therefore has the potential to contribute to the general understanding of this subject and have practical significance to the field of planning.

The major premise for undertaking this study maintains that teleworking is fundamentally changing *how and where people can and do work and live*, the very essence of community development. The work situation is directly related to most aspects of community from activity patterns and the general quality of life to the place of residence decision, available leisure time, peak hour work trips, and numerous other factors. This intertwined relationship between work and daily living make an independent study of this new work form a worthwhile research effort.

Since commuting represents roughly 40% of all auto use in the United States, the potential impacts from the reduction of daily commute trips alone makes telework an important area of study and public policy (Nilles, 1997). The latest national transportation mobility report by the Texas Transportation Institute estimated the economic cost of traffic congestion was $74 billion dollars in 1996 for 70 major metropolitan areas in the United States (Lomax, et al., 1998).

1.2 Scope and Limitations

This research examines teleworking as one part of the changing work place of the Information Economy. The main chapters are predicated upon a brief review of the macroeconomic change. The research then focuses on home-based telecommuting and

telecenter-based telecommuting, two forms of work accounting for more than 90% of all telework. The second element of the research focuses on the physical impacts of telework in local communities and regions.

The majority of the research collected and analyzed pertains to telework and its related physical impacts in the United States. Some of the research was supplemented with information about other developed nations or advanced economies. The reasons for utilizing information about these countries were, first, to access the broader body of knowledge in Europe and Japan particularly. Both areas have a significant degree of telework in practice and a growing body of research. Secondly, the experiences in developed countries have been similar and make the findings of this larger body of research largely transferable to other advanced economies of the world. Research on telework in emerging economies and less developed countries was excluded from the scope of study because the research is very limited. Also, telework experiences and issues in these countries generally require separate consideration because of the relative stage of economic development, and the resulting social, economic and technological conditions present.

Finally, a general comment about the complex nature of development is also warranted. Local and regional development is the result of interrelated and complex factors, as planning students, practitioners, elected officials, and taxpayers learn through study and real practice. For the purposes of academic research, it is necessary to assign labels and make determinations that may oversimplify the real dynamics of development. Attempts have been made to minimize such shortcomings in this document.

1.3 THESIS ORGANIZATION

There are three main subtopics in this research document. In Chapter Two, characteristics of the Information Economy are presented and related to the discussion of telework. This chapter places telework in the context the larger economic restructuring underway, and it also provides a historical perspective about macroeconomic transitions. Chapter Three details all of the forms of telework and presents an analysis of the home-based telecommuting and telecenter-based telecommuting, the two most prevalent forms of telework.

Chapter Four contains the findings and analysis regarding the physical impacts of telework in the United States. The factors of empahsis are spatial development patterns, land use relationships, transportation impacts, and environmental impacts. The document concludes with a review discussion of the major findings, issues for planners, and areas for further research.

1.4 DEFINITIONS

At the outset, it is necessary to define several important concepts that are employed regularly throughout the document. The central topic of the research is the telework concept. For the purposes of this research, telework is defined as, "utilizing information technology to partially or fully substitute information technology for travel to a regular place of work." The concept and its operationalization are discussed further at the beginning of Chapter Three. Several other key terms and concepts regarding

planning, economics and telecommunications are defined below to clarify the subsequent observations, analysis, and discussion.

- *Broadband telecommunications*: high-speed, high capacity telecommunications networks that utilize fiber optic technologies, advanced mobile wireless technologies, or next generation satellite communications systems (Low Earth Orbit Satellites); also referred to as high bandwidth telecommunications.
- *Information Economy*: the current economic era in which information-based economic activities account for a growing share of employment, output, and market value.
- *Information sector*: those occupations and economic activities primarily involved with the creation, processing, management and exchange of information. Those occupations are concentrated in the administrative functions and certain technical, professional and sales-related occupations.
- *Home-based telecommuting*: a form of telework in which the employee works from a residence in place of commuting to a central workplace.
- *Telecenter*: a facility offering teleworkers access to workstations, telephones, computers, and other information technology equipment to perform regular work functions outside of the regular workplace. These facilities are employer-owned, publicly subsidized, or privately operated, and are often referred to as telework centers, telecommuting centers, or teleservice centers.
- *Telecenter-based telecommuting*: a form of telework in which the employee works at a telecenter facility in place of commuting to regular workplace.

1.5 RESEARCH METHODOLOGY

The primary research methodology was a comprehensive literature review or periodicals, journals, and books. As a new and evolving topic, the available literature on the telework and telecommuting is limited in depth. The body of research has improved significantly, however, since commencing this research on the topic in 1995. A large part of the research consists of reports by government agencies or consulting firms with expertise in related fields. Journal articles and related news accounts were useful secondary source of information. Because of the nature of the topic, the literature reviewed was interdisciplinary.

The use of the Internet to conduct a substantial amount of research is noteworthy. Use of the Internet allowed access to the latest information available in this new field. Website addresses are cited in the References section of this document for those sources that were accessed via the Internet.

CHAPTER 2

THE INFORMATION ECONOMY: THE LARGER CONTEXT OF THE TELEWORKING PHENOMENON

2.1 MACROECONOMIC TRANSITION TO A NEW ERA

The United States is experiencing a macroeconomic transition that is redefining economic relationships on every level. The advanced economies of Europe, Asia, and Canada are generally experiencing the same trends. Telework is a new form of work that has emerged during this dynamic economic change and the associated technology advances.

The shift underlying this structural change has been the ongoing movement from an economy primarily dominated by goods producing sectors to an economy where information production, exchange, and management have become central economic activities. Graph 1 illustrates this economic trend by depicting the long-term employment distribution of the American labor force according to four basic sectors: agriculture, industry, service, and information.

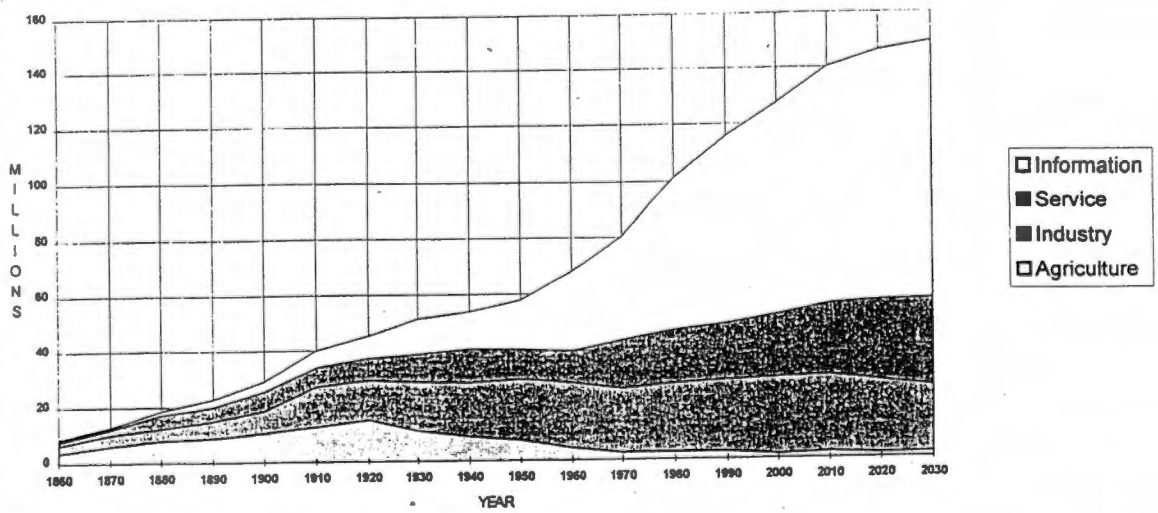

Figure 1. The Historical and Forecasted Growth of the U.S. Workforce by Major Sector, 1860-2030. Source: Jack M. Nilles (1997).

The data in Graph 1 denotes the rapid growth of the information sector as a component of a contemporary economy. The number of information workers surpassed the Industry sector in the early 1960s, and has grown exponentially since then to currently represent over 55% of the total United States employment.

The historical employment data for the four economic sectors in Graph 1 was originally developed by Porat in 1977, and has since been updated by JALA International, a consulting firm that prepared the long-term forecast. In a study about changing structure of the United States economy, Porat aggregated each individual occupation covered by the U.S. Bureau of Labor Statistics into one of the four economic sectors (Porat, 1977). The information sector was generally defined to include workers that create, process, and transmit information as their primary economic output. The detailed occupational analysis placed nearly all managers, executives, and clerical jobs in the information sector, and approximately 50% of the sales, professional and technical occupations. Operatives, laborers, and farm-related jobs were categorized in the industrial or agricultural sectors, while a wide range of service occupations comprise the service sector (Park et al., 1996).

2.2 Definition of the Information Economy

Economists, sociologists, urban planners, geographers, historians, and futurists have all offered numerous labels for the fundamental shift toward a knowledge-intensive, information economy, including these labels: Post-Industrial economy, Post-Fordist economy, Service Economy, Knowledge-based Economy, the New Economy, and the

Third Wave. While each term has distinct merits, the Information Economy name has been selected to characterize the new economy manifested by the large and growing importance of information workers and information-based activities.

A working definition of the Information Economy concept is comprised of four key elements. First, the accumulation of that knowledge replaces physical capital as the primary economic resource. Second, innovations in this economy improve quality of life more than greater increases in real output. Third, economic growth will be focused in the communications, information and leisure sectors. Fourth, the Information Economy can develop technological and administrative means of addressing social issues (Babe, 1994). In this type of economy, knowledge and information have become the strategic resources and value-added inputs to most economic activities, including agriculture and durable goods manufacturing. These new resources are supplanting the land, labor and capital which were the foundations of the industrial economy.

The rapid emergence of the Information Economy has been paralleled and enabled by the advances in information technology during the past four decades. The interrelationship between economic growth and technology are continuing with convergence of three crucial technologies at present: Computers, Telecommunications, and Media. The emerging opportunities attest to the robustness of the Information Economy as a true economic era rather than a short-term fad. To place the technological, economic and social facets of the new economy in historical perspective, Table 1 shows a summary of previous economic eras and several related social factors.

Table 1. Previous Economic Eras, Technological Drivers and Social Factors

	The Four Kondraiteff Waves (Long Waves)			
	First	**Second**	**Third**	**Fourth**
Dates	1787-1845	1846-1895	1896-1947	1948-2000
Key innovations	power loom, puddling	Bessemer steel, steamship	alternating current, electric light; automobile	transistor, computer, communications, information technology
Key industries	cotton, iron	steel, machine tools, ships	autos, electrical engineering, chemicals	electronics, computers, communications, aerospace, producer services
Industrial organization	small factories, lasisez faire	large factories, capital concentration, joint stock company	giant factories, "Fordism", cartels, finance capital	mixture of large "Fordist" and small factories (subcontract), multinationals
Labor	machine minders	craft labor	deskilling	bipolar
Geography	migration to towns, esp. coalfields and ports	growth of towns on coalfields	age of urbanization	suburbanization, deurbanization, new industrial regions
International	Britain: workshop of the world	Germany and United States compete: capital export	American and German leadership: colonization	American hegemony; Japanese challenge; rise of NICs; new international division of labor
Historical	European wars, early railways	Opening of North America, global transport and communications	World Wars, early mass consumption, Great Depression	Cold War, space race, global village, mass consumption
Role of government	minimal, army/police	early imperialism	advanced imperialism, science and education	welfare state, warfare state, organized R&D

Source: Peter Hall and Paschal Preston (1986).

This table places the scope of change evidenced by the Information Economy's emergence in context with other preceding era shifts[2]. A techno-economic paradigm driven by a transformative technology such as the power loom, electricity, or the automobile in previous years is central to each era (Hall et al, 1986). Marshall McLuhan, the communications expert and author, captured the pervasiveness of the Information Economy, as he noted, "The new electronic interdependence recreates the world in the image of a global village (83 Jung, 1995)."

Policy-makers in all levels of government are acknowledging the importance of the Information Economy and the associated transformations. National governments in

[2] Kondraitteff Waves (long waves) are economic cycles that are part of a theoretical approach to the study of economic eras, technology, and innovation. The theory is one useful approach to economic history, but this study does not attempt to judge the overall merits of the theory beyond its utility as an analytical tool.

the Singapore, France, Denmark, the United Kingdom, and the United States—through the National Information Infrastructure project— have developed strategies. International governing bodies such as the European Commission have studied the issues thoroughly and developed policy positions. The states of Utah, North Carolina, California, Nebraska, and major cities like New York, San Francisco and Toronto are examples of governments in North America that have also developed economic strategies to address this economy. Most of these bodies passed resolutions and policy statements acknowledging the vital importance of technology and telecommunications to the changing economy in the early 1990s. Since then, these and other governing bodies have experienced varying degrees of progress beyond these pronouncements toward understanding the issues, preparing appropriate policies, and pursuing implementation strategies. Telework has been regular component of these strategies and policies.

2.3 Key Aspects of the Information Economy and Telework: Telecommunications and New Organizational Structures

Because of their importance to teleworking in the Information Economy, the following two sections provide further detail about the telecommunications industry and the evolving organizational structures now in use. A brief review of the changes in the telecommunication industry shown in Table 2 reveals significant technology upgrades to high capacity communications have been undertaken. The other most significant feature is market-driven competitiveness, which should improve the cost and selection of services available to teleworkers and teleworking organizations.

Table 2. Comparison of the Changing Characteristics of Telecommunications Systems

Characteristics	Industrial Era	Information Economy Era
Regulation	Single national monopoly (public or private) governed by national telephone administration	Liberalized competition
Telecom Providers	Private monopoly or government agency- -Post, Telegraph, and Telephone Administration (PTT)	Wide variety: privatized or market-driven PTT, divested regional providers, new private entrants, other utilities
Technologies	Analog Public Switched Telephone (PSTN) network; mainly copper cables and electromechanical switching	Wide variety: updated digital PSTN and new digital networks interlinked with competing systems such as cable, radio, microwave, cellular, satellite, etc.
Services	Basic telephony: telephone, telex and some data; separate TV and radio services	Vast array of voice, data, audio, image and video communications; fiber optics, wireless networks and digital switching
Geography	Spatial Equalization: desired universal access to, and diffusion of, telephone	Spatial Polarization: "cherry picking" lucrative markets on an increasingly international basis; focusing on business centers
Urban Policy Relevance	Negligible: national regulation, ensured relatively equal access; policy-making divorced from city/local level	Substantial and growing: new importance of access to networks plus growing unevenness of "telegeography"; new economic and social policy opportunities

Source: Adapted from Graham and Marvin, (1996).

The future of composition of the telecommunications industry is currently being, and will continue to be, determined through the continuous interplay of technological innovations, market economics, government policy, and corporate competitive advantages and reorganizations. This process is occurring at an uneven pace around the world as national telecommunications markets are liberalized or deregulated to allow increased competition. Members of the World Trade Organization have agreed to open national telecommunications markets by 1998, resulting in the eventual divestiture or privatization of national telecommunications monopolies (Cairncoss, 1997). While the future providers of telecommunications services are unsettled, the types of telecommunications services demanded in the Information Economy are clear: grounded

and wireless broadband networks integrated to support digital voice, video, and data communications globally.

Two emerging trends further depict the probable future state of telecommunications in advanced economies. First, many experts anticipate that wireless telephony will become the primary mode of voice telephone communications over the long-term due to the flexibility demanded in the information age and declining costs. Secondly, data flows, rather than voice flows, will dominate telecommunications traffic. The content of these data communications flows will include *digital* voice messages, video and audio signals, and true data transmission (Cairncross, 1997). The rapid diffusion rates of mobile telephones and Internet usage support those expectations.

Telecommunications and information technologies have significantly altered both the transactions and organizational framework of businesses. These changes, particularly the organizational changes, have greatly expanded the potential of teleworking (9 Park, et. al., 1996).

The types of organizational structures in use generally reflect the prevailing economic base and technological capabilities of the time. The *industrial organizational model* required physical centralization to support mass production systems operated by a large workforce of manual laborers. The industrial model relied on central locations immediately accessible to the transportation system (10 Park, et. al., 1996; Office of Technology Assessment, 1995). Although the industrial model originated with manufacturing operations, the centralized and hierarchic organizational model was applied in most service and information industries. Organizational activities and communications were conducted on a face-to-face basis and, therefore, relied on close

physical proximity. This organizational approach inherently necessitated that employees commute to the workplace (10 Park, et. al., 1996).

A *dispersed organizational model* was an outgrowth of the industrial model's shortcomings, largely traffic congestion and increased office costs. In the dispersed model, the various functions of an organization were literally scattered among multiple facilities rather than concentrated in a centralized complex. Telecommunications supplanted direct interaction as the primary mode of organizational communications in this model. At some pioneering organizations, telecommuting was first conducted from the satellite offices of these dispersed organizations. As described by Jack Nilles, the telecommuter in the satellite office operated a "dumb" computer terminal that was linked via dedicated phone lines to the mainframe computers at a central office location. Occasionally, employees in the dispersed organization were given the option of choosing the office location they would work from on a daily basis (10 Park, et. al., 1996). The dispersed organization altered commuting patterns by distributing some commuting traffic from traditional office locations in the central business district to the emerging suburban employment centers. This dispersed organizational model introduced the suburb-to-suburb commute that has come to confound many transportation planning efforts.

Until the 1990s, most organizations embodied either the industrial or dispersed organizational model. The newest general business structure is *the networked organizational model*. This new archetype of business has been enabled by advances in telecommunications and information technologies that have increased the capabilities of individual workers at lower, and steadily declining, costs. Employees in networked

organization may now utilize information technologies to readily communicate with the regular workplace from home, the field, or remote facilities. Typically, those telecommuters in a networked organization are still commuting to the workplace at least two days per week, and then they will conduct business from those alternative locations during the remainder of the workweek (11 Park, et. al., 1996). To the degree that work in the networked organization is conducted from other locations, the use of information technologies substitutes for the traditional commute trip.

Temporary-team groupings and *home & mini-businesses* are two types of businesses that are also becoming more common in the Information Economy. The temporary-team grouping is a group of individuals or businesses that collaborate on an ad hoc basis to accomplish a short-term goal such as an advertising campaign, product kick-off, or consulting engagement. These teams dissemble and reassemble in new combinations as business conditions warrant (12 Park, et. al., 1996). Improvements in telecommunications and information technologies have minimized costs and physical limitations that previously prohibited business transactions. Jack Nilles and others have further noted that the innovation achievable through these temporary teams has become a valuable resource in the Information Economy (12 Park, et. al., 1996; Davis, 1993).

Home-based businesses and very small enterprises, the so-called *home and mini-businesses*[3], have grown substantially in recent years and have accounted for a large share of new employment growth. The majority of these types of companies are engaged in the service and information industries. The primary factors driving the growth of these types

[3] According to the U.S. Census Bureau, *mini-businesses* are companies with fewer than five employees. *Small businesses* and *medium-sized businesses* have 5-50 employees and 51-500 employees, respectively.

of businesses have been:

- The migration of highly-skilled workers from corporations and medium-sized businesses due to downsizing or voluntary departures to pursue entrepreneurial opportunities; and,
- The information technologies that enable an individual or small team to operate a competitive business; these technologies also supplant most of the functions traditionally performed by administrative staff at larger organizations (12-13 Park, et. al., 1996).

Information and communications technologies supporting these types of businesses include standard and advanced telephone services, fax, e-mail and data transfer, videoconferencing, and network computing. Observers of technology and small business practices have both widely cited the Internet as a major enabling technology of small business operations during the past four years (13 Park, et. al., 1996; CyberDialogue, Inc.,1997)

CHAPTER 3

OBSERVATIONS ABOUT THE TELEWORK PHENOMENON

3.1 THE DEFINITION AND CHARACTERISTICS OF TELEWORK

3.11 The Telework Concept

Telework is a form of work that partially or fully substitutes information technology for physical travel to a place of work.[4] Jack M. Nilles, recognized as one of the leading telework experts in the United States, regularly describes telework in colloquial terms as "sending the work to the worker rather than sending the worker to work (11 USDOT, 1993; 2 Nilles, 1997)". The two distinguishing attributes that operationalize this concept are the substitution of work-related travel, and the use of some form of information technology. The substitution effect of telework connotes a reduction in commuting, and potentially a reduction or reorganization of work space. Due to the locational independence inherent in this new form of work, this conceptualization differs from previous traditional work forms evolving since the Industrial Revolution, which depended upon the physical presence of the worker (2 Nilles, 1997; Park et al., 1996).

It should be noted that in the United States "telecommuting" has often been adopted as a synonymous term for the "telework" concept, which originated in Europe. However, Jack Nilles, widely attributed with first inventing the telecommuting term in the United States, Gil Gordon, John S. Niles, and other prominent American researchers

[4] Note that the term "information technology" has been defined broadly as the combination of telecommunications and computer technologies. Many job functions that are suitable for telework simply require a telephone.

Nilles, 1997, Niles, 1994). For the purposes of this document, telework is employed as an umbrella term that includes telecommuting as one form of telework.

The concept of telework covers a broad array of work arrangements that are redefining the work place and forms of work. The two primary modes of telework are home-based telecommuting and telecenter-based telecommuting (3 Nilles, 1997). Numerous other forms of telework are rapidly emerging as business conditions, social and economic changes, and technologic innovations facilitate other new forms of work. Hoteling, the virtual or mobile office, and concentrative teleworking are the other major forms of telework. These typologies of telework are further defined in Table 3 on the following page and are applied in the remainder of this research.

As depicted in the telework typologies, most forms of telework are "distributive" because they move employees out of central offices and into new work places: the home office, telecenters, client facilities, and the many places of business travel. Telecommuting, hoteling, virtual offices, and mobile work are all forms of distributed work. By definition, concentrative telework assembles workers in a remote office facility to conduct work at a distance from the traditional work place. In many cases, particularly with offshore telework operations, concentrative telework is part of a reorganization or serves as a wholesale replacement of a traditional office (Management Technology Associates, 1996; 146, 153 Graham et al., 1996).

Table 3. Typology of All Forms of Telework

TYPE OF TELEWORK	DESCRIPTION
Home-based Telecommuting	
Typical home-based telecommuter	Employee regularly works at home (informally or formally) 1-3 days per week.
Full-time home telecommuter	Employee routinely works from a home office within the same metro area as the regular workplace; travels to workplace one day per week or less frequently.
Long-distance telecommuter	Employee working from a distant residential location in a home office, convenient branch office, or both; employer would have provided space in regular office if the employee lived in commuting distance; allows employer to accommodate valuable employees.
Independent homeworkers	Self-employed person or business owner that chooses to routinely operate out of a home office.
Telecenter-based Telecommuting	
Multiple-employer telecenter	Employee works part-time at a different employer-provided facility or leased telecenter space for convenience or travel reduction; maintains a desk at regular workplace.
Telecenter/branch worker	Employee reassigned to work routinely from a remote telecenter or branch satellite office within the same metro as regular workplace; space at central office is eliminated, downsized or reconfigured as a shared-office.
Satellite telecenter telecommuter	Individual employees or an entire work group (department) are reassigned to an employer-provided satellite facility within the same metro area as the regular workplace.
Hoteling	
Hoteling workers	Employee that teleworks regularly reserves a temporary workstation at a company office on an hourly, daily or weekly basis; phones, computers and e-mail are routed to these workstations and "concierge" support services are available.
Nonterritorial workers	Teleworking employees have access to individual workstations and meeting rooms in open-plan office on a first-come, first-serve basis; there are no assigned offices.
Virtual of Mobile Offices	
Virtual office worker	Employee provided with necessary home and portable office equipment due to extensive field work (80% or more of work time); desk at central office is eliminated.
Mobile professionals	Employee reports to work in regular workplace but is able to work continuously with location independence because of extensive travel; sales professionals, service technicians, field auditors, etc.
Remote regional field workers	Employee assigned to operate in geographic region that is removed from the regular workplace; works in home office, branch office, rented office space, or a combination of accommodations.
Concentrative Telework	
Remote branch/back office	Employer opens a new office in a remote location; existing employees are transferred to live and work in the remote location or new staff is hired locally; can include offshore telework facilities.

Source: John M. Niles (1994), Becker, et al. (1993), Graham, et al. (1996), Management Technology Associates (1996), and Mahlon Apgar, IV (1998) as modified by author.

The nature of the Information Economy results in a complex mix of telework practiced at a given organization or by individual employees. For the purposes of studying and discussing the topic, it is useful to differentiate the various forms of telework. Those distinctions are blurred in the fast emerging Information Economy. The observations of Franklin Becker, et al., in a review of corporate real estate practices, succinctly characterize the changing workplace: "The concept of the workplace shifts from being a real estate commodity to a set of places, information technology resources, and management policies that are used dynamically to convene the work force despite constraints of time and space (84 Becker et al., 1993)."

3.12 The Driving Forces Behind the Emergence of Telework in the 1990s

Although telework has been a topic of discussion since the 1950s, it did not receive significant attention until the early 1970s when terminal-based access to mainframes was prevalent among corporations (4 USDOT, 1993). In the United States, the Oil Crisis in 1973 also prompted greater interest in telework as energy conservation became a serious policy issue (Nilles, 1976). During the 1990s, a combination of social, economic, and technological factors have been the driving forces behind the emergence of telework in the United States: information technology advances; a continuing economic shift to an information economy; competitive business conditions; changing workforce characteristics; and traffic congestion and environmental impacts (USDOT 1993; USDOE, 1994; Niles, 1994; Office of Technology Assessment, 1995; Nilles, 1997). Each of these factors is examined more closely in the following sections.

Information Technology Innovations

Advances in information technology during the past three decades have greatly enhanced the ability to communicate and work from remote locations (Turnbull, 1997; Nilles 1997; USDOT, 1993). While the technical platforms of telework are improving rapidly, these technology improvements in the areas of computing and telecommunications have also steadily reduced the cost of processing information.

Computing power has improved exponentially as the rapid development of microprocessors and semiconductors yields greater speed and memory capacity. Mobile computing is readily available via laptop computers and a growing assortment of portable information appliances (Niles, 1994; Burrows et al., 1999). More sophisticated and user-friendly software, such as groupware or data transfer applications, supports collaborative work among persons in different locations through network computing (Niles, 1994). In the modern economy, a large percentage of information workers now rely upon computers to conduct daily business (Nilles, 1997).

An ongoing transformation of the world's telecommunication networks, facilitated by the application of computer technology to telecom networks, is also allowing more information to be exchanged at much lower costs. The transformative potential of the improved communications networks have been demonstrated by the rapid and widespread adoption of the fax, mobile phone and the Internet (Cairncross, 1997). Over the mid-to-long term, the deployment of broadband telecommunication networks and global wireless communications will enhance the ability to work anytime and anyplace. The rapid development of network computing during the 1990s has also facilitated telework. Workers can access proprietary company networks or the Internet

through telephone systems throughout the world, resulting in increased connectivity and "location independence" (Niles, 1994; Nilles, 1997).

The Economic Transformation

The continuing economic shift to an Information Economy is manifested in the changing nature of work and occupations. A growing majority of the modern workforce is comprised of information workers— those employees in occupations that primarily involve the creation, processing or exchange of information. Information and knowledge have become the primary value-added inputs and products of the Information Economy across every economic sector, including agriculture and manufacturing (9 USDOT, 1993). The share of information workers is over 55% in the United States, and in a slightly lower range in the advanced economies of Europe, Canada, Japan and Australia (3 Nilles, 1997).

Strong employment growth among small businesses is also an important factor fueling the growth of telework because small businesses have adopted telecommuting more widely and quickly than larger businesses (Niles, 1994). The characteristics of the Information Economy are discussed more fully below. In regards to telework trends, this structural economic change is most significant because of the expanding pool of potential teleworkers resulting from this transformation.

Employee Characteristics and Values

The changing demographics, attitudes and values of employees are aligned with several telework characteristics and benefits. First, the modern family structure has

evolved beyond the single-earner nuclear family. Many families are dual-income households or single-parent households, both of which place more women in the workplace. Second, the time demands of contemporary lifestyles, in part accentuated by new family structures, have placed greater importance on quality of life issues such as balancing career and family time. Third, more employees have highly mobile careers with more frequent job changes, placing greater emphasis on professional development and empowerment in the workplace. The economics of metropolitan housing markets is a fourth factor because many homebuyers have opted to purchase housing in the suburban and exurban fringe. These more dispersed residential location decisions tend to increase commute times and exacerbate the time demands facing employees (9 USDOT, 1993). As a result, modern employees in the United States are seeking more flexible work arrangements. The psychological benefit of the greater flexibility and control realized through telework are considered an important employee motivator for telework adoption (14-16 Park, et. al., 1996).

During the 1990s, flexible schedules have become commonplace in the American workplace. According to data from the U.S. Bureau of Labor Statistics, 27% of employees in the United States had a flexible schedule arrangement in 1997. This represents an 83% increase since 1991, when approximately 15% of the workforce worked flexible schedules. This trend demonstrates the reduced importance of when work is conducted and the more results-oriented management environment now pervasive in the business community (Challenger, 1998). And there is significant evidence of support for flexible-location work arrangements among employees (Niles, 1994).

The employee need for greater flexibility, time management, and job satisfaction is consistent with the benefits of telework and contributes to the demand for telework. Results from surveys of businesses with telecommuting programs in the Silicon Valley region of California reveal that telecommuters there find telework to be a rewarding work form, and most telecommuters wanted to increase the frequency of telecommuting (13-14 Strategic Decisions Group, 1996). Increased employee interest in telework options is also supported by the age demographics of the United States. Baby boomers, the dominant cohort group in the United States, have reached an age when they are most likely to undertake home-based telecommuting. The average age of home-based telecommuters was estimated to be 38 years old in 1994, according to survey research (Braus, 1998).

Competitive Business Conditions

Economic globalization has been one of the most definitive forces affecting the competitive business environment during the past 30 years. Combined with other factors, global economic competition has significantly increased business pressures to increase productivity and reduce business costs. In this environment, productivity in all forms-- more output, creativity and greater customer service-- has become a business imperative (10 USDOT, 1993).

The drive for productivity improvements was the impetus for a trend of reorganizations that began in the 1980s and has continued through the present. Corporate downsizing, internal reorganizations, facility closures and consolidations, and the general flattening of organizational structures are all types of organizational changes that are

attributable to the competitive business environment. A widespread adoption of information technology has also occurred throughout the 1990s, resulting in new business relationships with customers, vendors, and employees. The emergence of the virtual organization, where company units and personnel in different locations are linked via computer networks and advanced communications, is one new organizational structure that relies upon telework to conduct business (Office of Technology Assessment, 1995; Lake, 1995).

Individual productivity improvements are regularly cited as one of the primary benefits of telework. Multiple studies of telecommuting programs throughout California have consistently demonstrated employee productivity gains ranging from 10% to 30% (Nilles, et. al., 1996; Strategic Decsions Group, 1996; JALA International, 1990 and 1993). Time savings resulting from eliminated or reduced commuting is one source of productivity improvments, as part of that time is often used to complete more work. For example, employees at one business unit of AT&T are gaining, or saving, five work weeks per year through telework by eliminating a 50-minute daily commute (128 Apgar, 1998). As illustrated in the Table 4 on the following page, the potential reasons for increased productivity range from the number of hours worked to reduced absenteeism. Telework allows companies to capitalize on their investments in information technology, and also permits nearly unlimited communication with employees, including training sessions, regardless of locational constraints (2 Skinner, 1999).

Table 4. Possible Factors Increasing Productivity Through Telework

More Hours Worked Per Day
➢ Some employees may work some of the time they would have spent commuting
➢ Less nonproductive socializing
➢ No decompression time necessary
➢ Facilitates off-hours work in the evening and on weekends
More Work Completed Per Hour
➢ Fewer interruptions and distractions (assuming a suitable telecommuting setting is available)
➢ Work done at times that are suitable to the individuals internal clock
➢ As applicable, moving tasks off mainframes or company networks, or shifting to off peak hours, increases productivity potential for those working online during peak hours
➢ Group norms not followed
Less Time Missed From Work
➢ Less incidental absence
➢ Less sick leave

Source: U.S. Department of Transportation, 1993.

In the current competitive global economy, pressures to reduce business costs accompany the productivity imperative. Lower real estate costs, employee retention and reduced turnover are several forms of cost reduction that are possible through telework. Significant facility costs reductions are possible with large-scale teleworking, as AT&T has demonstrated in its implementation of a company-wide telework program. The company achieved real cost savings in the first year of telecommuting for most employees, or by the second year if the company had to provide office furniture or other home office expenses for the telecommuter. AT&T estimates the one-time expense per employee is $6,000 to begin telecommuting (93 Becker, 1993). Cost-benefit analyses of home-based telecommuting support the AT&T's findings about realizing a net return in the first or second year of operation (Park et al., 1996; Strategic Decisions Group, 1996).

To realize substantial facility cost savings, the amount of actual rentable space has to be reduced. For many companies with part-time teleworkers or a large mobile work force, hoteling and other alternative officing arrangements must be coupled with telecommuting to achieve net facility cost savings. According to surveys of companies employing this combined telework strategy in California, the facility cost savings have been substantial, ranging from 30% to 70% of traditional office arrangements (18 Strategic Decisions Group, 1996). On the corporate level, IBM joins AT&T as one of the most aggressive adopters of telework in the United States. AT&T has saved $550 million in cash flow by reducing office space through telework between 1991 and 1997. In the case of IBM North America, savings exceed $100 million annually in just the sales and distribution unit (121 Apgar, 1998).

In addition to cost pressures and productivity demands, businesses in the current and emerging competitive environment face a growing structural labor shortage. This shortage is a function of demographic changes and insufficient workforce skills and training for the knowledge-based industries of the Information Economy. The demographic changes underway in many advanced economies are simply a matter having smaller working age cohort groups as the population ages. In the United States, this change is largely attributable to the aging of the 72 million person "baby boom", and the smaller replacement generation known as the "baby bust". While unemployment rates are a function of several factors in addition to demographics, the United States has witnessed low unemployment rates ranging between 4% and 5% since 1997. Many metropolitan areas have experienced acute labor shortages as unemployment rates have declined to record levels below 2%. Coupled with the higher skills and educational

requirements associated with knowledge and information-based industries, the U.S. Bureau of Labor Statistics forecasts demand for 151 million jobs in 2006 and only 141 million employed persons in the United States— a 10 million worker shortfall (Challenger, 1998).

These structural labor shortages in the United States and other advanced economies may be an incentive to utilize telework to maximize the available workforce by attracting and retaining valuable employees (Niles, 1994). Employee retention and improved employer-worker relationships were considered benefits of telecommuting programs among Silicon Valley companies (18 Strategic Decisions Group, 1996). Among large corporations, recruiting and retaining skilled and motivated employees is a crucial motivation for businesses to adopt telework (122 Apgar, 1998). Recent business surveys conducted in Utah and Colorado reveal that attracting and retaining skilled workers is the primary business issue for over 70% of businesses in those states. Of those surveyed, half of those businesses believe severe traffic congestion negatively affects workforce attraction and retention, and therefore economic competitiveness (US West, 1998).

In this business environment, competition is primarily focused on customers and resources, such as information or quality workers (6 Nilles, 1997). The Information Economy, and telework specifically, will continue to affect the competition for both types of resources.

Traffic Congestion and Environmental Issues

During the early 1970s, traffic congestion and fuel conservation were issues that stimulated serious discussions and research about telework (Nilles, 1976). Twenty years later, significant one-time occurrences like the 1993 earthquake in Northridge, California, and the traffic anticipated during the 1996 Olympic Games in Atlanta were catalysts for the actual adoption of telework. Today, mitigation of traffic congestion, air quality problems and other environmental issues associated with development and commuting patterns in modern metropolitan areas are driving forces of the telework phenomenon (Turnbull, 1997; Nilles, 1997; Office of Technology Assessment, 1995; Bagley, 1994; USDOT, 1993). Traffic congestion is increasing to severe levels in many metropolitan areas, as demonstrated in national transportation mobility research and contemporaneous observations of residents, businesses, governments and the media (Lomax et al., 1998).

In the earliest American research on telecommuting, Nilles succinctly characterized the traffic congestion and the conventional options to alleviate it. He noted that commuting "has required the construction of major urban highway systems in most metropolitan areas. These systems are both inefficient (in terms of variable loading) and costly to build and maintain. The other transit options—widespread bus networks and fixed rail transit—are similarly costly and suffer from the same problems of variable loading. A dilemma clearly exists (3 Nilles, 1976)." Given the increasing traffic congestion and travel costs, air quality problems, and growth management issues facing many communities and regions, the dilemma has digressed to a crisis in many metropolitan areas. In metropolitan Atlanta for example, thirteen metropolitan counties

are not eligible to receive federal funds for new road construction because of the region's air quality attainment status fails to meet the federal standards.

A variety of federal and state environmental legislation, regulatory enforcement, and incentives have been a related factor influencing telework levels. Most environmental legislation has focused on vehicle trip reduction and air quality restrictions (USDOT, 1993; Becker, 1993). These statutes require the private sector in certain non-attainment areas to comply with trip reduction mandates. Regulatory incentives and penalties can make telework strategies a more compelling option.

The federal Clean Air Act has been the most substantial regulatory factor because of costly fines and penalties that can be levied on major employers. These provisions have induced many employers to adopt regional workplace strategies that include substantial telework options (122 Apgar, 1998). On the state level, California has the most rigorous state environmental laws in the country because the state had to deal with severe traffic conditions years before other regions of the country. By law, regional air quality districts were established throughout California, and each district was required to adopt an Air Quality Management Plan. For example, the Southern California Air Quality District requires medium and large employers to reduce commuting levels, and has mandated a 20% reduction in commuting through telework by 2010 (JALA, 1993).

The travel costs of congestion for individuals, businesses and metropolitan economies are also a growing factor regarding telework adoption (Skinner, 1999; Office of Technology Assessment, 1995). The primary travel costs caused by commuting are lost time and productivity and fuel consumption. Using the case of Atlanta, severe traffic congestion on the metro highway system costs the economy an estimated $2.1 billion in

1996, according the Texas A&M Transportation Institute. In a study of 70 major metropolitan areas in the United States, the total estimated travel costs[5] were $74 billion dollars for 1996 alone. Eighty-eight percent of the estimated travel costs resulted from time delays (Lomax et al, 1998). This time variable is closely related to business productivity concerns of employers and the quality of life interests that are important to employees.

The Convergence of the Driving Forces

As evidenced in the preceding descriptions, the forces driving the telework phenomenon are complex and interrelated. For example, severe levels of traffic congestion may reduce employee productivity, degrade the quality of life enjoyed by workers and residents, and increase business costs in a given metropolitan area. The convergence of the five identified factors has increased the general interest in telework and the actual rate of adoption by an unquantifiable magnitude (Nilles, 1993). Actual levels of telework are subject to additional factors ranging from technology and business management practices to personal decision-making. However, the major factors influencing the growth of telework are substantial and clearly trending towards increased telework levels.

Several researchers and experts have identified business issues, namely organizational productivity and costs, as the determinant factor regarding telework

[5] The Texas A&M Institute of Transportation calculates congestion costs according to multiple calculations applying the following factors autos and trucks: vehicle travel speed, delay, system travel speed, fuel economy, wasted fuel, recurring delays and costs, and the value of a person's time.

Assessment, 1995; Niles, 1994). Ultimately, the ongoing rate of telework will result from the interplay of these major driving forces, a collection of potential barriers to further telework, and the perceived advantages of teleworking among related actors. Several potential barriers to greater adoption of telework are outlined in the following section.

3.13 Potential Obstacles Affecting the Adoption of Telework

Research and analyses of telework practices, pilot telecommuting and telework projects, and surveys have revealed several potential obstacles to further telework adoption. The findings indicate that the greatest obstacles to widespread teleworking are social factors such as management attitudes, employee isolation, and inadequate training.

Technical and economic obstacles are much less prevalent as the body of low cost, high productivity information technologies expands rapidly. Necessary information technologies already exist and are rapidly improving. At the simplest level of technology application, a significant amount of telework only requires a telephone, as noted in the discussion of the telework concept. One other type of "man-made" obstacle is government regulation. A brief synopsis of the primary barriers to successful telework adoption follows.

Management Attitudes and Practices

Business cultures, exhibited by management attitudes, and existing work processes are the greatest obstacles to the successful implementation of telework (Apgar, 1998; Strategic Decisions Group, 1996; Park et al., 1996; Becker et al., 1993). The

managerial concerns about managing remote workers are a principal barrier for many organizations (93 Becker, 1993; 38 Strategic Decisions Group, 1996). Telework requires a results-oriented management style rather than the employee monitoring approach that many organizations practice in the physical workplace (18 Park et al., 1996).

Many organizations have industrial organizational structures characterized by hierarchies and centralized decision-making. These organizational structures and attendant work processes are generally antithetical to the information economy where workers must be flexible, effective communicators, and have a greater degree of decision-making responsibility. New organizational approaches capitalize on the knowledge, expertise and skills through decentralized structures and flexible work processes (6-7 Nilles, 1997).

Surveys of companies in California's Silicon Valley demonstrated that management issues are a fundamental obstacle to the adoption of telework arrangements. Although managers and coworkers find the benefits of telecommuting outweigh the costs, they perceive the productivity improvements of telecommuters to be lower than those reported by the actual telecommuter. The full acceptance and support, or "buy-in", of telecommuting by senior and middle management remains a major concern of telecommuters, their managers and coworkers (12-13 Strategic Decisions Group, 1996).

Research about corporate real estate practices identified shortcomings of implemented telework programs. These programs had common failings that further illustrate management issues that can inhibit the adoption of telework. In most cases, these telework initiatives were a small independent program that was not part of an integrated workplace strategy. Independent programs are often too small to demonstrate

a significant impact on business and they typically do not involve the range of managers and decision-makers necessary for a successful program. Relating the effects of telework programs on an organization's competitive advantage, shareholder value, or similar tangible business terms can also influence the adoption of telework among businesses (94 Becker et al., 1993).

Employee Concerns about Telework Arrangements

There are several areas of legitimate concern about how teleworking employees are affected by a remote work arrangement. The primary employee concern observed in research is the potential negative impact of teleworking on career advancement and work relationships with both managers and peers (USDOT, 1993; Park et al., 1996; Strategic Decisions Group). In California, surveyed telecommuters expressed concerns about inclusion on projects or other opportunities that may be more readily available to colleagues in the office (Strategic Decisions Group, 1996). Other employee concerns include not having adequate workspace for home-based telecommuting; access to sufficient technology and support services; and, the potential for social isolation if the workflow is not managed appropriately (USDOT, 1993; Park et al., 1996).

Insufficient Knowledge and Training Regarding Telework

Greater rates of telework adoption require a better understanding of telework and its impacts on the careers and personal lives of employees and managers, and the overall success of their organizations. Executives, line managers and other decision makers must be aware of the effects of teleworking on individual performance, organizational

productivity and costs, and management practices that effectively support telework (USDOT, 1993; 19 Park et al., 1996). Common misperceptions about the cost of supporting teleworkers, adverse career impacts, and what types of jobs are suitable for telework persist, despite growing recognition of telework and telecommuting.

Research has demonstrated the need to educate managers and employers about telecommuting practice and its effects on business operations. Among telecommuters, managers and coworkers, the degree of concern about barriers to further implementation of telecommuting are greatly reduced as the duration of telecommuting experience within the organization increases. In the case of Silicon Valley companies, levels of concern about barriers to telecommuting declined significantly after two years of telework experience (23 Strategic Decisions Group, 1996).

Regulatory Barriers

Numerous types of regulations and laws emanating from all levels of government inhibit the adoption of telework. On the local level, zoning ordinances that restrict the location of businesses in residential areas without provisions for home offices are the norm (177 Office of Technology Assessment, 1995; 20 Park et al., 1996). Since home-based telecommuting is the largest form of telework, zoning and land use regulations prohibiting this activity are a legal obstacle. Typically, jurisdictions do not enforce these technical violations of the zoning code, but it may represent a deterrent to a segment of potential telecommuters. The location of telecenters in residential areas, or in close proximity, is a more contentious zoning issue because of the commercial nature of these facilities. To increase the success and degree of telecenter-based telecommuting,

telecenters should be located close enough to residential areas to minimize commute distances, and ideally permitting walking or biking to the telecenter (Mohktarian, 1997). Overall, zoning ordinances are not a significant deterrent to telework at present. However, as telework becomes a more widespread form of work, zoning regulations will become an issue unless provisions are amended.

Certain aspects of federal and state tax laws discourage telework by generally increasing or complicating tax liability, while decreasing available tax deductions for this form of work. The federal income tax provisions regarding home office expenses require that the home office is the only place of business to be eligible for any business expense deductions. Since many telecommuters are part-time teleworkers, their occassional use of a home office is not deductible since they usually maintain a regular office workspace as well (48 USDOT, 1993; Park et al., 1996).

State laws complicate the tax liability of businesses conducting operations with teleworkers in multiple states. Many states apply corporate franchise taxes to companies with even one teleworker located in a given state. Those states will often subject the corporation to taxation of all revenues earned from business in that state, not just the revenue attributable to that individual teleworker. State income taxes are also a problem, as several states assess income taxes based on the location work is performed instead of where the worker resides. In the case of teleworkers, this type of regulation requires detailed accounting of how many hours or days of work are conducted in various states.

At a minimum, the complications resulting from these tax laws increase the cost of maintaining telework operations. More serious tax implications arise if companies are

discouraged from adopting telework, or businesses relocate operations to jurisdictions where the barriers to greater telework adoption are minimized.

Another less significant legal obstacle is in the area of worker insurance and liability. Employer insurance policies generally cover employee liability, personal injury and other aspects of regular work. Liability for equipment damaged at a teleworker's workspace or third party injuries will depend on the individual insurance policy and any contracts between the employer and teleworker (48 USDOT, 1993). Formal telework programs usually avoid liability problems by entering contractual agreements with teleworkers that clarify these issues (177 Office of Technology Assessment, 1995; Park et al., 1996). Workers compensation, insurance liability, and the involvement of labor unions are much more serious issues in European telework policy and practice.

As noted above in the discussion of the driving forces of telework, regulations can also provide incentives for telework, as evidenced in certain provisions of air quality legislation and traffic mitigation policies. The recent trends have demonstrated increasing support for telework adoption in state and federal legislation (21 Park et al., 1996).

Ready Access to Technology

The availability, capabilities and costs of information technology determine the overall accessibility of technology for potential teleworkers. Present conditions and trends suggest that general access to technology is adequate and improving. Costs of information technology such as computers are declining swiftly and telecommunications

pricing is expected to decline over the long-term as service providers in the United States, and around the world, face further deregulation of markets.

On the micro-level of the firm, two technology issues that were identified as potential obstacles to further telework among California companies: 1) the policies dictating whom pays the for home technology of telecommuters; and 2) the need to adopt technologies supporting group work. Current technology levels, however, generally meet and exceed the technical requirements of home-based telecommuters (14 Strategic Decisions Group, 1996).

On the metropolitan and national level, telework rates will be lower if significant segments of a given population do not have access to supporting technologies. Although technology costs are declining, low-income populations that are typically located in inner city neighborhoods or rural areas are still at a disadvantage regarding technology access and adoption. Research indicates that household income, education, and skill levels correlate more directly with access to telecommunications and computer technology than specific geographic areas. In this respect, some rural areas with a better-educated and more affluent population will have access to necessary technologies. For urban and rural neighborhoods with lower income residents, poor educational attainment and weak skill sets, access to technology will prohibit some telework opportunities. (188 Office of Technology Assessment, 1995).

Most of this discussion presumes home-based telecommuting would be the largest share of telework activity. Telecenter-based telecommuting has been a serious option in distressed neighborhoods of the United States. These areas rely on government and non-profit funded projects, which have not been widely implemented. Most telecenters serve

suburban areas from which workers typically telecommute to urban and suburban employment centers. Several early telecenters focused on serving distressed urban neighborhoods were planned in California (174 Office of Technology Assessment, 1995). These centers would effectively supplant reverse commuting strategies that are designed to provide inner city residents access to employment opportunities in the growing suburban employment centers.

As the role of high speed communications increases in business operations during the next ten years and beyond, then the geography of advanced telecommunication infrastructures will become a more critical factor. Higher income urban and suburban areas are generally the markets that first attract upgraded telecommunications services and higher capacity, broadband networks (Graham et al., 1996).

Potential Obstacles as "Constraints" on Teleworking

The collection of obstacles presented are variables that affect the rate of telework adoption, but telework researchers and experts do not view any combination of obstacles as an absolute or insurmountable barrier (USDOT, 1993; Park et al., 1996). To date these obstacles have been constraints on telework adoption rates, however, the resistance of these obstacles is perceived to be weakened as more successful telework approaches are accomplished, as technology and management practices improve, and as the more influential driving forces stimulate further demand for telework in the United States and other advanced economies.

3.14 Current and Forecasted Magnitude of Teleworking

Teleworkers are a substantial and growing part of the modern economy in the United States, Canada, and the advanced nations of Europe and Asia. Before explaining the telework estimates and forecasts, it is important to define the larger social groups, or telework universe, from which actual teleworkers are derived. A schematic of the telework universe in Figure 2 depicts major sources of the ultimate teleworkers.

While many jobs have specific tasks that may be amenable to telework arrangements, it is important to note that not every occupation is amenable to telework. The most suitable jobs for telework are held by information workers that spend the majority of their work time generating, processing and exchanging information (54 USDOT, 1993). As outlined in Chapter Three, this group of occupations now accounts for the largest segment of the United States labor force at roughly 58% of all workers (4

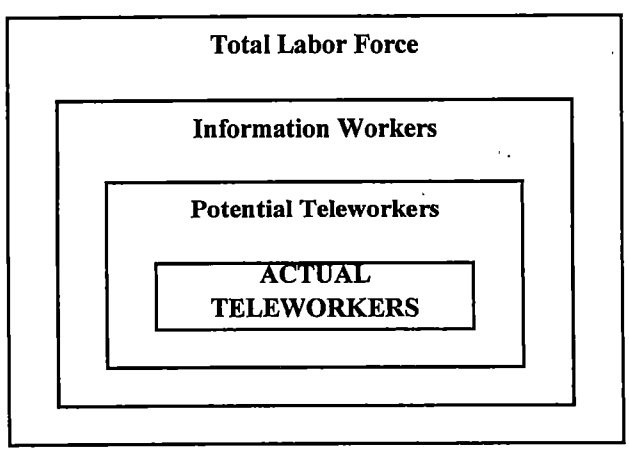

Figure 2. Telework Universe. Source: U.S. Department of Transportation (1993).

Nilles, 1997). For various reasons, a percentage of information workers are not potential teleworkers. Factors limiting the telework potential of a specific information worker include personal characteristics and preferences, employer decisions, unique job circumstances and other job specific issues. As shown in Figure 4.2, those information workers that are suitable for telework constitute the pool of potential telecommuters in a region or country. Actual teleworkers are those persons that are suitable for telework arrangements and have the means to do so on a part-time or full-time basis.

Methodologies for Estimating and Forecasting Telework

Estimating the volume of telework conducted in a given geography is a difficult task. Definitions of telework and telecommuting vary significantly among researchers, governments, businesses and organizations. Second, there is difficulty counting teleworkers because the number of teleworkers is an elusive population that changes in size. The actual telework population fluctuates based on the frequency and duration of telework, as for example, part-time teleworkers actively telecommute and other teleworkers possibly stop teleworking. Third, the majority of teleworkers are informal practitioners and not in formal telework programs.

In the relatively young business and academic fields concerned with telework in the United States, the best available telework estimates and forecasts are developed by a small group of private consultants and market research firms. Even recent federal government reports citing estimates and forecasts employed expert panels and the methodologies of the same collection of private firms. Outside of the United States, non-profit telework organizations and national governments provide the most

reliable information about the telework levels and trends. There are two basic methodologies that have been employed by these sources to estimate and forecast levels of telework. A "bottom-up" forecasting approach relies on surveys, focus groups, and case studies and then extrapolates findings to a larger unit of analysis, for example statewide or nationally. A "top-down" forecasting methodology estimates the potential population of workers that can telework, and then estimates levels of adoption according numerous relevant factors (Office of Technology Assessment, 1995).

Given the limited pool of reliable estimates and forecasts, the remainder of this section will provide estimates and forecasts of global telework levels, the best estimates and forecasts available in the United States, and miscellaneous evidence to further gauge the magnitude of telework. At present, all of the sources of estimates and forecasts define telework as telecommuting from the home or telecenters. For this reason, telecommuting will be the operative term for the discussion of these forecasts. Telework is not defined broadly enough by any sources to include hoteling, virtual or mobile officing, or other teleworking.

Global Telecommuting Estimate and Forecast

A brief review of global estimates and forecasts illustrates the significance of telework and telecommuting, and establishes a frame of reference for the subsequent analysis of telework in the advanced economies of North America, Europe and Asia. JALA International, Inc., the telework research and consulting firm founded by Jack M. Nilles, has modeled telework for every region of the world to develop long-term projections of global telework levels. Employing a "top down" methodology, the

projections were developed to demonstrate the current and potential future role of telework in global economic activity. JALA International estimates the current number of information workers in each nation and then estimates current telecommuting levels as a penetration rate of that population using models refined since the 1970s. To estimate telecommuting levels, assumptions must be made about maximum percentage of information workers who telecommute and the penetration rate over time. As with most long-term projections, the estimates represent a likely course of events that can change if the underlying assumptions about telework implementation are altered by actual events (9 Nilles, 1997).

According to projections by JALA International, by 1998 there were more than 26 million estimated telecommuters in OECD countries, commonly accepted as the advanced or developed nations of the world. With an estimated contribution of nearly 6 million teleworkers from the rest of the world, the total number of teleworkers globally exceeded 32 million in 1998. Presently, the United States accounts for 50% of the world's telework population (9-10 Nilles, 1997).

By the year 2000, JALA International expects global telework levels to surpass 40 million persons. Within the next 20 years, the JALA International forecast projects more than 200 million teleworkers worldwide, about 50% of which will be from the advanced OECD nations (10 Nilles, 1997; Nairn, 1997). Currently and over the long-term, the United States is estimated to be the largest telework market followed respectively by Japan, Germany, the United Kingdom, France and Italy. Long-term forecasts by JALA International project global telecommuting levels will progress to over 350 million telecommuters during next 30 years (9-10 Nilles, 1997).

United States Telecommuting Volumes and Forecasts

As of 1999, there are more than 20 million persons telecommting on a part-time or full-time basis in the United States, according to the most recent estimates by JALA International. That figure includes both home-based and telecenter-based telecommuting. As shown in the figure below, the number of telecommuters increased 70% annually during the early adoption stage between 1990 and 1995, from approximately 2 million persons to 9 million persons. Between 1995 and 2000, the growth rate has slowed to an estimated 33% annually as the base number of telecommuters increased. Following the year 2000, the annual growth rate of telecommuting is expected to remain between two and seven percent as population of telecommuters expands to an estimated 42 million by

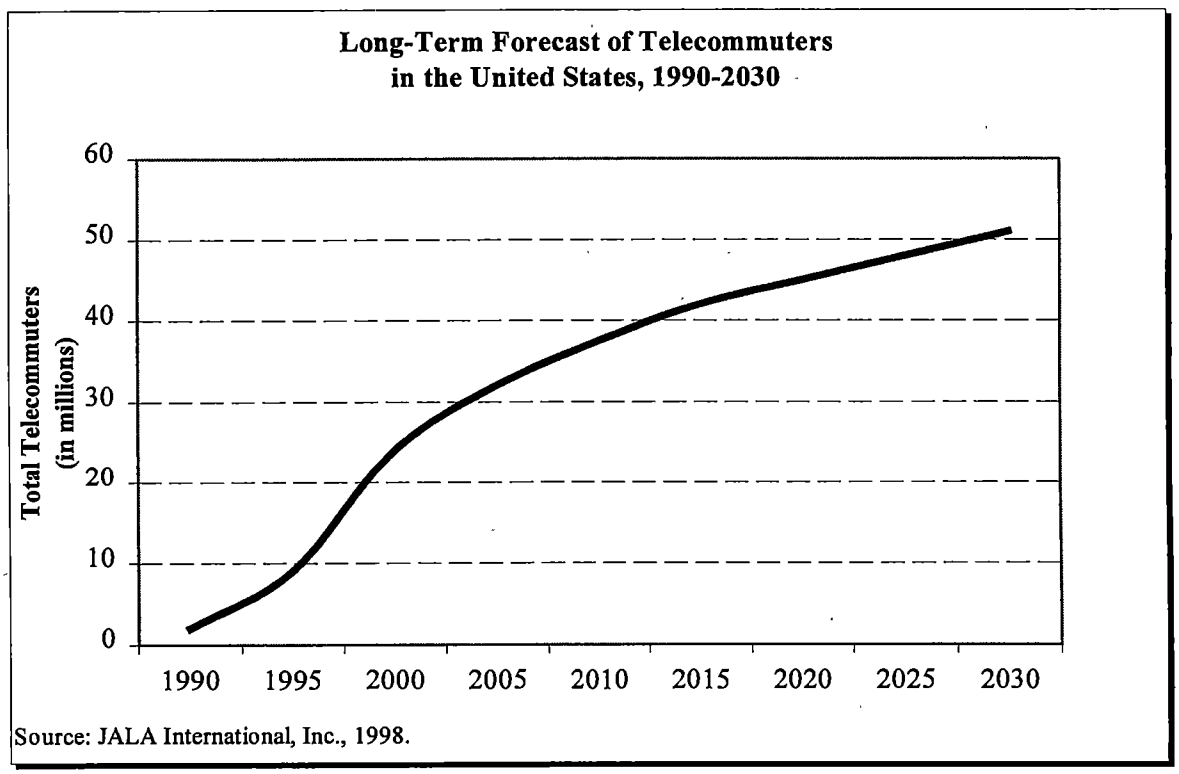

Figure 3. Telecommuting Forecasts for the United States.

2015. According to this forecast model, the maturation of telecommuting will occur between 2020 and 2030 and the number of telecommuters will eventually exceed 50 million in 2030, or more than 60% of all information workers (JALA, 1998; Park et al.,1996). The estimates and forecasts developed by JALA Inernational are widely considered the most current and reliable data in the field of telework.

Another set of data set is reviewed briefly at this point to provide necessary background information for the discussion of physical development impacts in Chapter Four. One of the first comprehensive studies of telecommuting in the United States was prepared in 1993 by the U.S. Department of Transportation. This report, entitled *Transportation Implications of Telecommuting*, is noteworthy because the estimates and forecasts from the report were applied in subsequent analyses of telecommuting impacts by other federal agencies. Some of those subsequent reports contain the most rigorous analyses of physical, environmental and travel-related impacts of telecommuting to date.

The data set of estimates and forecasts used by the Department of Transportation span from 1992 through 2002, and were developed by JALA International and Link Resources, a market research firm. This data projected a lower and upper bound range of telecommuters over the ten-year period. Beginning from a base total of 2 million telecommuters in 1992, the Department of Transportation projections range from 5.8 million and 9.2 million telecommuters in 1999. Current estimates of approximately 20 million telecommuters demonstrate strong real growth rates of telework during the past five years, and that these initial projections were conservative. The upper bound estimate for 2002 was 15 million telecommuters. An analysis of the various impact analyses fro the upper bound data will provide some of the relative insights into the magnitude of

telecommuting impacts. Notwithstanding the conservative baseline information, the impact analyses of this data illustrates an order of magnitude that suits the exploratory purposes and objectives of this research.

Factors Influencing the Impacts of Telecommuting Volumes

The impacts of telecommuting and telework are a function of the frequency and duration of the activity, in addition the volumes of teleworkers. Very simply, 20 million part-time telecommuters will have different social, physical and economic impacts than 20 million full-time telecommuters. The frequency of telework is expected to increase in the near-term future for several reasons:

- Teleworkers consistently express an interest in teleworking more often in surveys and pilot projects;
- A majority of non-teleworkers and companies without telework programs are interested in initiating telework in the near-term, according to surveys; and,
- The driving forces of telework are increasingly relevant and material (Strategic Decisions Group, 1996; Mohktarian, 1997; Satellite Office Association of Japan, 1997; Park, et al., 1996).

3.15 Characteristics of Teleworkers

Teleworkers are primarily information workers involved with knowledge functions, analytical functions or sales and marketing functions. These information workers are actually employed across all of the basic industries— agriculture, manufacturing, services and the information sectors, as depicted in the Table 5 on the following page (2 Nilles, 1997).

Table 5. Common Information Worker Occupations

Accountant	Clerk/typist	Human resources	School administrator
Actuary	Commercial artist	Journalist	Software engineer
Administrative assistant	Consultant	Industrial engineer	Statistician
Advertising executive	Contract monitor	Lawyer	Stock analyst
Agent	Computer scientist	Manager	Stock broker
Analyst	Data entry clerk	Market analyst	Surveyor
Architect	Data search specialist	Professor/teacher	Systems analyst
Appraiser	Economist	Programmer	Telemarketer
Auditor	Engineer	Purchaser	Telephone operator
Banker	Executive	Receptionist	Training designer
Bookkeeper	Financial analyst	Realtor	Word processor
Broker	Graphic artist	Researcher	Writer

Source: Link Resources in U.S. Department of Transportation (1993).

Jack Nilles, founder of JALA International, a telework consultancy, estimates that approximately 40% of the current labor force could telework part-time in the United States and the United Kingdom (Nilles, 1997; Nairn, 1997; Office of Technology Assessment, 1995). A slightly lower share of the workforce in other western European nations would be amenable to telework. In certain regions with serious traffic congestion, a high percentage of information workers, or other mitigating factors, 47% or more of the labor force may be suitable for telework. Southern California is an example of one such region (Park et al., 1996).

Current levels of telework equate to 10% of the United States labor force with lower penetration rates in Europe ranging from 5% to 8% (Nairn, 1997; Nilles, 1997). Various factors determine the actual rates of telework including organizational knowledge of telework practices, job and employee suitability, and management support (Office of Technology Assessment, 1995). On an international level, actual adoption of telework will also be influenced by population growth rates, income levels, information

technology infrastructure, government regulations affecting technology and the business climate, education, and other demographic factors (9 Nilles, 1997).

Three basic job tasks are considered most amenable to teleworking: routine information-processing tasks, mobile activities, and professional and knowledge-related tasks (Office of Technology Assessment, 1995). Table 6 summarizes the characteristics of each type of job tasks, recognizing that a given occupation may entail more than one of these tasks.

As shown in the Table 6, the pool of potential teleworkers partially depends upon the suitability of certain job tasks and functions to telework arrangements. Other factors that must be considered are whether a job requires the worker to be in a specific physical location to work; the worker's level of self-motivation and past performance; and how the position relates to colleagues in the company (Strategic Decisions Group, 1996).

Table 6. Basic Job Tasks Amenable to Teleworking

Type of Job Function	Description	Representative Occupations	Resources
Routine Information-processing Tasks	Well-defined information and data handling tasks that are not location dependent	Customer service, directory assistance, dispatcher, data entry	Adequate telephone service; possibly computer w/ modem for network access
Mobile Activities	Duties performed at the customer's site or in the field; may require occasional to office for meetings or use of shared resources	Sales staff, service representatives, delivery staff, some professionals (insurance claims agents or certain consultants)	Mobile telephone, voice mail, laptop with modem access to company network;
Professional & Knowledge-related Tasks	Non-routine processing, manipulating, and analyzing of data and information; most work involves computer files and/or paper documents	Writers/editors, software engineers, executives, marketing professionals, consultants	Telephone, fax, computer w/ modem

Source: U.S. Office of Technology Assessment (1995).

Many companies with successful telecommuting programs are attempting to expand the telework option to more employees.

An examination of the most common tasks actually performed while teleworker yields additional insights into potential telework levels. The most common tasks performed by both managers and regular professionals telecommuting are shown in Table 7. Most of the activities completed by teleworking employees require a minimal amount of technology. While managers and executives have always been strong candidates for telework, these survey findings suggest that staff employees are equally suited for teleworking (Strategic Decisions Group, 1996).

Table 7. Most Common Activities Performed by Teleworkers from Home

Teleworking Employees			Teleworking Managers		
Rank	Activity	% of employees	Rank	Activity	% of managers
1	*Sending/receiving e-mail*	76%	1	*Thinking*	63%
2	*Thinking*	63%	2	*Calculating*	53%
3	*Writing*	60%	3	*Spreadsheet analysis*	51%
4	*Reading*	53%	4	*Computer programming*	47%
5	*Phone work*	52%	4	*Design work*	47%
6	*Planning*	48%	6	*Project management*	41%
7	*Editing*	45%	6	*Data manipulation*	41%
8	*Computer programming*	44%	8	*Reading*	37%
8	*Analysis*	44%	8	*Contract management*	37%
10	*Research*	43%	10	*Research*	35%

Source: Strategic Decisions Group (1996).

Company Size of Teleworking Businesses

Since the beginning of the 1990s, larger corporations have increased telework levels to achieve cost savings, retain quality employees, and to comply with traffic reduction mandates. A single, definitive set of current data regarding the degree of teleworking by business size is not available, but information from various sources indicates that telework levels have increased among all business sizes. During the 1990s, the levels of

telecommuting among U.S. companies have been increasing at between 35% and 38% annually. A Bell Atlantic study determined that approximately 2 million businesses in the United States already had a formal telecwork program in 1995 (Becker et al., 1993; Park, et al., 1996). Overall, the evidence from a variety of sources demonstrates that telework has become a common business practice among businesses of all sizes during the 1990s. This is largely attributed to the proliferation of lower cost network computing and the expansion of the Internet.

Research indicates that at least 25% of Fortune 1000 companies have a formal telecommuting program for employees (Skinner, 1999). Actual levels of telework among large corporations are substantially higher given the degree of informal telework in practice, with estimates as high as two-thirds of the Fortune 1000. Table 8 lists a sampling of large corporations and government agencies that have adopted telework programs.

Table 8. Sampling of Major Organizations with Telework Programs

Private Sector		
3 Com	Coca-Cola	Pacific Bell
Aetna Life Insurance	Compaq	Sears
America West	Delta Airlines	Sun Microsystems
American Airlines	Digital Equipment	Steelcase
American Express	Eastman Kodak	TRW
American Express	EDS	Unisys
Andersen Consulting	Ernst & Young	United Airlines
Arthur Andersen	First Interstate Bank	**Public Sector**
Bankers Trust	Ford	Federal Flexible Workplace Pilot Project
Bell Atlantic	Georgia Power	State of California
Bell South	GTE	State of Arizona
Best Western	Health Net	State of Minnesota
Blue Cross/Blue Shield	Hughes Electronics	State of Texas
Chevron	IBM	City of Los Angeles
Chiat-Day	JC Penney	County of Los Angeles
Cigna	MCI	City of San Antonio
Cisco Systems	Merrill Lynch	Washington State Energy Office
Citibank	Mobil Oil	U.S. General Services Adminsistration

Source: U.S. Department of Transportation (1993); Becker et al., (1993); Park et al., (1996); Strategic Decisions Group (1996); Mahlon Apgar, IV (1998).

Data from the beginning of the decade show that telework has been more aggressively adopted by small and medium-sized businesses than by larger corporations. According to surveys by Link Resources, a technology research firm in New York, small and medium-sized businesses accounted for 70% to 80% of all telecommuters in the United States during the 1990's (USDOT, 1993; Skinner, 1999). The notably stronger adoption of telecommuting among smaller companies and organizations is attributed to four general factors:

- Less formal organizational culture;
- Greater ease of innovation;
- More flexible standard operating procedures
- Staff flexibility is typically beneficial to both employees and employers in small organizations (18 USDOT, 1993).

Frequency and Duration of Teleworking

Contrary to perceptions of a full-time telecommuter working at a residence in a bucolic setting, most telecommuting currently occurs on a part-time basis. In 1997, home-based telecommuters averaged 18.6 hours per week and telecommuted for a median of 12.0 hours (Cyber Dialogue, Inc., 1997). This equates 2.35 days on average and 1.5 median days.

One area of debate among observers is the future degree of home-based telecommuting versus telecenter-based telecommuting. One view assumes that the telecenter may be a palatable "intermediate step" towards home-based telecommuting for employers that are inexperienced at managing flexible work arrangements. This perspective assumes that many such telecommuters will convert to home-based

telecommuting making it the dominant form of telecommuting in both the near and long-term (170 Office of Technology Assessment, 1995).

Gil Gordon, a management consultant and national telecommuting expert, and others anticipate a gradual increases in all other forms of telework. Gordon predicts that as telework becomes more common, salaried telecommuters will balance home-based telecommuting with one or two days in the central office, a satellite office, or as mobile worker in the field (Shellenbarger, 1995).

As of 1992, 84% of telecommuters were part-time, home-based telecommuters, 15% were full-time, home-based telecommuters, and the remaining 1% were telecenter-based telecommuters. Since then, the telecommuting mix has changed modestly, however, small growth in telecenter use on a part-time and full-time basis, and in combination with home-based telecommuting, is expected to reduce the number of full-time, home-based telecommuters. Given the steady overall growth rate of telework, the part-time, home-based telecommuting has remained constant as an 80% to 85% share of telecommuting in the United States.

Most experts on all sides of the debate acknowledge that full-time, home-based telecommuting will become the least practiced form of telecommuting in the future. The future mix of part-time and full-time telecommuting from the home, telecenters, or both, is much less certain, and will be determined by the degree that these forms of telecommuting serve the needs of different market segments (Bagley, et. al., 1994).

Initial evidence suggests that the telecenter-based telecommuting has developed slower than expected in the United States, and will be explored further in section 4.22 of this document. The telecommuting experience in Los Angeles supports that finding.

Bruce Roberts, the Rideshare Program Administrator for the City of Los Angeles Department of Personnel is a recognized authority on implementing telecommuting programs. He has observed that the degree and types of telework will vary according to local conditions, and the variations are especially notable when comparing telework in different countries. The varied success of telework centers is an illustrative example of the different telework climates in the United States, Europe and Japan. To date, telecenters have struggled to operate at full occupancy in the United States. In the Los Angeles metropolitan area, roughly two-thirds of telecenters established during the 1990s have failed without public subsidies. Several factors have inhibited the operation of telecenters in the United States:

- Home computers have become ubiquitous: Household computer ownership rates are very high among the office-working population; for the entire United States penetration rates for home computers now exceed 45%.
- The cost of rapid technological obsolescence that outdates the computers and related capital equipment in telecenters, thereby, reducing the attractiveness of the telecenter option.
- Relatively large American homes provide adequate space for a home office (Roberts, 1998).

By comparison, in Europe and Japan, accessibility to quality personal computers and related office equipment at telecenters and the relatively expensive property markets both enhance the viability of telecenters over home-based telecommuting (Roberts, 1998; Satellite Office Association of Japan, 1997).

Formal and Informal Telework Programs

The frequency and duration of telecommuting in an organization is influenced by whether that telecommuting occurs within a formal program framework or on an informal

basis. Initial evidence indicates that formal telecommuting programs tend to be more successful than informal telecommuting practices (14 Strategic Decisions Group, 1996; Nilles, 1997; Roberts, 1998). Those telecommuters with a set telecommuting schedule telecommuted 2.3 days per week as compared with the 1.6 days per week for informal telecommuters in California (44 Strategic Decisions Group, 1996). The adoption of formal telecommuting programs generates increased levels of both formal and informal telecommuting within those organizations. The greater frequency, or success, of formal telecommuting programs is attributable to the technology support, management and training, and organizational changes that are employed to execute a formal program. Many formal telecommuting programs are preceded by a pilot project to determine overall feasibility, resource requirements, management support necessary, and other organizational issues requiring attention.

Informal telecommuting tends to be most successful at high technology companies that have the technological resources and expertise, flexible management, and a conducive organizational culture that supports telework practices in a fashion similar to the formal programs adopted by regular companies (39 Strategic Decisions Group, 1996). In the case of the telework population in the Silicon Valley region, the number of informal telecommuters is at least double the size of the formal telecommuting pool (28 Strategic Decisions Group, 1996). Nationwide research supports this finding (USDOT, 1993).

Conventional Versus Contract Employment Status

Although the majority of telecommuters in the United States are conventional, salaried employees, surveys indicate that a substantial share of the other telecommuters, about 30%, are contract employees working as a contractor or temporary employee (Cyber Dialogue, Inc., 1998). In the past two years, conventional employees have been added to the telecommuting pool at three to six times the rate of contract employees. This trend is a function of increasing diffusion of technology among businesses, particularly network computing and e-mail communication, coupled with the growing acceptance of flexible work arrangements these applications facilitate. This suggests that concerns about extensive downsizing and outsourcing contract services, or even "electronic sweatshops" are unfounded in the United States at this juncture (Cyber Dialogue, Inc., 1997).

Teleworker Productivity

The general consensus about productivity increases for teleworkers is approximately a 20% improvement according to numerous third party surveys and studies, internal corporate research, and expert opinions (Nilles, 1997; Cairn, 1998; Park, et al., 1996; AT&T, 1998; JALA, 1990, 1993). Pilot projects conducted in California during the early 1990s reported productivity improvements ranging from 12.5% to 20% (JALA, 1990, 1993). More recently, a national survey of teleworkers by AT&T showed a 22% productivity increase among teleworkers experiencing work improvements. Companies in the Silicon Valley region have consistently reported individual teleworker

productivity gains of up to 30% on average since initiating a telework research initiative in 1994 (Strategic Decisions Group, 1996).

The reasons cited for increased productivity focus on fewer interruptions, better concentration, reduced commute times, working at peak times, and greater job satisfaction. In the AT&T national survey, 71% of those experiencing productivity improvements were primarily due to fewer interruptions and better concentration. For 11% of those in the national teleworker survey, productivity decreased. On average, teleworkers reported a 5% decline in productivity due to excessive distractions and interruptions (50%), a lack of technical support (14%), and difficulties balancing work and life responsibilities (7%). The remaining 50% of the respondents to this national survey indicated little change in productivity (AT&T, 1998).

While available information supports the general finding of 20% productivity gains, survey research among Silicon Valley companies revealed differences in the perceived teleworker productivity improvements depending on the position and perspective of employees in the organization. Teleworkers assessed personal productivity improvements most optimistically in the 17% to 25% range over a three year period. For the same period, managers and coworkers perceived telecommuter productivity levels increased between 5% and 16% when compared with normal work arrangements (20 Strategic Decisions Group, 1996).

Perceived group productivity improvements are lower overall than personal productivity levels according to both teleworkers and managers. Teleworkers estimated work productivity increases ranging from 7% to 7.5%. Managers reported group productivity gains of 5% while coworkers estimated increases of 2.5% to 4% (20

Strategic Decisions Group, 1996). These survey responses reflect the same relative differences that personal productivity assessments demonstrated among the different types of worker. In addition to personal productivity improvements, the impact of telework on work group productivity will affect the diffusion rate of telework among businesses.

Technological Support and Requirements

Technologies used by a typical home-based telecommuter include traditional phone service, a personal computer or laptop computer with a modem, e-mail, and a facsimile machine (Office of Technology Assessment, 1995). Telecenter-based telecommuters, hoteling teleworkers, or mobile office teleworkers typically have access to more advanced information technology such as computer networks, mobile phones, and possibly access to high-speed, broadband communications networks.

Table 9. Primary Telework Technologies and Services

Technology or Service	**Commonly Used Examples**
Personal Computer Products	Personal computer, modem, fax board
Telephone Lines/Products	Telephone answering machine, multiple phone lines, cordless phone, fax, two-line phone
Central Office Telephone Services	Call waiting, call forwarding, three-way calling, speed dial, caller identification
Messaging/Mobile Communications	E-mail, computer bulletin boards, paging, voice mail, cellular mobile phone, personal communication networks/services
Text Processing	Word processing, desktop publishing and other software
Utilities	Spreadsheet software, database retrieval, file transfer
Image Processing	Manipulation, display and storage of images for animation, 3-D modeling, fax, videoconferencing, scanning
Advanced Data Applications	Computer simulation, statistical software, mathematical packages
Symbolic Reasoning	Artificial intelligence support for logical and quantitative reasoning

Source: U.S. Department of Transportation (1993).

A rapidly growing number of new technological applications are available to teleworkers, particularly in the area of mobile technology. While the full spectrum of technologies continues to expand, the primary technologies and services utilized by teleworkers are classified in the following table.

The information technology that has been developed over the last thirty years accelerates the compression of time and space. Currently available technologies already enable the new work forms and work places employed by teleworkers around the world. The model displayed in Figure 4 provides a simple illustration of typical information technology applications of teleworkers in light of the time-space convergence underway in the Information Economy.

		TIME	
		Synchronous	**Asynchronous**
SPACE	**Same Location**	Face-to-face meetings One → One One → Many Many → Many	Office bulletin board Mailbox/Memos
	Different Location	Telephone Shared screens/Groupware Videoconferencing One → One One → Many Many → Many	E-mail Voice mail Fax Electronic bulletin board Other network computing

Figure 4. Time-Space Convergence and Information Technology of Teleworkers. Source: Strategic Decisions Group (1996).

As shown in the Figure 3 above, information technology facilitates telework by expanding communications opportunities to different locations, expanding the number of participants, and taking advantage of the efficiencies of asynchronous communications.

The Core Information Technologies

A report prepared for the Southern California Telecommuting Partnership succinctly surmised that the future adoption of telework would be greatly influenced by "the availability, capability, and cost of telecommunications and information systems." The core technologies supporting telework are in the areas of computers and microelectronics, telecommunications, and networks, all of which have been increasingly integrated during the 1990s to maximize the potential of information technologies (21 Park, et. al., 1996). The primary function of these integrated core technologies is to process larger amounts of information more efficiently - - an end result which better enables teleworking.

Computers, supported by increasingly more powerful microprocessors and computer software allow a telecommuter to process information outside of the principal workplace (22 Park, et. al., 1996). Thomas Moore, one of the founders of the Intel Corporation, articulated a postulate about microprocessors and computers that has described the rapid rate of technological change and obsolescence that has become a worldwide standard of digital technology. In what has been termed "Moore's Law", he predicted that the processing power of microprocessors would double every 18 months (Gilder, 1989; Park et al., 1996). This trend of increasing computer power enables more job functions to be successfully telecommuted.

Telecommunications systems are the vital infrastructure that supports the transmission of information among different locations anywhere in the world. Data transfer, e-mail, voice mail, fax, file sharing, teleconferencing, and videoconferencing are some of the numerous telecommuting activities supported by telecommunications. Substantial advances in telecommunications are leading towards broadband communications networks which will greatly improve the capabilities of network computing and other activities that will make telework easier for a greater number of job functions (22-23 Park et. al., 1996).

Computer networks have become the crucial capital infrastructure of modern businesses in the Information Economy. These wide area networks (WANs) and local area networks (LANs) are digital technologies that capitalize on the connectivity possible via telecommunications systems (23 Park, et. al., 1996). For teleworkers, computer networks provide a means of remote access that permits comprehensive use of the organization's computer resources and direct communications with colleagues from the home, a telecenter, a client site, or anywhere in the field.

New Enabling Technologies

The evolving centrality and ubiquity of the Internet has now made it feasible for companies to provide "gateways" to company networks (WANs or LANs) on the Internet rather than requiring a remote dial-up. Teleworkers in these organizations can access the company network from any location they can log on the Internet, providing virtually global access to computer networks. Telework experts note that the growing diffusion of network computing among businesses and organizations has an indirectly positive

influence on the adoption of telecommuting (23 Park, et. al., 1996). They indicate that organizational experience with network computing acclimates an organization to many of the technological, operational and management issues associated with telework.

More advanced and ubiquitous network computing could be supported with a universal network or "pervasive computing" model. A universal model places applications on the network, typically the Internet, and places the computing power on the network rather than burdening a worker's personal computer or the office server computer. This model then allows a worker to connect company networks via a variety of devices that are more efficient than personal computers (Economist, 1998). Wider diffusion of network computing, whether under the client server model or the universal model, will have the same general effect of making it easier to adopt and successfully implement telework.

Although desktop videoconferencing is becoming less expensive, market acceptance and demand are yet unproven. Videoconferencing and certain large data file transfers generally require faster data transmission available via current digital telephony (Office of Technology Assessment, 1995). Any technologies that accelerate the shift from paper-based documents and office systems to digital documents and computer-based systems make telework easier, cheaper, and, therefore, a more viable option for a larger portion of the workforce. Electronic imaging which digitizes documents for access by personal computer and "groupware" or "shareware" software, such as Lotus Notes, are two examples of technology applications that make it easier to move work to the workers (Office of Technology Assessment, 1995).

Actual Technology Usage of Teleworkers

Nilles estimates that about 30% of all telecommuters in 1990 did not require any technology beyond basic telephone service (Nairn, 1997). Telecommuters can perform many job functions with merely a telephone, notepad and pen (21 Park, et. al., 1996; Roberts).

According to most telework experts, existing technologies are sufficient to sustain considerably higher levels of teleworking in the United States during the near to mid-term (Office of Technology Assessment, 1995; USDOT, 1993). Feedback from telecommuting employees indicates that current technology supports stand-alone teleworkers universally, and that remote group work conducted on a regular basis may require more advanced technological support. Managers and employees telecommuting in Silicon Valley indicated that technology supporting remote group work was not currently a major concern, although such technological improvements are expected to accelerate telework (31 Strategic Decisions Group, 1996; OTA, 1995).

As shown in Figure 5 on the next page, a majority of surveyed telecommuters used a computer, modem, printer, extra phone line, and voice mail. This data also shows the degree to which telecommuters and employers shared the expense of the information technology products and services used for telecommuting. Eighty percent of telecommuters surveyed in Silicon Valley were satisfied with the level of technological support and services provided by their employers. By comparison, approximately 90% of those surveyed telecommuters were satisfied with the technology and services available in the regular workplace (31 Strategic Decisions Group, 1996).

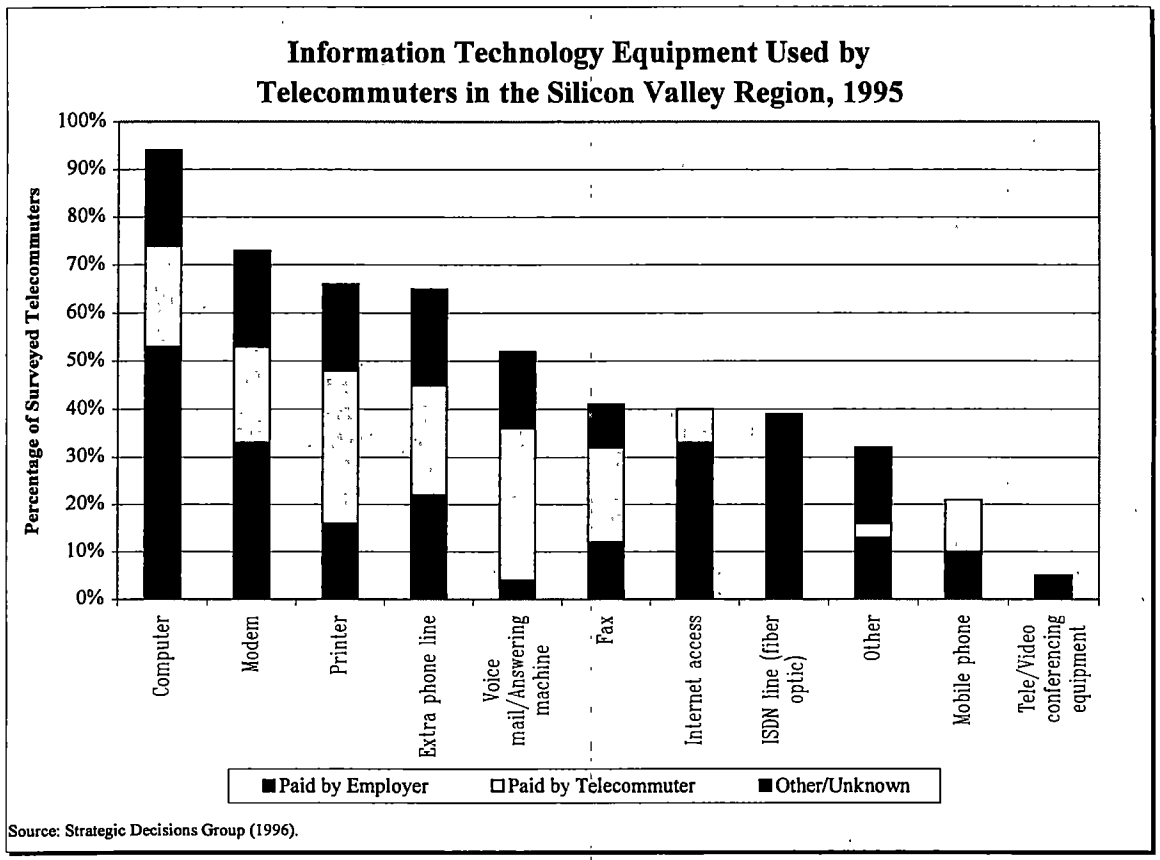

Figure 5. Technology Usage and Payment Responsibility.

Overall, adequate technology is available to support existing teleworkers and a further expansion of telework. At the same time, technology improvements enabling greater levels of telework with greater ease are regularly entering the marketplace. On average, teleworkers are satisfied with the technology available and cost sharing to enable a telework arrangement.

3.2 FORMS OF TELEWORK

3.21 Home-based Telecommuting

Home-based telecommuting is the most common form of telework, and typically entails working from the home on a part-time or full-time basis during normal working hours. These telecommuters substitute telecommunications and technology for a commute to a regular place of work. Typically, the commute trip being eliminated is a suburb-to-suburb commute or a suburb-to-city commute depending on the concentrations of urban and suburban employment centers. Home-based telecommuting rarely entails a reverse commute from the city to suburbs. The part-time, home based commuter accounts for 80% to 85% of telecommuting in the United States. Full-time telecommuters account for an additional 10% to 13% of all telecommuters at present. Long distance telecommuters and so-called independent homeworkers are business owners or self employed persons that primarily work out of the home (Niles, 1994).

Current Magnitude

According to survey findings by Cyber Dialogue/FindSVP, a market research firm considered a leading source of estimates on home-based telecommuting[6] in the United States, the number of home-based telecommuters in the United States increased from 8.5 million in 1995 to 11.1 million in 1997. This significant growth in telecommuting represents a 15.3% annual growth rate since 1995. These relatively strong levels of telecommuting between 1995 and 1997 exceed the high-growth scenario

[6] In the Cyber Dialogue/FindSVP survey, "telecommuting" was defined as working at home during normal business hours at least one day per month.

forecast prepared by the U.S. Department of Transportation in 1993 by 19% (Cyber Dialogue, Inc.; USDOT, 1993). Over the long-term, telecommuting has increased at an annual growth rate of 31% during the past seven years, reflecting the higher growth rates associated with the early adoption of a new practice (Cyber Dialogue, Inc., 1997).

The recent surge in telecommuting during the past two years has been supported by three major factors:

1. Strong economy approaching full employment requires efficient deployment of labor and increased management flexibility to retain productive employees and attract new employees;
2. Rapid adoption of information technology in the form of corporate computer networks, and use of the e-mail, voice mail and the Internet;
3. Changing management practices that increasingly emphasize results over physical presence and the application of technology to achieve higher productivity (Cyber Dialogue, Inc., 1997).

Flexecutives- A Unique Type of Long-distance Telecommuter

Due to a steady stream of teleworkers moving to small towns and resort areas, the term "flexecutives", or location-flexible executives, has been coined to describe this growing group (51 Leinberger, 1994). Formerly, it was only freelance professionals such as artists, writers and consultants that had the ability to live in these locations. During the 1980s, however, middle and upper management executives also began to select small towns and resorts as their place of residence. Their extensive travel and time out of the office made the shift to full-time telework more palatable since most of these executives "lived on airplanes" (52 Leinberger, 1994). This collection of professionals now live in locations with a highly desirable quality of life, and commute to work via jet airplanes and information technology. "Flexecutives can live where they choose and still remain plugged in to the economic mainstream. They are redefining the American Dream of

living on a one-acre lot with a spouse, two children, a dog, two cars – and a two-hour roundtrip commute to work (51 Leinberger, 1994)."

There are two main traits flexecutives are seeking in these smaller towns: 1) distinctive "attractor" attributes in a small town setting and 2) proximity to an airport servicing the metropolitan base of operations, or that is commutable in one day. This second factor requires same day, round-trip air service between the central office and place of residence. A combination of quality of life factors that are particularly strong in resorts and small towns lure the flexecutives (beautiful setting, climate, small-town values, distinctive geography, culture, quality shopping and restaurants). The single day commute and accessible air service, in particular, limits the field of potential locations substantially. The second phase of the flexecutive trend is the actual relocation of an entire company or company unit to a small town. One of the better known examples was the relocation of Mrs. Field's Cookies from San Francisco to Park City, Utah. The company founder and her family were lured by the mountain setting and small-town values (53 Leinberger, 1994).

In the process of moving residences and businesses to these areas, these towns are effectively becoming another suburb of certain major metropolitan areas. With the continued improvement of the national economy and rapid technological advances, both phases of the flexecutive trend are expected to accelerate. The magnitude of the trend is not, however, readily gauged with quantifiable data.

Information Technology Requirements

In addition to a reliance on standard phone service, home-based telecommuters have embraced personal computers as a fundamental telecommuting tool. Ownership rates of personal computers have increased from 43% to 75% of the estimated home-based telecommuters in the United States between 1990 and 1997 (Cyber Dialogue, Inc., 1997).

Over the past fifteen years, the cost of home office products have declined, substantially minimizing cost barriers to home-based telecommuting. In 1983, a computer, operating software, printer and answering machine cost approximately $10,000. By 1990, the same office equipment cost $5,000, and the same package with an additional fax machine cost just $3,000 in 1993 (41 Braus, 1993). Office equipment costs have continued to decline, especially for powerful personal computers as the cost of computer semiconductors continues to decline rapidly.

Rapid growth trends for both e-mail and Internet use among telecommuters have emerged in recent years. According to surveys by Cyber Dialogue, Inc., the share of home-based telecommuters in the United States who utilize e-mail increased from 9% in 1994 to 31% currently, reflecting an annual growth rate of 56% during that period. Regular use of the Internet had already reached 35% of all telecommuters in 1997, based on available survey findings (Cyber Dialogue, Inc., 1997).

Home-based telecommuters exhibit a "strong home technology adopter profile" according to Thomas Miller, vice president of Cyber Dialogue, Inc., a market research firm which tracks telecommuting, work-at-home and information technology user trends

in the United States. Miller surmises that, "Today's telecommuters appear to have discovered how to take advantage of personal information technologies to empower themselves and their families to improve the balance between work and personal life. They are clearly in the top 20% of households that know how to use technology to their best knowledge (Cyber Dialogue, Inc., 1997)."

3.22 Telecenter-based Telecommuting

Definition and Characteristics

Telecenters are defined as technologically advanced office facilities providing temporary or longer-term office space and technologies enabling telecommuters to work closer to home during normal business hours. The three defining characteristics of telecenters are:

1. a location closer to the residence than the regular place of work;
2. access to office equipment and telecommunications systems that allow telecommuters to perform a full range of business functions; and,
3. part-time and full-time telecommuters work at the telecenter, and may also telecommute from home part-time, during normal business hours (USDOT, 1993).

Telecenters are generally located near large residential concentrations where the facilities are accessible to the professional, managerial and office-serving labor pool, typically in the suburbs or near public transit stations (USDOT, 1993). For the purposes of this research, there are two basic kinds of telecenters that will be discussed and analyzed: Satellite Telecenters and Multi-Employer Telecenters. While more detailed breakdowns are defined in some of the previous research literature, these definitions are sufficiently defined to distinguish all types of telecenters.

Satellite telecenters are single-employer telework facilities established by large corporations or federal and state government agencies to decentralize the workplace structure through technology (Bagley, et. al., 1994). The mix of employees distinguishes this facility from the typical branch office. Usually, the employees working at a satellite telecenter are not co-workers from the same department (95 Becker, 1993). Unlike a traditional regional or branch office, a satellite telecenter operates by remote work supervision and reduces the amount of commute travel required. Satellite telecenters may yield these large organizations a variety of economic and operational efficiencies by reducing office space costs, accessing new labor markets, and retaining highly skilled employees (Bagley, et. al., 1994).

Multiple-employer telecenters are telework centers that provide office space, equipment and resources to telecommuters employed by different organizations. Various private businesses, non-profit organizations and government agencies operate these telecenters and charge the users for space and services through a fee structure and lease agreements. Most of the early telecenters were government supported pilot projects, and today many telecenters, including privately operated facilities, receive some public funding. Multiple-employment telecenters are the broadest type of telecenter and have two notable subcategories worth identifying. The telecottage is the first significant subcategory.

Telecottages are the dominant form of telecenter outside of the United States, particularly in the United Kingdom and Western Europe. Most of these facilities are established and operated with government funding and some eventually become independent, private operations. Telecottages are multiple-purpose centers that were

established to stimulate economic development in rural areas (Bagley et. al., 1994). The primary functions of the typical telecottage entail provision of a combination of some of the following services:

- vital access to information technology (computers and telecommunications links to the outside world);
- job training for home-based and telecenter based teleworkers;
- information technology skills training;
- brokerage of remote/telework services to organizations in other regions;
- small business assistance and services;
- business services to local home-businesses;
- distance learning facilities (Bagley, et. al., 1994).

The second significant subcategory of the multiple-employment telecenters is neighborhood telecenters. Neighborhood telecenters are smaller facilities intended to serve teleworkers in the immediate area surrounding the center, ideally in walking distance of residential neighborhoods.

In the case of California where there is a substantial inventory of telecenters, most telecenters are publicly funded and operated by either a local government or the regional transportation management association. Less than one-third of the active telecenters in California are privately operated, and most of these facilities received some public funding in the form of grants. Private donations of equipment and services from area businesses were common among both private and publicly operated telecenters (Buckinger, et al., 1997).

Current Magnitude

Telecenters are a new phenomenon without precise tallies of facilities nationally or internationally. As of 1993, when data was collected for the first comprehensive

telecenter study, there were only twelve known multiple-employer telecenters in the United States. Satellite centers are not as readily quantifiable but there is evidence of increasing numbers of these centers (Bagley et al., 1994; Apgar, 1998). Between 1994 and 1997, a total of 16 new neighborhood telecenters were opened in California as part of a state initiative (Mohktarian et al., 1997). National figures are not available, but the number of new telecenters and experiments since the mid-1980s demonstrates a growing interest in telecenter-based telecommuting.

The first known telecenter was a multiple-employer, demonstration facility established in Marne-la-Valle, France in 1981. In the United States, Pacific Bell reportedly opened one of the earliest satellite telecenters in 1985, and the State of Hawaii established the first multiple-employer telecenter (telework center) four years later (Bagley, et. al., 1994).

In most advanced countries, the main external motivations for the establishment of telecenters have often been new state and federal regulations regarding air quality, traffic congestion and energy conservation. Some governments have also supported the development of telecenters as an economic development strategy as exemplified by the Kentucky rural telecenter project and Finnish telecottages (95 Becker, 1993). From the perspective of businesses, companies establish satellite telecenters or allow employees to telecommute from telecenters to reduce costs or increase productivity.

In the United States, California has been the leading state for telecenter development. A total of 45 multiple-employer telecenters have been established in California since 1991. As of September 1997, 21 telecenters closed when demonstration projects ended or due to financial instability. Nineteen of the currently operating

facilities are regional telecenters and the other five were neighborhood telecenters (Buckinger, et al., 1997).

There are several reasons for California's leading position which may be instructive regarding the adoption of telecenter-based telecommuting elsewhere. First, the state government has supported numerous telecenter pilot projects and telecenter research programs. Secondly, California has generally been at the forefront of telecommuting as a state due to serious air quality problems and strict state regulations requiring trip reduction strategies, including telecenter-based telecommuting. Thirdly, the state's sizable high technology business community develops products enabling telework. Pacific Bell, Symantec, Cisco Systems and other companies have embraced telework for both internal operations and as a business opportunity.

The ranks of multiple-employment telecenters are likely to change substantially during the next three to five years as executive office suites and even full-service copy centers, such as Kinkos, reposition their products and services to serve the telework market. HQ Business Centers, Omni Office Group, Regus, Your Office USA, and Optima Worldwide are major executive office providers, and cumulatively have over 1,200 facilities worldwide in their respective national and international networks of facilities. Each of these companies is presently undergoing rapid expansions through new construction and property acquisitions in North America, Europe and Asia. For example, Regus, a British company plans to open 90 new facilities during the next year. A sampling of products and services offered by Regus are shown in Table 10 above. Aggressive business plans and service offerings illustrate how quickly these companies may introduce a new supply of sophisticated, market-responsive telecenters.

Table 10. Sampling of Products and Services Offered by Regus (Executive Offices)

Products & Services	Description
Regus Link	Telecenter office space can be rented on an hourly basis by individuals; teleworkers are provided a business address and administrative support
Touchdown	Membership service with daily rates for access to any facility with 24-hour reservations around the world; serves business travelers and mobile workers
Business Center	Company leases office space on weekly, monthly or annual basis; access to all facilities and support.
Netspace	Turnkey office space with custom information technology infrastructure and services developed and managed for clients; priced per person not by square footage; fast-track delivery of custom space
Video Conferencing	State-of-the-art systems available on an hourly basis with global service and translators
Worldwide Meeting Facilities	Access to meeting rooms through global network

Source: Regus (1999).

As evidenced by the mix of flexible, customer-oriented services, executive office companies are targeting the telework market. The current and future volume of telecommuters working out of executive office facilities is not quantifiable and may represent an undercount of telecommuting levels. While this research cannot directly address them, those executive office facilities portend an accelerated expansion of telecenter facilities that are located and operated to profitably meet the needs of telecommuters. Such facilities and operations would address the major shortcomings of the publicly subsidized telecenters established so far in the United States, and could have a significant impact on the adoption of telework and metropolitan development patterns.

Characteristics of telecenter-based telecommuters

Telecenter-based telecommuters are professionals employed in public and professional organizations. In California, the most common occupations were

government employees, engineers, lawyers, real estate professionals, bookkeepers and other professionals (Buckinger, et al., 1997). Administrative occupations were not in evidence at studied telecenters (Bagley, et. al., 1994).

Based on the experience in North America and Japan, satellite telecenters have been received positively by employees. Worker productivity and job satisfaction generally improves at satellite telecenters due to fewer interruptions and reduced stress levels (95 Becker, 1993). Early participants in this form of telework have identified some concerns about satellite telecenters. The primary shortcomings to date have been a lack of technical support, concerns about inclusion in current projects and future career advancement, manager training, and enhanced communication with co-workers and managers. These concerns do not outweigh the benefits of satellite telecenters in the view of participating employees (95 Becker, 1993).

Location and Physical Requirements

Site selection for a telecenter varies by the type of center and according to the goals of the operators. A location in close proximity to residential areas and with access to personal and business services are two primary site selection criteria applicable to most telecenters. Sites that are within walking or biking distance of residential areas are preferable since it provides opportunities to eliminate commute trips as home-based telecommuting does (Bagley, 1994). Evidence from a study of state-funded telecenters in California that were established for that purpose, termed the Neighborhood Telecenters Project, indicates that complete elimination of commute trips is difficult to accomplish. Most of the neighborhood telecenters were still several miles from the residences of

telecommuters using the centers, and typically generated a high percentage of interstate highway trips (Mokhtarian, et. al., 1997).

Zoning regulations that severely restrict the operation of a commercial facility near residential neighborhoods can inhibit site selection and the positive effects of telecenters. Telecenters relying on telecommuters from a larger area, greater than a local neighborhood, must consider sites that are highly accessible via highway and transit, if possible (Bagley, et. al., 1994).

The size of telecenters in California ranges from 420 to 14,000 total square feet and between two and 40 workstations. The average facility size is 3,036 square feet and provides 12 workstations (Buckinger, et al., 1997). In addition to individual workstations, Common features of telecenters established included: equipment room, reception desk, site administrator's office, conference room, and a kitchen. The type and mix of spaces consisted of workstations in open office cubicles or private offices (Bagley, et. al., 1994).

According to interviews in California, site administrators have observed a high level of demand for private offices rather than open workstations or cubicles among many tenant companies and individual teleworkers (Buckinger, et al., 1997). This finding suggests that the actual design and build-out of telecenter facilities may directly affect the volume, frequency and duration of telecenter-based telecommuting. If the apparent demand for private office space is met, future telecenters will be much larger than current facilities and will retain characteristics similar to many executive office suites prevalent in North America, Europe and Asia.

Factors Affecting the Adoption of Telecenter-based Telecommuting

Multiple-employer telecenters have been one of the most difficult types of telework facilities to establish in the United States due to numerous forms of resistance from the business community, the primary source of potential tenants for these facilities. In addition to the general resistance of telework by management, the primary barriers inhibiting multiple-employer telecenters in the early 1990s have been as follows:

1. The cost effectiveness of maintaining two office spaces (central office and telecenter) for telecommuters;
2. Managers' discomfort with telework arrangements;
3. Security concerns regarding proprietary employee and company information;
4. High degree of coordination required between all parties: telecenter operators, tenants, telecommuters and their managers; and,
5. The "differential distribution" of costs and benefits places the greatest burdens on employers (Bagley, et. al., 1994).

Of those cited barriers, the economic issues have been the major hindrance to the adoption of telecenter-based commuting among business managers and executives. The mentioned "differential distribution" of costs highlights the various costs employers incur when implementing a telecenter-based telecommuting. Resources expended on reorganization efforts, reconfiguration of central office spaces, new office and mobile equipment purchases, training, and in most cases, dual-rent for telecenter and central office space are some of the possible direct and indirect costs incurred. By comparison, the costs, if any, are modest for employees and resident communities, while all three groups-- employees, communities and employers-- experience any benefits of the telecenter-based telecommuting arrangement.

The more intangible benefits, such as productivity improvements, job satisfaction, and quality of life improvements may offset some costs, but must be better quantified to

address the employer concerns regarding the telecenter work option. Also, evidence from case studies and cost-benefit analyses indicates that true savings on office rent are achievable when alternative officing arrangements, i.e. hoteling or other shared-space arrangements, are coupled with telecenter use (Bagley, et. al., 1994).

Among the early telecenters, none of the seven operating facilities were profitable as of year-end 1992. Most multiple-user facilities were either closed or converted to a single-employer telecenter after an initial demonstration period (Bagley, et. al., 1994).

Despite the barriers observed to date, multiple-employer telecenters may have certain advantages over satellite telecenters that may allow these facilities to become an integral aspect of telework. According to an in-depth analysis of telecenters in the United States and abroad that was conducted by transportation researchers at the University of California-Davis, the primary advantages of multiple-employer telecenters are as follows:

- Higher marketability to small and medium-sized businesses: shared facility offers economies of scale
- Lower risk opportunity for large employers to test telecenter-based telecommuting: substantially reduced financial and organizational commitment as compared with satellite telecenters; may, however, serve as a useful "incubator" or pilot center for future satellite telecenters
- Greater potential to reduce commuting: with a larger pool of potential telecommuters in close proximity, commute travel will typically be shorter than that of a single-employer, satellite center drawing from a larger area (Bagley, et. al., 1994).

Over the long-term, all forms of telecenter-based telecommuting may also have potential advantages over home-based telecommuting which address some of the general barriers limiting the general adoption of telecommuting. The advantages listed below

pertain to both employers and employees:

- Separation of work and home life;
- More direct interaction (professional and social);
- Reduced costs through shared equipment and resources;
- A professional atmosphere with adequate workspace;
- Managers have greater confidence in employee productivity (Bagley, et. al., 1994).

In addition to potential advantages and barriers, several critical success factors have been identified based upon the in-depth of surveys of existing telecenters performed by the Institute for Transportation Studies at the University of California-Davis. Among the early telecenters, ineffective marketing was a serious shortcoming. Comprehensive marketing efforts that address product development, design, positioning and pricing, and promotions are necessary to operate a profitable telecenter. The study recommends these general marketing guidelines:

- Establish and maintain marketing as an operational priority
- Employ professional marketing expertise (in-house or contract)
- Market early, well before opening, and regularly
- Promote the center in all possible media outlets, particularly free news accounts and direct marketing (Bagley, et. al., 1994).

Many active telecenters in California have developed broader offerings beyond telecommuting space to generate more operating revenue. Drop-in use of valuable equipment and services like videoconferencing, Internet access, and multimedia equipment are reliable sources of supplementary revenue. Successful telecenters are also establishing relationships with area colleges and offering distance learning classes (Buckinger, et al., 1997).

As with other forms of telework, training both the "telemanagers" and the telecommuters can directly influence the implementation of telecenter-based

telecommuting. While training has not seriously inhibited any of telecenters established in the early 1990s, it may become a critical success factor if telecenter-based telecommuting becomes a widespread form of work in the Information Economy (Bagley, et. al., 1994).

Information Technology Requirements

Individual workstations are generally supplied with the following basic information technology, equipment and services: telephone and voice mail, personal computers, e-mail and internet access, and access to facsimile, copying machines and meeting rooms. Most telecenters set up a local area network (LAN) to achieve the cost efficiencies of shared software and computer accessories. The LAN also allows the telecenter management to maintain the equipment more efficiently, to communicate with the telecommuters electronically regarding center operations, and the network permits telecommuters at the telecenter to collaborate via the network if necessary. Occasionally, a telecenter operator will not provide a computer giving the tenant employer the opportunity to supply telecommuters with a computer that is most suitable for their role in company operations (Bagley, et al., 1994; USDOT, 1993).

Many corporate satellite telecenters, high-end telework centers, or public demonstration sites also have advanced telecommunications infrastructure, such as fiber-optic broadband capacity, to facilitate high-speed data transfer and videoconferencing. Additional clerical services, in the form of secretarial support, and mail retrieval, are also more prevalent at satellite telecenters and the noted high-end telework centers.

CHAPTER 4

FINDINGS AND ANALYSIS

4.1 PHYSICAL IMPACTS OF TELEWORK

As noted in Chapter Three, a pervasive economic transformation is underway in the United States. This ongoing structural economic change is reshaping the landscape of communities and regions across the United States. Telework is one aspect of those changes that represents a new work form and the resultant new relationships and work practices. This section of findings and analysis presents a review of the physical impacts of teleworking on communities and regions. Although the social and economic impacts of telework are outside the scope of this analysis, the interrelationships with the physical development impacts are explicitly acknowledged.

These findings are most applicable to the United States since the majority of the research was conducted in the United States. The findings may also be informative to advanced economies like Japan, New Zealand, Australia, and Europe. Emerging nations and less developed countries may also be experiencing changes associated with telework, but the experience will be significantly different given the different underlying characteristics, systems, and stages of development of these nations.

Most discussions of the impacts of telework focus on traffic congestion, air pollution and energy consumption and the quantifiable change estimated for each variable at the metropolitan or national level (Office of Technology Assessment, 1995). In applying a more comprehensive planning perspective, this section of the research will

also assess the spatial impacts of telework as economic activities are redistributed throughout metropolitan areas. These spatial impacts inherently affect land use and travel patterns, transportation and infrastructure demands, and environmental factors, beyond the quantifiable measures of volume that are typically examined, including the issues of air pollution and energy consumption. Research demonstrates the generalized direct effects of telecommuting: reduced traffic congestion, lower fuel consumption, reduced emissions, and highway capacity improvements/or reduced expansion requirements. It is important to note that, while these direct effects are valid conclusions, the interactions between pertinent factors are complex and often synergistic (Graham et al., 1996).

4.11 Spatial Development Patterns and Land Use

The decentralization of the contemporary metropolitan area has been one primary issues in the field of planning. Numerous suburban employment centers, termed suburban "metro cores" by Christopher Leinberger, a national authority on metropolitan development trends, have emerged since the 1960s in the United States. In many cases, the office employment in these metro cores has grown to exceed the CBD and traditional urban metro cores. The result has fundamentally altered land use patterns and produced multiple suburb-to-suburb commuting patterns that have complicated traffic issues and transportation demand in most metropolitan areas. In theory, teleworkers employed by companies located in suburban metro cores may be able to live further from the urban center. The overall body of empirical evidence regarding how teleworking is impacting

residential land use patterns is limited and inconclusive. As telework is more widely adopted, the type and characteristics of telework, particularly the degree of part-time and full-time telecommuting, will affect the residential location decision (172 Office of Technology Assessment, 1995).

Intra-metropolitan Trends and Decentralization

The intra-metropolitan spatial impacts of telework are complex and will vary on a region-by-region basis as metropolitan and rural areas deal with increasing telework levels. The debate over whether telework causes the decentralization of cities and accelerates "sprawl" has mixed support in the research literature. Observations to date show that there has not been empirical evidence from telework case studies or pilot projects to demonstrate the dispersion and decentralization of metropolitan communities (Office of Technology Assessment, 1995; Nilles, 1991). However, most researchers acknowledge that telework is still evolving and the potential for further decentralization and dispersion is substantial.

One of the first factors affecting the spatial development patterns resulting from telework is the type and frequency of telecommuting. For example, a trend toward more full-time, home-based telecommuting would be expected to decrease the physical and social links to the physical workplace. Most telecommuters are actually expected to be part-time telecommuters that split time between the home, a central workplace, and telecenters. This work pattern requires a residence within reasonable commuting distance of the metropolitan area. However, the fact that these telecommuters do not travel to the

central office increases the ability to move into the outer suburbs or exurbs. Residential dispersion into the suburbs and exurbs of metropolitan areas has been an ongoing trend independent of telework.

Household characteristics are a second factor influencing the impact of telework on residential location decisions within metropolitan areas (Office of Technology Assessment, 1995). Dual-income families are less likely to move because of school considerations or other job commitments. Single-income households are more mobile and amenable to relocating with job changes (Office of Technology Assessment, 1995).

Empirical data from the State of California Telecommuting Pilot Project was one of the first studies to directly assess the question. Specifically, two years of monitoring telecommuters of all types and control groups did not reveal a significant pattern in household moving patterns. Surveys indicate, however, that the ability to telecommute will influence household move decisions. The conclusion from this project regarding urban sprawl is that telecommuting does not "yet" accelerate dispersion, and telecommuting by the program participants did yield net travel reduction relative to telecommuting intensity. Also, the percentage of potential telecommuters that required a telecenter-based program was approximately 50%, which reinforces the opinions of other observers about the mix of home-based and telecenter-based telecommuters (Nilles, 1991). A larger share of telecenter-based telecommuters is more likely to live closer to the workplace and the urban core.

Nilles identified an urban dilemma with two diametrically opposed outcomes. As the nature of work becomes more location independent, there are opportunities to reduce

metropolitan congestion and "bring" work and training to disadvantaged areas through telework. The increased location independence also presents the risk of increased dispersion and urban sprawl since the new work arrangements allow workers to live further from urban centers. The new residences in exurban locations expand the necessary service area for infrastructure and public services (Nilles, 1997). One of the major conclusions of the telecommuting study by the U.S Department of Energy was a potential indirect effect as telecommuting would in fact increase sprawl as the relationship between place of residence and the workplace become more disconnected (USDOE, 1994).

Residential location decisions will place greater importance on quality of life issues as telework becomes more prevalent. Proximity to work and commute times, previously one of the determinant factors, will be supplanted by the quality of schools, shopping, community amenities and recreation (Flehr et al, 1998).

Office Space Demand

Many observers have predicted a significant decrease in demand for office space as individual teleworkers and virtual organizations become more prevalent. The expectation has been that a sizable loss of tenants would leave a substantial inventory of vacant office space in central business districts and other large office submarkets wwithin metropolitan areas (Toffler, 1980; Massotti, 1994; Linneman, 1998). Large corporations are, in fact, reducing their real estate holdings per worker, applying technology, and using more efficient space management techniques, including telework (Apgar, 1998;

Linneman 1998; Becker et al., 1993). But empirical research has not yet evidenced a decline in office space demand due to telework or these other changes in corporate real estate. The Wharton Real Estate Center at the University of Pennsylvania performed an office demand analysis in 1998 to assess the national office market conditions. The model accounted for negative factors, like telecommuting increases, and conservatively projected 1.25% annual growth in office space demand (Linneman, 1998). The primary driver of continued demand is the ongoing economic shift to office-using employment in the information and service sectors, which counterbalances the other factors.

The major change related to the office workplace is the type and configuration of office space demanded. Technologically advanced buildings with large floor plates to accommodate flat organizational structures, team management, and open space practices are in demand (Apgar 1998; Massotti, 1994). These requirements generally favor suburban office locations. The overall impact of telework on office space demand is not perceptible, but any impacts will be more evident on a metropolitan scale of analysis where shifts between employment centers are discernable. If telecenters become more prevalent, those new office spaces would likely account for a share of new office supply in suburban markets.

Centralizing Forces

While telework is an emerging and rapidly developing phenomenon, research about the substitution of information technology for face-to-face communications yields insights about the potential spatial impacts. Preliminary research findings by Gaspar and

Glaesar, economists at Stanford University and Harvard University respectively, suggest that the communications power of information technology has presumably increased the number of potential contacts, and thereby generated more business travel (41 Gaspar et al., 1996). Instead of direct substitution, there appears to be a complementary relationship between information technology improvements to date and the degree of face-to-face communications generated. The effective result is an increasing role in the communications process for personal meeting places, many of which are in cities and metropolitan areas.

The extension of this reasoning is that urban areas will grow in importance as information technology expands the potential number of contacts. The two underlying assumptions of this reasoning are, first, urban development reduces the transportation costs associated with face-to-face communications; and, second, that effective communication about complex tasks requires personal interaction (Gaspar et al., 1996). The fact that most mobile office workers are spending extensive amounts of time in the field with customers or colleagues supports this reinforcing effect of the spatial importance of metropolitan areas. Commenting on the complementary relationship between the development and communications, Jean Gottman has noted the historical effect of the telephone: "the telephone has been used in the evolution of settlement in diverse ways but mainly as a help in the development of larger metropolitan systems with a more diversified and complex structure (Gottman, 1997)."

Nonmetropolitan Areas

"Technology advances, especially in computers and telecommunications, are overcoming traditional penalties of space and distance, opening up new opportunities for nonmetropolitan America (Burgess, 1994)." As illustrated in the above quote, select small communities have new opportunities and will be affected by the flexecutive trend noted in Chapter 4. While this trend largely consists of the movement of home-based telecommuters to small towns and resorts, increasingly these executives and professionals are also relocating company units to their new hometowns. This can also result in corporate satellite offices or sufficient market demand for multi-tenant telecenters.

The greatest physical impact is the rapid increase in residential property values that typically precipitates a shortage of available housing (54 Leinberger, 1994). Resort towns and small towns are, therefore, faced with land use planning and general policy decisions that determine what type of residents may live in the community. There are obvious direct effects on labor force availability and the quality of life impacts on existing local residents.

An array of growth management issues is the second most common physical impact associated with this trend. New development, rehabilitations, and redevelopment generated by these new residents and businesses can cause conflicts over environmental issues, historic preservation, zoning and land use decisions, and infrastructure development. As expected, the economic and social impacts that have also been

witnessed in these "flexecutive towns" are mixed depending on the existing conditions of these communities.

On an intra-metropolitan scale, there is a restructuring associated with this flexecutive trend that has significant effects on the origin city and new locale. As this trend continues and a larger number flexecutives and companies accumulate in these smaller towns, the flexecutive towns become "defacto" suburbs of major metropolitan areas. For example, Santa Barbara has evolved into a flexecutive location for Los Angeles. Other resort areas that meet the requirements of the Los Angeles flexecutive are Monterey and Carmel, California; Lake Tahoe, Nevada; Park City, Utah; and Santa Fe, New Mexico. Interestingly, some flexecutive locations have ties to a single metropolitan area or multiple economic centers around the country. Santa Barbara, Carmel and Monterey, California are towns with a single, direct relationship to Los Angeles. Santa Fe, New Mexico, is effectively becoming a flexecutive suburb of multiple metropolitan areas, including New York, Chicago, Dallas and Los Angeles (52 Leinberger, 1994).

Areas with a mild four-season climate have been favored over the resort communities with mild winters and very hot summers, such as Arizona. Charlottesville, Virginia; Annapolis, Maryland; Hilton Head, South Carolina; Asheville, North Carolina; Telluride Colorado; and Bend, Oregon are examples of areas with a mild climate that also meet the transportation and quality of life requirements of flexecutives (52 Leinberger, 1994). The potential of resort areas as telework locations is evident in Europe as well. In

Spain's Balearic Islands, a network of resort offices have been constructed with advanced telecommunications links to Northern Europe (147 Graham, 1996).

The impacts of these intrametropolitan shifts are greatest on the small towns and resorts receiving the flexecutives, and possibly related business units. Since most of flexecutive towns have small populations, the relocation of just a small percentage of the 16 million person metropolitan population of Los Angeles, or other large economic centers, will have substantial physical, social and economic impacts. The net effect on the development patterns of the source metropolitan areas is insignificant, although the drain of business and civic leadership can be an important, albeit intangible, social loss (54 Leinberger, 1994).

Numerous researchers have asserted that the new forms of work enabled by information technology may expand opportunities for rural development (Nilles, 1997; Graham et al., 1996; Lake, 1995). Two primary applications of technology are: 1) telework opportunities for both rural residents and transferees from metropolitan areas, and, 2) training rural residents for employment requiring new skills. According to Jack Nilles, the telework expert, the following basic infrastructure and services are necessary to support this new means of rural development:

- Technological infrastructure, i.e. adequate telecommunications, computers, software;
- Affordable, quality education and training of the rural population;
- Business support services (12 Nilles, 1997).

The latter point is decreasing in importance as the costs of office equipment and computer peripherals decline, and also due to the growing number of teleservices, both commercial and self-service, offered via the Internet.

4.13 Transportation Systems

The current state of traffic congestion in most metropolitan areas of the United States is poor and declining according to national transportation mobility research. While many larger metropolitan areas have been plagued with traffic problems for decades, smaller metropolitan areas are also witnessing serious problems. In small and medium metropolitan areas, the time commuters waited in traffic congestion increased fourfold over the last 14 years (Lomax, et al., 1998). The estimated economic cost of traffic congestion in the United States was $74 billion, based upon the combined expense of fuel consumption and productivity losses for 70 metropolitan areas in 1996 (Lomax et al., 1998). Others have produced a *national economic cost estimate* of $90 billion in productivity losses alone, excluding fuel costs (6 Nilles, 1997). According to either methodology, the economic cost of traffic congestion is substantial enough to demonstrate the scope of problem.

Findings Regarding General Telework Impacts

The direct effects of telework on travel behavior are positive according to most analyses. The reduction of peak hour travel is the major direct effect of telecommuting. This form of traffic reduction is demonstrably less expensive than the supply-side alternatives that would be necessary to achieve similar results (Office of Technology Assessment, 1995). In a 1993 telecommuting study[6], the U.S. Department of

[6] The forecasts in *Transportation Implications of Telecommuting* were prepared in 1993. Real telecommuting levels for subsequent years have exceeded the high growth forecast significantly. The model also assumed a quicker adoption of telecenter-based telecommuting than has been realized since 1993. Nevertheless, the impact analysis provides a valuable example of the potential effects of telework.

Transportation forecasted a 2.3% to 4.5% annual reduction of total vehicle commuting miles traveled in 2002. The national reduction of actual miles traveled nationally is estimated between 17.6 and 35.1 billion miles based on a range of telecommuting forecasts (USDOT, 1993). On a national basis, these reductions are minimized by the fast-growing rate of vehicle miles driven annually, which is due to new demographic groups entering the driving population (Office of Technology Assessment, 1995).

Although telecommuting yields a relatively small net reduction in total vehicle trips, it has a significant impact on peak hour traffic in severely congested metropolitan areas. Small improvements in traffic flow due to telework can greatly improve travel times during peak hour traffic. Telework also redistributes the vehicle trips in terms of both time and location. Reductions in peak hour traffic congestion are, therefore, offset by new traffic generated on suburban roadways (Office of Technology Assessment, 1995). Latent demand generated by telecommuting may be as high as 50% of the peak traffic reduction due increased driving, especially of single-occupancy vehicles, by other commuters that previously did not drive under the severe traffic congestion conditions (Office of Technology Assessment, 1995; USDOE, 1994).

A review of multiple pilot telecommuting projects by the U.S. Department of Transportation resulted in the following basic findings:

- Commute travel is reduced;
- Non-commute trips remain constant;
- Telecommuters make fewer linked trips;
- Telecommuters typically contract their activity space;
- Fewer peak period trips are made by telecommuters (USDOT, 1993).

The findings regarding the change in the activity spaces of telecommuters are supported and expanded upon in other telecommuting research (Pendayala et al., 1991; JALA, 1990). While telecommuters may be expected to conduct more activities nearer the home, the activity space of the entire household also contracts. The telecommuter and household members typically reduce the distances normally traveled on both commuting and non-commuting days (Pendayala et al., 1991; Collins, 1986). This changing activity space of telecommuters may have a significant cumulative impact on local traffic and community businesses at the neighborhood level, or larger impacts if telework is widely adopted in the future.

In terms of reducing time delays, the forecast through 2010 for major metropolitan areas shows 50% the delay reduction is projected to occur in the ten largest metropolitan areas. The 75 largest metros account for 75% of total delay reduction among 339 metro areas (Office of Technology Assessment, 1995).

Two simple stimulation effects that have been observed among teleworkers, especially home-based and telecommuters, are noted in the following examples. First, trips associated with "just-in-time" delivery, like express mail and courier services, are frequently attributed to teleworkers. Second, teleworkers generate more trips for personal and business services near the residence. Those trips typically include home food delivery, delivery of catalog or home shopping purchases, and shopping at neighborhood retail centers that may have been incorporated into the commute to the traditional workplace or lunch hour.

Findings Regarding Telecenter-based Telecommuting

According to an extensive survey of telecenters, the widespread adoption of telecenter-based telecommuting has the potential to yield substantial commuting reductions for two reasons. First, telecenter-based telecommuters may exhibit higher average levels of telecommuting than home-based telecommuters. Secondly, telecenters expand telecommuting opportunities to employees that are prohibited from home-based telecommuting opportunities by reluctant management or the inability to provide necessary workspace and resources at home (Bagley, et. al., 1994).

The mileage and time savings associated with telecenter-based telecommuting appear to be substantial, even though this form of telecommuting requires a short commute to and from the telecenter. During 1992, 163 workers telecommuting from seven telecenters saved an average of 93.4 vehicle-miles of travel per telecenter use. This pool of telecommuters also saved 2.8 hours of commute time per telecenter use. These reductions are not generalizable to other areas since the telecommuters in the Western States, particularly Southern California, had substantially longer commutes in total mileage and time traveled. This is a function of the longer than average distance the surveyed telecommuters live from the regular workplace and the slower driving speeds on their commuting routes, which average 35 mph (Bagley, et. al., 1994).

In the case of neighborhood telecenters, the positive transportation impacts were a 58% reduction in person miles traveled and a 53% reduction in vehicle miles traveled. Weighted for the frequency of telecenter-based telecommuting, and the reductions in person miles and vehicle miles traveled respectively averaged 11.9% and 11.5%.

Interestingly, most telecenter-based telecommuters drove alone to and from the center and did not exhibit any trip chaining.

4.15 Environmental Factors

Telecommuters primarily reduce vehicle emissions and fuel consumption by driving fewer miles (USDOE, 1994). However, indirect effects of telecommuting can offset a portion of positive direct effects such as reduced emissions. Figure 6 below graphically depicts the interplay between direct and indirect effects as measured by fuel consumption. The forecasted direct benefit of telecommuting (2.9) is reduced urban sprawl (-0.5) associated with residential relocations to cheaper and more distant locations. The stronger indirect effect is the projected latent demand (-1.1), which is the

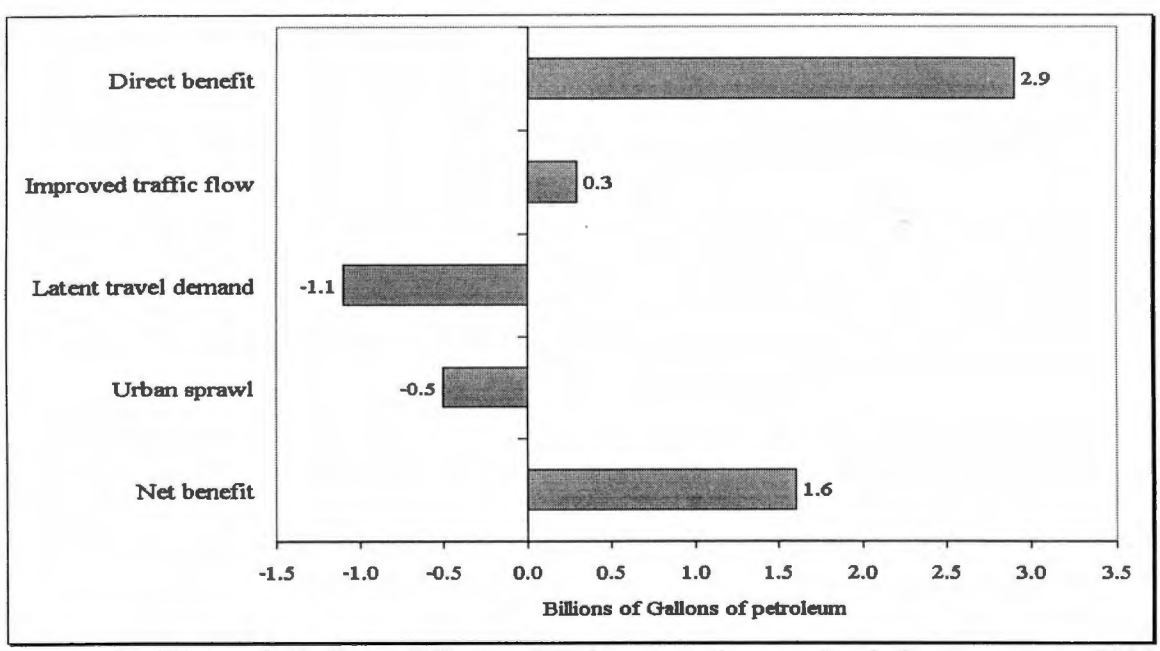

Figure 6. Direct & Indirect Effects of Telecommuting on Fuel Consumption, 2010. Source: United States Department of Energy (1994).

response by non-commuters who begin commuting via the highways because of real or perceived available capacity.

The four major air pollutants generated by auto traffic are carbon monoxide, organic gases, nitrogen oxide, and particulates. The Department of Transportation forecasted the following upper bound reductions of emissions in 2002, based on the conservative estimate of 15 million telecommuters. Carbon monoxide, the largest component of air pollution, was forecasted at a 3.4% reduction, hydrocarbons at 2.7%, and a 2.2% reduction of nitrogen oxides (USDOT, 1993).

Telecenter Use and Air Emissions

The Residential Area Based Offices project in California studied 16 neighborhood telecenters for over a year. Telecommuters reduced their total vehicle miles traveled by 35.2 miles on average, from 66.4 miles to 31.2 miles. Based upon that 53% reduction in vehicle miles traveled (commute and all other trips), the telecommuting from neighborhood telecenters decreased carbon monoxide emissions by 21%, nitrogen oxides by 35%, particulate matter by 51%, and particulate matter by 15%. When compared with the trip to the regular office, average telecommuting vehicle miles traveled decreased by 67% for telecenter-based telecommuters, from 49.7 miles to 16.2 miles (Mohktarian, 1997). These data demonstrate that the overall air quality conditions can improve with increased telecommuting frequencies.

CHAPTER 5

SUMMARY & DISCUSSION

5.1 SUMMARY

This thesis topic was selected because the potential changes associated with telework may fundamentally alter the aspects of the communities and regions the planning field serves. Telework and the application of information technology redefine how and where people can work, and hence, a series of decisions and daily activities that impact social, economic and physical elements of communities.

At the outset of this research in 1995, telework and telecommuting were generally familiar concepts to the some of the working public, and an actual work option practiced by a small but growing segment of the workforce. The body of available research four years ago was fragmented and of limited depth because telework was still an emerging phenomenon. Since then, the general awareness of the both concept and practice of telework have increased, and more extensive research is being conducted by academics, governments, businesses, and non-profit organizations with interests in topic. The intent of this thesis is to contribute exploratory research that assesses telework and the related-physical development impacts from the planning perspective. It may serve to introduce the topic and planning issues worth further investigation in research, policy and practice.

5.2 PLANNING ISSUES AND THE ROLE OF PLANNERS

The forecasts of telework levels project a significant numeric increase in the number of teleworkers in the United States and internationally over the near and long-

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5.2 PLANNING ISSUES AND THE ROLE OF PLANNERS

The forecasts of telework levels project a significant numeric increase in the number of teleworkers in the United States and internationally over the near and long-

term periods. The physical impacts of telework are complex and would benefit from the interdisciplinary research and professional practices offered by planners. Based upon the research completed, a series of planning issues are outlined in the concluding section of this document for further consideration. These issues address the fundamental role of the planner relative to telework issues and the potential physical impacts.

- Planners are well-suited to develop an information base supporting local policy decisions related to telework. This includes applying local modeling to the study of telework impacts. Effective models have been applied on the national level, and provide a basic methodology that is transferable to local and regional analysis. Planners also can enhance this role by fully understanding the characteristics of teleworking, particularly those factors and trends affecting the adoption rate of telework.
- Planning practitioner's and researchers may improve planning results and processes by incorporating telework into comprehensive planning functions addressing land use, transportation, environmental quality, economic development, and capital improvements. On a larger level, the impacts of information technology and the Information Economy require similar treatment in long-range planning functions.
- The planner is well positioned to serve an instrumental role affecting policy discussions and decision making. Planning professionals can "frame the debate" regarding telework issues by providing sound information about the potential implications of telework.

- Planning professionals are positioned to address the zoning and land use conflicts associated with teleworking. Many zoning ordinances prohibit home-based telecommuting and hinder the location of telecenters in, or near, residential areas. Planners may also serve a role resolving potential legal conflicts over deed restrictions commonly prohibiting any commercial uses in residential subdivisions.
- To minimize the indirect traffic impacts of telework, such as latent travel demand, a comprehensive transportation planning effort comprised of travel demand management, intelligent transportation systems, and alternative modes of transportation may be warranted. Planners can develop and coordinate comprehensive programming solutions.

The general planning perspective entails consideration of the numerous interrelated social, economic, and physical factors that determine the development of communities and regions. This research suggests that telework is anther variable worthy of inclusion in the regular planning processes and analyses.

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VITA

Robert Kelly Mulvihill was born in Syracuse, New York in 1970. He was a long-time resident of New Jersey, and graduated from Middletown High School South in Middletown, New Jersey in 1989. He attended Clemson University where he earned a Bachelor of Arts in Sociology degree. In the fall of 1993, Mr. Mulvihill entered the School of Planning graduate program at the University of Tennessee, Knoxville, to study urban planning. Upon completion of coursework in 1995, Mr. Mulvihill worked as development consultant for a planning and engineering consulting firm and a national real estate consultancy. The Master of Science in Planning degree was conferred in August of 1999.

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