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TRAFFIC REDUCTION BY TELECOMMUTING: A STATUS REVIEW AND SELECTED BIBLIOGRAPHY

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Abstract—Telecommuting is defined as a subset of teleworking. Two main forms of telecommuting (home and regional center) are described. The means by which these forms of telecommuting may alter urban transportation patterns are outlined, followed by a review of the empirical evidence to date on the impacts and usefulness of telecommuting. Factors affecting the diffusion rate of telecommuting are discussed, including the commuting environment, technological sufficiency, technological familiarity, the social aspects of work, other telecommuter motivations, management issues, legal and regulatory barriers and incentives, and labor entitlement issues. A brief reference to other work in progress is followed by a set of forecasts of possible telecommuting futures.

THE NATURE OF TELECOMMUTING

Telecommuting is a term coined by the author in 1973 to refer to the partial or total substitution of telecommunications, with or without the assistance of computers, for the twice-daily commute to work. Telecommuting is a subset of *teleworking*, a similarly coined term that includes all work-related substitutions of telecommunications and related information technologies for travel (from substitution of telephone calls or electronic mail for personal visits to the use of full-motion videoconferencing as a substitute for executive travel). In either case the emphasis is on substitution: the worker newly engaged in tele-*X*-ing is altering his/her previous travel behavior.

The focus of this paper is on telecommuting. Telecommuting is not a technology or collection of technologies. Rather, it is a work option that reduces dependency on transportation by increasing dependency on information technologies: telecommunications and, possibly, computers. Telecommuting can be accomplished with no more exotic a technology than a telephone. However, it is likely that most telecommuters in the near future will also be using microcomputers and modems as major work tools. For some telecommuters, fairly elaborate telecommunications (including videoconferencing, for example) and computer facilities may be the norm.

Home-based telecommuting

There are two main forms of telecommuting. The most newsworthy form is *home-based telecommuting*, in which an individual works from home instead of a traditional office. There is a considerable body of literature, developed since about 1973 and continuing to the present, speculating on the likely success/failure and social implications of home-based telecommuting (examples are in the bibliography at the end of the paper). Much of this literature focuses on the nature and advisability (mostly negative) of full-time home-based telecommuting, in which the worker almost never appears in the central office of the organization for which he/she works. While interesting in terms of its sociophilosophical analyses, that literature largely aims at a straw man and misses the point: most home-based telecommuting is (and is likely to be) part-time.

In particular, most contemporary home-based telecommuters are employees of larger organizations, as contrasted with proprietors of home-based businesses who by definition work mostly at home. This is not to say that the telecommuters are part-time workers. They have full-time jobs, part of which is spent telecommuting. Hence, most telecommuters share time between office settings: one at home, one in a traditional office environment (although either or both of these offices may depart in its physical arrangements from the traditional concept of an office).

Further, experienced home-based telecommuters save certain tasks for performance at home and others for the traditional office. For example, telecommuters often arrange meetings (formal or informal) such that they are clustered into one or a few days per week at the "main" office. Similarly, they cluster their "solo" tasks (such as reading, report preparation, analysis, telephoning, etc.) to be performed at home.

Regional center telecommuting

The second main form of telecommuting is regional center telecommuting. There are three variants of this, known as satellite center, local center, and neighborhood center telecommuting. There are the following distinctions among these versions.

Satellite centers are facilities set up by large organizations to house only their own telecommuting staff. Typically, they house from 20 to more than 100 workers, some of whom may still commute several

miles to get to the center—as contrasted with tens of miles commute distances otherwise. For example, Pacific Bell has established satellite work centers in Los Angeles and San Francisco. A branch bank is a well-established example, provided that its employees are local residents.

Local centers are facilities that house a number of telecommuters from different organizations (companies and/or government agencies) in a single structure. Except for the multiple landlord factor they are otherwise similar to satellite centers. The State of California is planning to establish such centers, each housing personnel from several state agencies, in the Sacramento area.

Neighborhood centers are smaller facilities, housing just a few workers, that can serve as mini-satellites or mini-local centers. The emphasis here is on neighborhood: each such center would be within a few blocks of the workers' residences. The author knows of no such centers currently in existence.

For all of these the common criterion should be that they are close to where the telecommuters live (with the neighborhood center being the closest) and the telecommuters work there instead of at home. Clearly, however, some telecommuters do and will share their work time among two or more of these options, including working at the distant central facility. The reason it may be important to distinguish among the variants is that they each have different implications for travel reduction.

A further distinction is important. Telecommuting, as defined above, applies primarily to people who are members of larger organizations rather than sole proprietors/employees of home-based businesses. The reasoning here is that home-based businesses (at least where all the business activity is centered in the home) only change transportation patterns if they employ people who otherwise would be working elsewhere. This latter possibility is not felt to be a major part of the home-based business scene today, although it may well change in the future. In particular, knowledge workers who use microcomputers and telephones to switch from working for some larger organization to becoming individual home-based entrepreneurs qualify as telecommuters. Current trends in the subcontracting of information work by large organizations indicate a steady rise in this form of telecommuting in the future (see Nilles, 1984).

IMPLICATIONS FOR TRAVEL REDUCTION

Each of these forms of telecommuting has the first-order effect of reducing work-related travel to some extent. Further, the reductions occur at times when the transportation network is most highly stressed: rush hours.† In most large urban areas the rate of increase of traffic congestion is steadily pulling away from all attempts to increase the number of passengers per vehicle mile. In fact, average vehicle occupancy rates declined in the United States from 1970 to 1980 while travel times appear to be increasing at a rate close to 1% per year. Attempts at adding to, or even maintaining, urban mass transit systems are not meeting with major success in any urban area in the United States. As central business district (CBD) land values escalate (as measured by office space rents), together with the daytime population density of the districts, the pressures on—and vulnerability of—the transportation grid climb apace. The dominant contemporary commuting pattern has shifted from suburb-to-central city to suburb-to-suburb. (For an analysis of the above, see Pisarki, 1987.) Telecommuting must certainly offer some hope of resolving this impasse.

In order to estimate what, if any, hope is provided by telecommuting it is necessary to examine its specific forms of impact. First the positive effects will be discussed.

Home-based telecommuting offers two travel reduction options: (1) complete substitution for the commute to and from work on the days when a home-based telecommuter is working the entire day from home; and (2) a shift of the commute time, presumably to times of lower traffic load on the network, on days when the home-based telecommuter goes to the office for only certain core hours, such as from 10:00 A.M. to 2:00 P.M.

Regional center telecommuting offers the following possibilities: (1) work trip length can be reduced to the extent that the residence locations of the centers's telecommuters are closer to the center than to the telecommuters' previous offices (this requires that the company select center locations as centroids of clusters of current or prospective employee residence locations); and (2) modal choice may be altered for suitably near centers such that private automobiles are supplanted by walking, jogging, cycling (weather permitting), or use of a local transit system (if any is available).

The magnitude of the impact of telecommuting on travel volumes depends on the number and modes of telecommuters, the number and physical disposition of regional centers, and the degree to which the telecommuters shift from their prior travel patterns.

To counter the positive effects there are some possible negative effects. First, demand may increase for additional trips, primarily shopping-oriented, that were previously chained together with the commute from work or that took place during lunch periods. Second, to the extent that regional center telecommuting does not produce modal choice shifts, traffic may increase on local roads and streets to unacceptably high levels; that is, the heavy loads are shifted from freeways designed for high traffic levels to local streets incapable of satisfying the demand. This may have serious implications for planning of mass transit systems, particularly those supporting

†In Los Angeles the rush "hour" lasts roughly 4 to 6 hours.

suburb-to-suburb travel. Third, the (civilization-suppressed) vagabond desires of most people might be exacerbated in telecommuters, causing them to increase leisure travel during nonworking hours and during vacation periods.

Thus, one can conceive of some counter scenarios. In the *transportation-idyllic* version, masses of telecommuters work from home, do not alter their nonwork habits, and the existing transportation infrastructure becomes sufficient for transportation demand for the next 20 years or more, until population growth finally causes network expansion.

In the *transportation-travesty* scenario, the telecommuters, while reducing daytime peak period traffic, create increased loads on the local infrastructure and intercity travel system far in excess of their work-related savings.

Which of these scenarios is closer to reality? An investigation is in order to discover what real telecommuters are doing today, to evaluate how—and whether—those activities may be generalized, and to engage in some preliminary forecasting. In order to estimate future trends it is necessary to understand the forces impelling or retarding acceptance of telecommuting and to assess the current status of telecommuting as a work option.

MOTIVATIONS FOR TELECOMMUTING

First, it may be useful to review the key motives for telecommuting. They can be segregated into three categories: public, organizational, and personal.

The public good

One clear motive for expansion of telecommuting is the reduction of transportation congestion, particularly in overcrowded urban areas. With that reduction comes an array of side effects such as improved air quality, decreased rates of traffic accidents and injury, diminished demand for new freeways (possibly), and reduced consumption of fossil fuels. For example, a forecast of the potential impacts of telecommuting on energy consumption in California (JALA Associates, Inc., 1983) showed an annual savings of 8 billion passenger miles and 7.5 billion kWh over the nontelecommuting case in the year 2000. These estimates are based on the critical assumption that telecommuting does not spawn compensatory travel for other purposes, as in the transportation-travesty scenario above.

Telecommuting may have other positive side effects as well. These include reductions in property crime (resulting from a greater likelihood of home-based telecommuters participating in "Neighborhood Watch" activities), increased participation in local government, educational, religious and community activities, and enhanced family life.

Organizational objectives

While laudable, public benefits are insufficient as major motivations for corporate or public agency decisions to commit their own funds and effort to encourage telecommuting. Direct, tangible economic benefits are far more persuasive. These include: productivity/effectiveness increases; cost reductions from decreased employment turnover rates (and associated recruitment and training costs), space savings in existing buildings, reduced rental rates (compared to city centers) for regional office space, reduced medical claims and sick leave; and enhanced access to or retention of scarce talent.

Telecommuter productivity may increase, compared to traditional office workers, because of a combination of harder (or more intense) work and more hours of actual work performed per day. This in turn may result from fewer distractions and interruptions and less commuting-related stress. One consequence of stress reduction is increased job satisfaction; hence, a lower quit rate and fewer medical problems. Space savings accrue to the extent that part-time telecommuters share office space or confine their in-office use to conference rooms. Several organizations claim to have been able to use telecommuting as the key incentive to retain key personnel who would otherwise have quit, or to attract people who did not want to change residences or commute farther to work.

These incentives must be balanced against a major disincentive: the reluctance to adopt a distinctive new (hence unknown and implicitly risky) work and management style. This has been a significant barrier to adoption of telecommuting, as is discussed below.

Personal factors

Cost savings (such as reduced clothing, lunch, and automobile expenses) are part of the inducement for home telecommuters. A more powerful motivation may come from the enhanced ability to interleave work and personal time priorities. Home-based telecommuting gives exceptional flexibility in this respect.

Given these theoretical advantages, it is important to address current realities to assess the relative weights of the arguments.

THE EMPIRICAL EVIDENCE TO DATE

A review

There are several difficulties to be overcome in acquiring empirical data on telecommuters' transportation habits. First, *most contemporary telecommuters are employees of organizations that have no formal policies vis à vis telecommuting*. Hence, it is difficult to locate individual telecommuters. Although several organizations have mounted formal telecommuting pilot projects over the past two decades, they have not kept records of the transportation effects of telecommuting in any controlled way. They also are generally loathe to release to the public whatever data they have. Hence, the researcher must generally be content with anecdotal evidence and mini-case studies that are not readily generalizable.

However, there is some empirical evidence to report on telecommuting-induced travel impacts.

In 1974 Nilles *et al.* reported on a study of 108 employees of an insurance firm in Los Angeles, covering a six-month period in 1973 (Nilles *et al.*, 1974, 1976). These employees were telecommuters in two satellite centers. While the average one-way commute distance for the company as a whole (2,700 employees) was 10.7 miles, the satellite center telecommuters had an average one-way commute of about 3.8 miles, a 65% reduction in one-way commute distance. There were no home-based telecommuters in that study. Although no formal survey was made at the time, spot interviews elicited the comments by telecommuters that there was no associated, offsetting increase in leisure trips.

One other interesting finding of the 1973 study was that residence distance was proportional to organizational level of the employee. That is, although the average commute distance for all employees was 10.7 miles, the average distances of residences of executives, middle management, and clerical workers from work was 16.6, 13.3 and 9.3 miles, respectively, in ratio of 1.8:1.4:1. These patterns probably could be considered typical for most contemporary large urban areas. The average commute distance in the Los Angeles area at that time was about 9.7 miles.

McClintock surveyed a set of 140 home-based telecommuters in 1983 (McClintock, 1984). He reported that half the responding telecommuters worked at home 31 hours or more per week and spent 10 days or less per month in the main office. A majority (58%) of the telecommuters' time was spent working with computers. Half of the individuals surveyed lived in large cities or their suburbs, where the transportation impacts are likely to be greatest. Unfortunately, no commuting distances were listed. Most of the survey respondents were professionals rather than secretarial or clerical workers.

In 1984 and 1985 Nilles *et al.* surveyed 906 middle managers and professionals in 8 Fortune 100 firms as part of a more general study of the organizational impacts of information technologies (Nilles *et al.*, 1986). Of that number, half reported that they spent time working at home with their computers in addition to going to the office. A small number (3.1%) said that they spent at least 8 hours per week working at home *instead of* going to the office (46.7% reported working at home *in addition to* working at the office), although only one was a full-time home-based telecommuter. None of these individuals was asked how far they lived from work, although most were in major metropolitan areas and presumably lived at least the average distance from work typical of those areas (that is, at least 15 miles if their residence pattern was the same as the 1973 insurance company study). The respondents came from locations all over the United States.

In a 1987 study of 44 telecommuters (and 35 non-telecommuters with similar jobs in the same organizations) in three large corporations (mostly located in the western United States), Nilles found that the telecommuters lived an average of 30.2 miles from work and spent an average of 40.8 minutes commuting when they did go to the office (Nilles, 1988). The nontelecommuters spent an average of 24.6 minutes to commute 14.8 miles. The telecommuters spent an average of 4.2 full days and 3.9 partial days per month (or 1 to 2 days per week) working from home, and an average of 7.2 full and 1.4 partial days per month, respectively, working at a satellite center. All of the satellite center workers also telecommuted part of the time from home. This suggests that a typical telecommuter (at least in 1988) might share time among all three options: home-based telecommuting, regional center telecommuting, and traditional commuting. No data were taken on non-work-related travel by the telecommuters and their families, although interviews with some of the telecommuters indicated that there was little, if any, generation of new trips. All of the telecommuters were managers or mid-level professionals.

In fact, most of the survey data for which trip information was available, or could be estimated, relates to the trip habits of managers and professionals. The 1973 study did, in addition, include secretarial and clerical workers. This group was found to live closer to work, on average, than the mid-level employees, as mentioned above. Other home-based telecommuting case reports, such as the Blue Cross/Blue Shield project (Geisler, 1985), are concerned entirely with clerical workers but do not provide commute distance information for similar workers. Hence, *ceteris paribus*, estimates based solely on trip distance savings by mid- and upper-level workers are likely to be too high if telecommuting turns out to be uniformly distributed among all levels of information workers.

Some tentative conclusions can be reached from these data†:

1. Home telecommuters come in a wide spectrum of intensities; some work only occasionally, others almost full-time, but the average at present for people with "normal" (that is, neither solo-activity-intensive or face-to-face interaction intensive) jobs is between one and two equivalent days per week.
2. Trip savings by home-based telecommuters are not offset noticeably by generation of new trips.
3. Some regional center telecommuters also telecommute from home.

†Since most of the publicly available data deal with small sample sizes and short test periods, rigorous statisticians may be left with considerable uneasiness about the generality of some of the conclusions given here. Data available to the author from more extensive tests in private organizations, while not publishable, give the author, at least, more confidence. However, more extensive tests, both in sample size and duration, with publicly available results are clearly needed here.

4. Load spreading telecommuting (that is, telecommuting from home during peak traffic periods with trips to and from the office during nonpeak hours) appears to be a significant option for telecommuters. Although this is a voluntary activity—impelled by the discomfort of rush-hour commuting—the result accrues to the benefit of the entire transportation system. Of course, this is true of *all* the public benefits derived from telecommuting that result from myriads of individual decisions.

5. The propensity to telecommute is proportional to commute distance/time. Therefore, the most highly motivated telecommuters tend to be those who live farthest from the office.

Adoption rate considerations

What these data do not show is the rate of adoption of telecommuting. These few documented studies, covering a few hundred individuals, do not show how many telecommuters there are today. Nor do they show how many there will be in 5, 10, or 20 years. They also fail to point out what the distribution of modal choices in telecommuting will be. *If telecommuting is restricted to a small, possibly elite, fraction of the work force its impact on transportation congestion will be minimal.* If telecommuting accounts for reductions of 5% or more of vehicle trips in congested periods then its impact could be significant. It is the author's estimation that the latter case is more likely and that the 5% reduction (compared to what would be the case otherwise) will occur in at least one major U.S. city in the mid-1990s; earlier if there is another intervening energy crisis.

The key to understanding these issues lies in the nature of technological substitution and social change (see, for example, Linstone and Sahal, 1976). Telecommuting constitutes a classic example of substitution of a new technology (in this case an evolving complex of technologies) for an older one (primarily private automobile transportation). It is a case in which the substitution will never be complete. That is, some fraction of the work force will never telecommute. In particular, telecommuting is largely confined to information workers. That immediately restricts its potential use to slightly more than half the work force in developed countries.

Further, analysis of the nature of information jobs leads to the conclusion that about 20% of information jobs, at present, do not allow significant amounts of telecommuting, even from regional centers. In particular, the extent to which the tasks required for job performance are independent of the location of the worker is an indication of the "telecommutability" of the job. A job (such as butcher, baker, candlestick maker—all nontelecommutable) is a collection of interrelated tasks, some or all of which may be location-independent. Information jobs constitute between 50% and 60% of contemporary U.S. civilian jobs. The exact percentage depends on the method of estimation. Each of these jobs can be task-analyzed to arrive at a location-independence value. The details of the analysis are beyond the scope of this paper. For general estimates and methodology, see Porat (1977).

Assuming conservatively that 50% of the workforce comprises information workers, 80% (100% − 20%) of the information workers and 40% of all workers are potential telecommuters. With an estimated 1987 workforce of 115 million, about 45 million are potential telecommuters in the United States in 1987, most of whom live within metropolitan areas. This gives an indication of the upper limit size of the telecommuting universe. This universe should grow in the future as both new information jobs and more powerful information technologies develop.

The next consideration is the rate at which, and the extent to which, telecommuting will be adopted by these potential telecommuters. This is a function of a number of factors, some of them technological but most of them sociological. Here are some of the major factors.

The commuting environment. As traffic congestion increases, and as baby boomers move farther out from city centers in search of affordable housing, both trip times and frustrations, not to mention physical dangers, increase proportionately. As the data indicate, this can be a significant factor in impelling a decision to telecommute.

Technological sufficiency. Until relatively recently the technology required for effective telecommuting was either too limited in capacity for all but a few types of information work or was too user-surly to be accepted by any but the most motivated workers. The capabilities of information technology, as measured by such factors as packing density and speed of manufactured microchips, have been increasing at roughly a 30% annual rate since the mid-1960s and are likely to do so into the 1990s. Much of the more recent improvement in information processing power has gone into increasing the conviviality of the technologies, thus materially lowering the barriers to its acceptance. The most significant lags at present are in telecommunications software and network interconnectability.

Technology familiarity. With more than 10 million personal computers in active use in the United States in 1987 (at least half of them in offices), a rapidly growing fraction of the information work force is becoming competent in routine use of computers and telecommunications to accomplish their work. By the mid-1990s it is quite possible that most U.S. information workers will have ready access to the primary supporting technologies of telecommuting.

Social aspects of work. Work for many people is an end in itself, a means of self-fulfillment and not just something to do in order to earn money to achieve their primary (nonwork) goals. The social aspects of work—socializing with colleagues, making new friends, etc.—can be major inducements to go to the office. Several writers have dismissed home-based telecommuting on the basis of this consideration alone, making the unwarranted assumption that te-

lecommuting is an either–or proposition; that one either does it all of the time or not at all. As our data presented here suggest, many, if not most, home-based telecommuters have developed home–office patterns in which the solitary-effort tasks are performed at home and the primary social and other face-to-face interaction is performed at the office.

The case is actually more complex. Many telecommuters and other users of computer-based electronic mail systems (once they have overcome the user training barriers) have discovered that a certain amount of social interaction is facilitated by the network and that home-based telecommuting is by no means synonymous with isolation. Nevertheless, the 1987 group of telecommuters felt that their involvement in office social activities was slightly less as a result of their telecommuting. The telecommuters surveyed in 1987 (Nilles, 1988) reported that they felt the quality of their working relationships had slightly improved over what they were before telecommuting began.

It is important to distinguish between social participation and working relationships. Although both home-based and satellite telecommuters seemed to feel that their involvement in office social activities is slightly worse, both job-related feedback from colleagues and quality of working relationships are felt to have slightly improved.

For telecommuters in regional centers the situation is similar. Where the regional centers have a mix of workers that is similar to that of the "main" office there may be no perceived difference in socialization. Where the regional center contains a diverse array of workers, and only a few representing any particular organizational unit, then the socialization factor may be perceived as indistinguishable from that of home-based telecommuters. Our interviews of satellite office telecommuters in 1987, where the telecommuters generally came from different parts of the company, indicated that the telecommuters looked positively on the increased diversity of their in-office contacts. However, other satellite office experiments have reported greater anomie among the workers.

Employee motivations. A major factor reported by almost all home-based telecommuters is that they feel more in control of their lives. Respondents to the 1987 survey also stated that they were better able to concentrate on crucial tasks, had lower feelings of work-related stress, and were able to get significantly more done. These personal satisfaction factors repeatedly have outweighed economic considerations for telecommuters. However, most of the telecommuters interviewed so far have been in the middle or higher family income range.

Management issues. A major deterrent to telecommuting is managers' resistance to change. Of particular importance is the set of attitudes that effective management requires large amounts of direct visual observation and/or frequent face-to-face contact (Nilles, 1988). In brief, the perceived return from telecommuting must be significantly higher than the "break-even" level before managers in most firms are willing to accept telecommuting. That is, although productivity improvements, reduced needs for office space, enhanced ability to attract or retain scarce talent, etc. can be claimed with increasing justification to significantly exceed the costs/risks of telecommuting, the risks perceived by managers—especially when combined with the lack of significant rewards for risk-taking or innovation and large penalties for failure—may still outweigh the claimed benefits.

Telecommuting requires a change in management style for some managers. Because of the loss of ready visual cues managers must move from a process to a product orientation when dealing with their subordinates; they must be significantly more concerned with identifying and negotiating for specific results than with monitoring work activities.

Additionally, managers do have to expend more effort on some management activities, particularly those of maintaining quality intraunit communications. Also, development of regional offices requires effort in planning and acquisition of facilities, selection of facility managers, and development of telecommunications networks. All of these require relatively intensive efforts over a period of several months. It is significantly easier to set up home-based telecommuters on a case-by-case basis. This explains the relative paucity of regional centers at present.

For these reasons it appears that management apprehensions about loss of control and unrewarded effort are currently the pacing factors in the adoption of telecommuting. Nevertheless, the number of firms and government agencies testing telecommuting appears to be steadily increasing, presently numbering in the hundreds. Electronic Services Unlimited, a New York-based consulting firm, estimates that more than 1,000 U.S. companies employed telecommuters in 1987. In 1984 a review of a variety of information sources by the author produced a list of about 250 companies with telecommuters, almost all of which had no formal telecommuting program. Further, some technological advances, such as low-cost videoconferencing, may materially lower these resistance barriers by allowing inexpensive, high-quality emulation of face-to-face interaction. This, in turn, acts to alleviate much of the manager's uneasiness about being in touch with his/her subordinates.

Finally, although the research to date is largely based on telecommuters as employees of large organizations, the growth of home-based information enterprises is expected to grow significantly over the next decade. Many of these enterprises will behave, for transportation planning purposes, as if they were home-based telecommuters. One survey of big business intentions to subcontract information work led to forecasts of increases as high as 200% over contemporary levels by the turn of the century (see

Nilles, 1984), with a nominal expectation of a 30% increase by that time. This could add several million telecommuters who report to management as subcontractors rather than employees. This may be a less threatening way for a company to adopt telecommuting since it eases the transition to product- rather than process-based management.

Legal and regulatory barriers and incentives. There are several potential regulatory barriers to home-based telecommuting, the most important of which are local zoning codes that prohibit home-based work. Several small cities, and now the City of Los Angeles, are modifying (or have modified) their zoning codes to specifically promote home-based telecommuting. Los Angeles also specifically includes telecommuting as a congestion reduction option for prospective developers of large office buildings. Other regulatory options being proposed (in California, at least) that would act to encourage telecommuting are mandatory parking fees for workers in CBDs and preferential business telephone rates for telecommuters and/or their employers.

Another key issue is liability, particularly for accidents that might occur in the home and for maintenance of equipment. In general, organizations that have been successful in adopting telecommuting also adopt a set of guidelines that clearly state the responsibilities of both the organization and the home-based telecommuters in these areas. These guidelines should also cover contingency plans for down time resulting from equipment malfunctions, family crises, etc.

Labor entitlement issues. Organized labor groups are particularly wary of home-based telecommuting as a ripe area for exploitation of workers, particularly routine information workers such as secretaries and clerks. The fear is that telecommuting will turn into an "electronic sweat shop" for these workers, complete with piece-work payment systems, work speed ups, etc. So far, union activity in this area has been passive. Nevertheless, the trend (if real) to more home-based subcontracting of information work may bring up these issues in the future with increasing frequency.

None of these resistance factors appears to be sufficient in itself to act as an absolute barrier, although the combination of factors can be—and has been—a significant deterrent to telecommuting. Many of the resistance factors appear to be steadily diminishing in effect as more experience (hence confidence) both with personal computers and with telecommuting is accumulated. Nevertheless, the social factors will continue to be the major controllers of the diffusion rate of telecommuting-enabling options.

WORK IN PROGRESS

Several telecommuting pilot projects are currently in advanced planning or early implementation phases. These include a project sponsored by the State of California involving more than 200 telecommuting State employees, a similar project by the City of Los Angeles, several corporate projects of various magnitudes, and a national project in Japan involving the coordinated participation of 20 corporations. Nippon Telephone and Telegraph concluded a three-year pilot project in 1987. The Southern California Association of Governments (SCAG) initiated a telecommuting project for its staff in mid-1987. Generally, the corporate projects do not involve collection of data on travel patterns, since corporate ac-

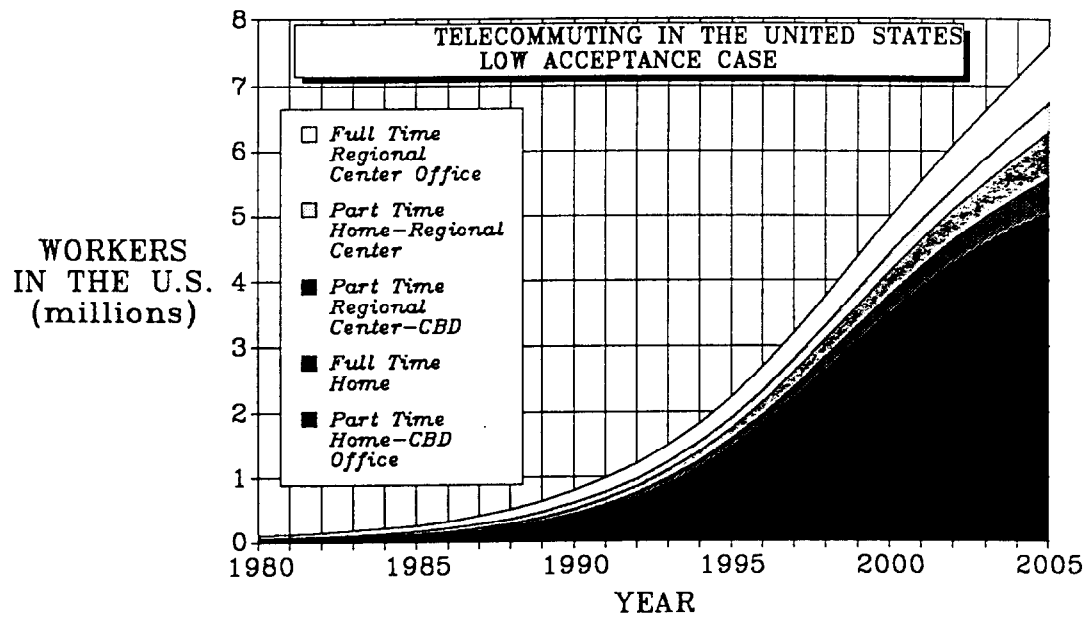

Fig. 1.

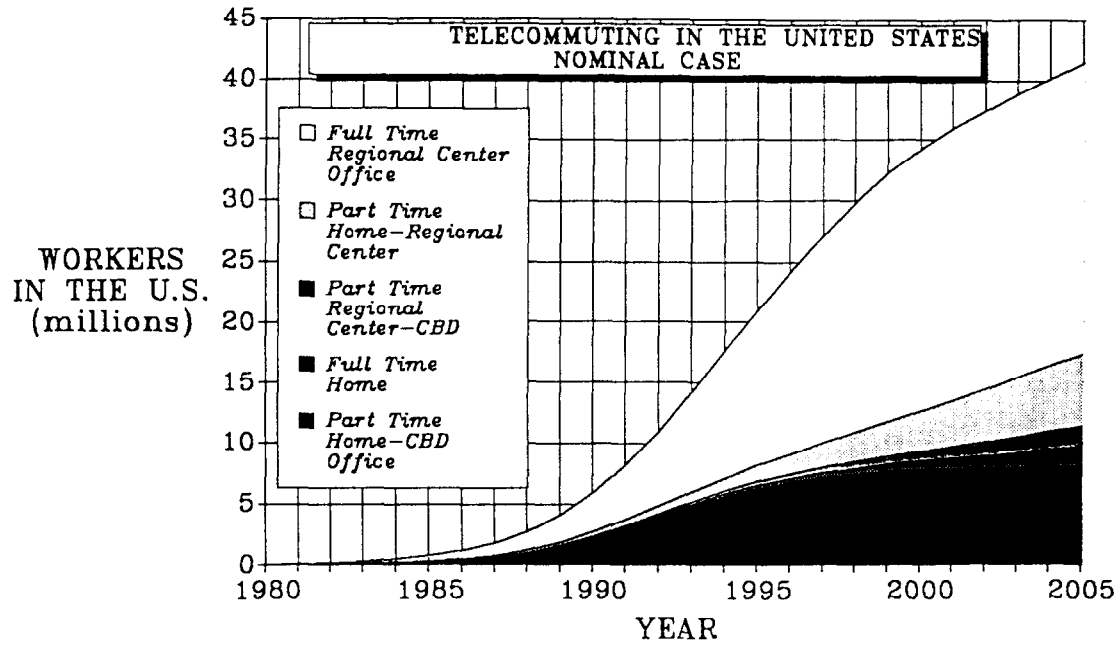

Fig. 2.

counting procedures generally externalize employee commuting costs (not recognizing that commuting costs are at least partially factored into wage demands).

In both the State of California and City of Los Angeles projects, the implementation plans include keeping longitudinal records of the travel activities of the telecommuters and their families. However, since these projects will not be concluded until the early 1990s, they do not give transportation planners an unassailable base of data upon which projections can be built today.

SOME ALTERNATIVE TRANSPORTATION FUTURES

Figures 1 through 3 show estimates of the growth of telecommuting in the United States under different assumptions concerning the nature of the modal

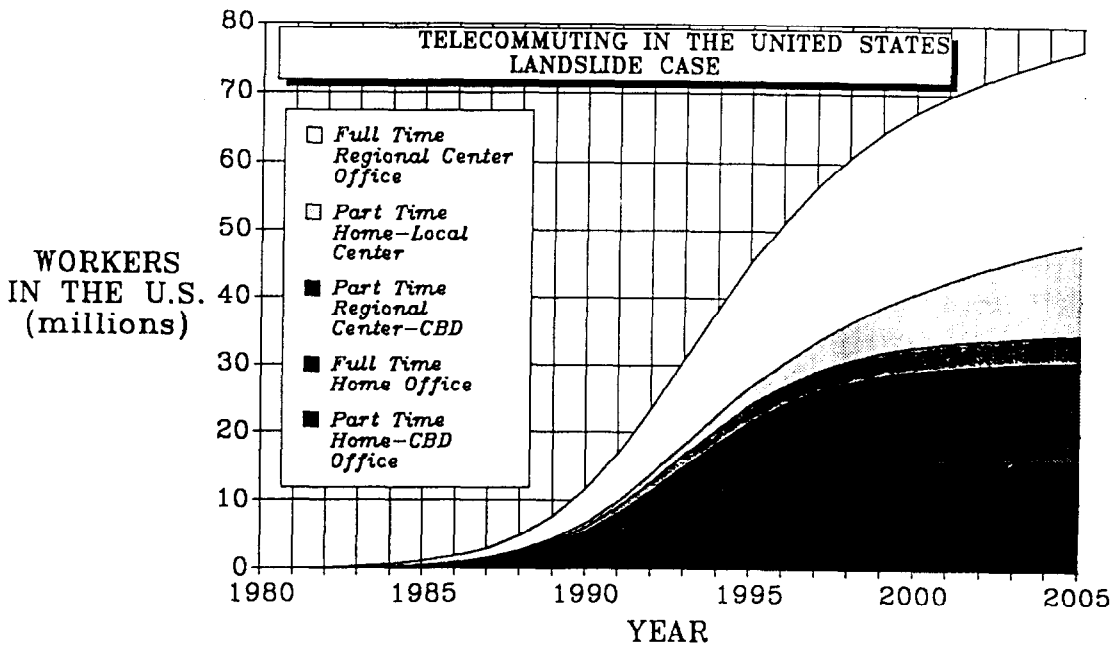

Fig. 3.

split for telecommuting and the market acceptance rates. They depict the future under very low growth, a reasonable "nominal" case, and very high acceptance—"landslide"—conditions, respectively. These forecasts were made in 1983. They all use the Blackman version of the technological substitution curve (see Linstone and Sahal, 1976). The data and assumptions for the curves are included in Tables 1 through 3.

Figure/Table 1 deals with a low acceptance case in which most telecommuting is part-time and home-based. This is consonant with perpetuation of the initial phase of telecommuting in which most telecommuters are managers or professionals who make individual telecommuting arrangements with their supervisors.

Figure/Table 2 represents a nominal forecast; one in which telecommuting is dominated by corporate moves to set up regional centers. Figure/Table 3 shows a mix where essentially all potential telecommuters eventually become active telecommuters.

There is a significant problem in verification at this stage. Telecommuting in 1987 is widely and sparsely scattered in the United States. Furthermore, many organizations that may have large numbers of part-time home telecommuters are not aware of the fact (at least at the Personnel Director's level and upwards). One estimate, based on the 1985–1986 survey (Nilles *et al.*, 1986), is that by the end of 1985 there were about 500,000 telecommuters of all sorts (excluding occasional telecommuters and home-based businesses). That places the "facts" somewhere between the totals of Figs. 1 and 2; that is, just below the nominal case.†

Note that none of these curves represents the "real" future. Their primary utility is in representing the range of possible societal responses to technological change. If the nominal trend (Fig. 2) is close to future reality, then more than 20 million employees would be telecommuting by 1995, about 40% of them part-time from home. If the home-based telecommuters were to do so one day per week, on average (but conveniently distributed uniformly across the work week), then about one- and one-half million commuters would disappear from the roads every work day. About twelve million would be commuting about half of their former distance—and likely using different roads in the process.‡ It could not be predicted at this point what the patterns might be, either in selection of the path to work or the distribution of days of telecommuting.

Because of the lack of data it is not possible to go beyond speculation at this point. Greater certainty depends on better data and/or larger concentrations of telecommuters. Thus, transportation planners could easily rationalize postponing considerations of telecommuting as a means of altering transportation patterns. At least that is a common approach today. The key question is: how much lead time is necessary in transportation planning in a particular region? The risk of planning errors resulting from sins of omission (such as exclusion of considerations of potential telecommuting impact) is directly proportional to the necessary lead time. If the lead time is relatively short, say two or three years, then planners can afford to ignore telecommuting until better data are developed.

On the other hand, the transportation congestion problems in most cities continue to mount, in spite of our various attempts to smooth traffic flow, have smaller cars, push mass transit and ride sharing, or use flex-time for workers. Hence, one could also take the approach that telecommuting should be at least as thoroughly and widely tested as many of our other approaches to congestion relief—if only to get good data sooner. If it continues the trend of current empirical results and is found to be benign to both employers and employees, it should be actively pursued.

At a minimum, telecommuting in particular, and teleworking in general, might allow cities to cope with increasing populations for a time without increasing investment in expanded transportation infrastructures. The telecommunications infrastructure necessary to widespread telecommuting is being developed rapidly by the private sector as the national telephone network converts to digital technology and switches to optical fibers for communications lines. Since this alternative is "free" in a sense (that is, it is not paid for out of transportation funds) it is important to intensify scrutiny of this alternative—or supplement—to the transportation options that are being examined today. One forecast seems certain: unless there is a significant alteration in current trends, for whatever reason, metropolitan areas will continue the present path of intensifying urban congestion. The telecommuting option is worth watching and/or trying as another means of alleviating this problem.

†These estimates are based on extrapolating the manager/professional responses to the 1985–1986 survey to the information work force in general, taking into account the fact that the responding organizations were relatively more "high tech" than the average of U.S. companies. The details of this extrapolation are beyond the scope of this summary paper. Other estimates mentioned in the press go as high as several million telecommuters at the end of 1986, far above the "landslide" case of Fig. 3.

‡That is, 40% of 20 million evenly divided by 5 days per week = 1.6 million per day; 60% of 20 million = 12 million regional center telecommuters daily.

BIBLIOGRAPHY

The following set of references comprises a set of professional papers, books, and articles that explore most of the key issues of telecommuting. They were selected primarily to provide a representative view of the contemporary literature. There is also a substantial volume of articles about telecommuting in the popular press, not referenced here. Finally, there are two newsletters about telecommuting. One,

Table 1. Low growth and acceptance scenario (Copyright 1986 JALA Associates, Inc.—Reprinted by permission)

TELECOMMUTING FORECAST FACTOR	Table 1: LOW GROWTH & ACCEPTANCE SCENARIO COPYRIGHT 1986 by JALA ASSOCIATES, INC. -- Reprinted by permission YEAR 1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
United States Labor Force	106940000	108215409	109506029	110812042	112133631	113471000	115688428	117949188	120254127	122604109	125000014	126254577	127521731
Infoworkers	53358996	54443230	55549494	56678238	57829917	59004920	61056244	63178882	65375315	67648108	70000008	70953289	71919552
Telecommuters													
Part-timers between X and CBD													
% of infowkrs	0.03	0.0404351	0.0544716	0.0733294	0.0986229	0.132474	0.1776449	0.2376853	0.3170749	0.4213294	0.5570057	0.7315144	0.9526128
# of home wkrs	16008	22014	30259	41562	57034	78166	108463	150167	207289	285021	389904	519034	685115
days/wk (average)	1	1	1	1	1	1	1.1	1.1	1.1	1.1	1.2	1.2	1.3
hours/wk	8	8	8	8	8	8	8.8	8.8	8.8	8.8	9.6	9.6	10.4
% of infowkrs	0.025	0.0290224	0.0336875	0.0390967	0.0453665	0.0526311	0.0610446	0.0707838	0.0820511	0.0950773	0.1101251	0.1274927	0.1475167
# Reg'l ctr. wkrs	13340	15801	18713	22159	26235	31055	37272	44720	53641	64318	77088	90460	106093
days/wk (ave)	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1	1	1.1	1.2	1.3
hours/wk	6.4	6.4	6.4	6.4	7.2	7.2	7.2	7.2	8	8	8.8	9.6	10.4
Part-timers between X & Regl Ctr													
% of infowkrs	0.05	0.0552005	0.0609352	0.0672576	0.0742262	0.0819047	0.090363	0.0996772	0.1099298	0.121211	0.1336182	0.147257	0.1622417
# of home wkrs	26679	30053	33849	38120	42925	48328	55172	62975	71867	81997	93533	104484	116683
days/wk (average)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
hours/wk	4	4	4	4	4	4	4	4	4	4	4	4	4
Full-timers													
% of infowkrs	0.02	0.0232116	0.0269344	0.0312479	0.0362437	0.042027	0.048718	0.0564539	0.0653909	0.0757063	0.0876005	0.1012985	0.1170525
# of home wkrs	10672	12637	14962	17711	20960	24798	29745	35667	42750	51214	61320	71875	84184
% of infowkrs	0.1	0.110401	0.1218705	0.1345153	0.1484523	0.1638095	0.1807261	0.1993543	0.2198596	0.2424219	0.2672363	0.2945141	0.3244833
# of loc ctr wkrs	53359	60106	67698	76241	85850	96656	110345	125950	143734	163994	187065	208967	233367
Total Telecommuters	120058	140611	165481	195793	233004	279003	340997	419479	519281	646544	808910	994820	1225442
as % of infoworkers	0.2%	0.3%	0.3%	0.3%	0.4%	0.5%	0.6%	0.7%	0.8%	1.0%	1.2%	1.4%	1.7%
TCing days/wk	360175	413396	475454	548109	636158	737550	880890	1045004	1250012	1494880	1841373	2187845	2674667
Total Home TCers	53359	64704	79070	97393	120919	151292	193380	248809	321906	418232	544757	695393	885982
as % of infoworkers	0.1%	0.1%	0.1%	0.2%	0.2%	0.3%	0.3%	0.4%	0.5%	0.6%	0.8%	1.0%	1.2%
Average Home TCing hrs/wk	4.4	4.6	4.8	5.0	5.2	5.4	6.1	6.3	6.6	6.8	7.6	7.8	8.6
Ave. home-CBD mi. (round-trip)	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4
Ave. home-RC mi. (round-trip)	9	9	9	9	9	8.4	8.4	8.4	8.4	8.4	8	8	8
Annual passenger - miles saved													
Home workers	69978438	85948751	105993607	131262030	163258139	203934973	270393002	346541665	445655458	574605519	781300266	990859299	1.323E+09
Reg. Ctr. workers	150747808	170144147	192031458	216733654	246023549	293679802	336208798	384876206	443630434	507944658	607160061	686444398	776493056
TOTAL PASSENGER-MILES/YR SAVED	220726246	256092898	298025066	347995683	409281688	497614775	606601799	731417871	889285892	1.083E+09	1.388E+09	1.677E+09	2.1E+09
Telecommuters' transport choice (%)													
Priv. auto	93.5	93.2	92.9	92.6	92.3	92	91.84	91.68	91.52	91.36	91.2	90.78	90.36
Bus	5.4	5.62	5.84	6.06	6.28	6.5	6.64	6.78	6.92	7.06	7.7	8	8.3
Rail	1.1	1.18	1.26	1.34	1.42	1.5	1.42	1.34	1.26	1.18	1.1	1.22	1.34

1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
128801603	130094320	131400012	132434787	133477711	134528848	135588262	136656020	137466349	138281483	139101451	139926281	140756002
72898974	73891734	74898007	75819454	76752238	77696498	78652375	79260492	79730483	80203260	80678842	81157243	81638481
1.227452	1.5611158	1.9547666	2.4038094	2.8967785	3.4157133	3.9383827	4.4419154	4.9066516	5.3189111	5.671956	5.9652815	6.2029246
894800	1153536	1464081	1822555	2223342	2653890	3097632	3520684	3912097	4265940	4576068	4841258	5063973
1.4	1.4	1.6	1.7	1.8	2	2.1	2.3	2.4	2.5	2.6	2.7	2.8
11.2	11.2	12.8	13.6	14.4	16	16.8	18.4	19.2	20	20.8	21.6	22.4
0.1705755	0.1970923	0.227537	0.2624276	0.3023294	0.3478528	0.3996477	0.4583949	0.5247926	0.5995383	0.6833045	0.7767086	0.8802768
124348	145635	170421	198971	232045	270269	314332	363326	418420	480849	551282	630355	718645
1.5	1.7	1.9	2.2	2.5	2.8	3.1	3.3	3.6	3.8	4	4.2	4.3
12	13.6	15.2	17.6	20	22.4	24.8	26.4	28.8	30.4	32	33.6	34.4
0.1786949	0.1967489	0.216545	0.2382341	0.2619767	0.2879423	0.3163097	0.3472658	0.381005	0.417728	0.4576397	0.5009479	0.5478603
130267	145381	162188	180628	201073	223721	248785	275245	303777	335031	369218	406556	447265
0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6
4	4	4	4	4	4	4	4	4.8	4.8	4.8	4.8	4.8
0.1351422	0.1558765	0.1795925	0.2066546	0.2374513	0.27239	0.3118891	0.3563676	0.4062307	0.4618517	0.5235511	0.5915719	0.6660533
98517	115180	134511	156684	182249	211637	245308	282459	323890	370420	422395	480103	543756
0.3573899	0.3934979	0.4330901	0.4764683	0.5239533	0.5758846	0.6326194	0.6945316	0.7620101	0.8354559	0.9152794	1.0018958	1.0957205
260534	290762	324376	361256	402146	447442	497570	550489	607554	670063	738437	813111	894530
1508466	1850494	2255577	2720094	3240855	3806959	4403627	4992203	5565738	6122303	6657400	7171383	7668169
2.1%	2.5%	3.0%	3.6%	4.2%	4.9%	5.6%	6.3%	7.0%	7.6%	8.3%	8.8%	9.4%
3299631	3964930	5041859	6216094	7604640	9471789	11318239	13598912	15734831	17895510	20128596	22428891	24729087
1123584	1414097	1760780	2159867	2606664	3089248	3591725	4078388	4539764	4971391	5367681	5727917	6054994
1.5%	1.9%	2.4%	2.8%	3.4%	4.0%	4.6%	5.1%	5.7%	6.2%	6.7%	7.1%	7.4%
9.4	9.5	11.0	11.8	12.6	14.0	14.8	16.2	16.9	17.5	18.1	18.6	19.1
19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4
8	8	7.2	7.2	7.2	7.2	7.2	6.6	6.6	6.6	6.6	6.6	6.6
1.761E+09	2.21E+09	3.042E+09	3.916E+09	4.956E+09	6.422E+09	7.8E+09	9.594E+09	1.111E+10	1.263E+10	1.413E+10	1.561E+10	1.705E+10
886179960	1.012E+09	1.239E+09	1.428E+09	1.649E+09	1.905E+09	2.203E+09	2.637E+09	3.034E+09	3.457E+09	3.937E+09	4.481E+09	5.048E+09
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
2.647E+09	3.222E+09	4.28E+09	5.344E+09	6.605E+09	8.327E+09	1E+10	1.223E+10	1.414E+10	1.608E+10	1.807E+10	2.009E+10	2.209E+10
**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********	**********
89.94	89.52	89.1	88.68	88.26	87.84	87.42	87	86.7	86.4	86.1	85.8	85.5
8.6	8.9	9.2	9.54	9.88	10.22	10.56	10.9	11.08	11.26	11.44	11.62	11.8
1.46	1.58	1.7	1.78	1.86	1.94	2.02	2.1	2.22	2.34	2.46	2.58	2.7

Table 2. Nominal growth and acceptance scenario (Copyright 1986 JALA Associates, Inc.—Reprinted by permission)

TELECOMMUTING FORECAST FACTOR	Table 2: NOMINAL GROWTH & ACCEPTANCE SCENARIO COPYRIGHT 1986 by JALA ASSOCIATES, INC. -- Reprinted by permission YEAR 1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
United States Labor Force	106940000	108215409	109506029	110812042	112133631	113471000	115688428	117949188	120254127	122604109	125000014	126254577	127521731
Infoworkers	53358996	54443230	55549494	56678238	57829917	59004920	61056244	63178882	65375315	67648108	70000008	70953289	71919552
Telecommuters													
Part-timers between X and CBD													
% of infowkrs	0.03	0.0493656	0.0811302	0.1330608	0.2175028	0.353612	0.5699336	0.9061585	1.4110547	2.1313373	3.0871397	4.2405757	5.4831416
# of home wkrs	16008	26876	45067	75417	125782	208648	347980	572501	922481	1441809	2160998	3008828	3943451
days/wk (average)	1	1	1	1	1	1.1	1.1	1.2	1.3	1.4	1.6	1.8	2.1
hours/wk	8	8	8	8	8	8.8	8.8	9.6	10.4	11.2	12.8	14.4	16.8
% of infowkrs	0.025	0.0305013	0.0372041	0.0453665	0.0552997	0.0673782	0.0820511	0.0998546	0.1214258	0.1475167	0.1790079	0.2169214	0.2624276
# Reg'l ctr. wkrs	13340	16606	20667	25713	31980	39756	50097	63087	79383	99792	125306	153913	188737
days/wk (ave)	0.8	0.8	0.8	0.9	0.9	0.9	1	1.2	1.4	1.7	2	2.5	3
hours/wk	6.4	6.4	6.4	7.2	7.2	7.2	8	9.6	11.2	13.6	16	20	24
Part-timers between X & Regl Ctr													
% of infowkrs	0.05	0.0641102	0.0821695	0.1052621	0.1347563	0.1723708	0.2202502	0.2810488	0.3580159	0.4550741	0.5768704	0.7287756	0.9167897
# of home wkrs	26679	34904	45645	59661	77929	101707	134477	177563	234054	307849	403809	517090	659351
days/wk (average)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6
hours/wk	4	4	4	4	4	4	4	4	4	4	4	4.8	4.8
Full-timers													
% of infowkrs	0.02	0.02441	0.0297877	0.0363428	0.0443297	0.054056	0.0658927	0.0802864	0.0977723	0.1189901	0.1446995	0.1757977	0.2133359
# of home wkrs	10672	13290	16547	20598	25636	31896	40232	50724	63919	80495	101290	124734	153430
% of infowkrs	0.1	0.1489383	0.2216486	0.3294637	0.4888616	0.7234974	1.0666793	1.5639492	2.2748127	3.2716115	4.6322202	6.4227112	8.6687805
# of reg ctr wkrs	53359	81087	123125	186734	282708	426899	651274	988086	1487166	2213183	3242555	4557125	6234548
Total Telecommuters	120058	172763	251051	368123	544035	808906	1224060	1851961	2787003	4143128	6033958	8361690	11179517
as % of infoworkers	0.2%	0.3%	0.5%	0.6%	0.9%	1.4%	2.0%	2.9%	4.3%	6.1%	8.6%	11.8%	15.5%
TCing days/wk	360175	529498	782783	1165049	1735249	2610122	3957644	6045537	9182814	13810494	20629338	29520222	41182959
Total Home TCers	53359	75070	107259	155676	229347	342251	522689	800788	1220454	1830153	2666097	3650652	4756232
as % of infoworkers	0.1%	0.1%	0.2%	0.3%	0.4%	0.6%	0.9%	1.3%	1.9%	2.7%	3.8%	5.1%	6.6%
Average Home TCing hrs/wk	4.4	4.7	5.1	5.4	5.7	6.6	6.9	7.8	8.6	9.5	11.0	12.5	14.6
Ave. home-CBD mi. (round-trip)	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4
Ave. home-RC mi. (round-trip)	9	9	9	9	9	8.4	8.4	8.4	8.4	8.4	8	8	8
Annual passenger - miles saved													
Home workers	69978438	94147269	128926658	179976982	256196866	392415937	589076654	948898667	1.532E+09	2.442E+09	3.999E+09	6.093E+09	9.128E+09
Reg. Ctr. workers	150747808	227351172	343058141	518994953	782033892	1.244E+09	1.895E+09	2.874E+09	4.323E+09	6.435E+09	9.77E+09	1.375E+10	1.884E+10
TOTAL PASSENGER-MILES/YR SAVED	220726246	321498441	471984798	698971935	1.038E+09	1.636E+09	2.484E+09	3.823E+09	5.855E+09	8.877E+09	1.377E+10	1.984E+10	2.796E+10
Telecommuters' transport choice (%)													
Priv. auto	93.5	93.2	92.9	92.6	92.3	92	91.84	91.68	91.52	91.36	91.2	90.78	90.36
Bus	5.4	5.62	5.84	6.06	6.28	6.5	6.64	6.78	6.92	7.06	7.7	8	8.3
Rail	1.1	1.18	1.26	1.34	1.42	1.5	1.42	1.34	1.26	1.18	1.1	1.22	1.34

1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
128801603	130094320	131400012	132434787	133477711	134528848	135588262	136656020	137466349	138281483	139101451	139926281	140756002
72898974	73891734	74898007	75819454	76752238	77696498	78652375	79260492	79730483	80203260	80678842	81157243	81638481
6.6682539	7.6743098	8.4473131	8.9969692	9.3666345	9.6060262	9.7572803	9.8513635	9.9093171	9.9448011	9.9664473	9.9796223	9.9876304
4861089	5670681	6326869	6821453	7189102	7463546	7674333	7808239	7900746	7976055	8040814	8099186	8153750
2.3	2.5	2.7	2.8	2.9	2.9	3	3	3	3	3	3	3
18.4	20	21.6	22.4	23.2	23.2	24	24	24	24	24	24	24
0.3168479	0.3816444	0.4583949	0.5487463	0.6543406	0.7767086	0.917131	1.0764698	1.2549823	1.4521415	1.6664915	1.8955767	2.1359749
230979	282004	343329	416056	502221	603475	721345	853215	1000603	1164665	1344506	1538398	1743777
3.5	3.9	4.2	4.4	4.5	4.6	4.7	4.7	4.8	4.8	4.8	4.8	4.8
28	31.2	33.6	35.2	36	36.8	37.6	37.6	38.4	38.4	38.4	38.4	38.4
1.1473064	1.4266802	1.7605536	2.1529396	2.6051283	3.114595	3.6741913	4.2719498	4.8917549	5.5149061	6.1222989	6.696705	7.2245964
836375	1054199	1318620	1632347	1999494	2419931	2889839	3385968	3900220	4423134	4939400	5434861	5898051
0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	1	1
4.8	4.8	4.8	5.6	5.6	5.6	6.4	6.4	6.4	7.2	7.2	8	8
0.2585338	0.3127898	0.3776831	0.4549625	0.5465174	0.6543223	0.7803497	0.926444	1.0941563	1.2845422	1.4979407	1.7337561	1.9902833
188468	231126	282877	344950	419464	508386	613764	734304	872376	1030245	1208521	1407069	1624837
11.323093	14.247306	17.230022	20.042683	22.50531	24.525249	26.095239	27.265209	28.110014	28.706233	29.120254	29.404532	29.598217
8254419	10527581	12904943	15196253	17273329	19055260	20524526	21610539	22412250	23023335	23493884	23863907	24163535
14371330	17765591	21176638	24411059	27383610	30050598	32423807	34392265	36086195	37617434	39027125	40343421	41583950
19.7%	24.0%	28.3%	32.2%	35.7%	38.7%	41.2%	43.4%	45.3%	46.9%	48.4%	49.7%	50.9%
54705191	69702573	85254800	99779373	112972001	123932450	134416642	141867817	148048438	153767278	158533556	163471609	167671291
5885932	6956006	7928366	8798750	9608060	10391863	11177936	11928511	12673342	13429434	14188735	14941116	15676638
8.1%	9.4%	10.6%	11.6%	12.5%	13.4%	14.2%	15.0%	15.9%	16.7%	17.6%	18.4%	19.2%
15.9	17.0	18.0	18.4	18.5	18.0	18.1	17.5	16.9	16.6	16.1	15.9	15.5
19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4
8	8	7.2	7.2	7.2	7.2	7.2	6.6	6.6	6.6	6.6	6.6	6.6
1.223E+10	1.547E+10	1.866E+10	2.101E+10	2.315E+10	2.44E+10	2.632E+10	2.733E+10	2.831E+10	2.934E+10	3.043E+10	3.161E+10	3.287E+10
2.497E+10	3.189E+10	4.189E+10	4.942E+10	5.63E+10	6.229E+10	6.737E+10	7.473E+10	7.795E+10	8.055E+10	8.271E+10	8.462E+10	8.629E+10
3.72E+10	4.736E+10	6.055E+10	7.043E+10	7.945E+10	8.669E+10	9.37E+10	1.021E+11	1.063E+11	1.099E+11	1.131E+11	1.162E+11	1.192E+11
89.94	89.52	89.1	88.68	88.26	87.84	87.42	87	86.7	86.4	86.1	85.8	85.5
8.6	8.9	9.2	9.54	9.88	10.22	10.56	10.9	11.08	11.26	11.44	11.62	11.8
1.46	1.58	1.7	1.78	1.86	1.94	2.02	2.1	2.22	2.34	2.46	2.58	2.7

Table 3. High growth and acceptance scenario (Copyright 1986 JALA Associates, Inc.—Reprinted by permission)

TELECOMMUTING FORECAST FACTOR	Table 3: HIGH GROWTH & ACCEPTANCE SCENARIO COPYRIGHT 1986 by JALA ASSOCIATES, INC. -- Reprinted by permission YEAR 1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
United States Labor Force	106940000	108215409	109506029	110812042	112133631	113471000	115688428	117949188	120254127	122604109	125000014	126254577	127521731
Infoworkers	53358996	54443230	55549494	56678238	57829917	59004920	61056244	63178882	65375315	67648108	70000008	70953289	71919552
Telecommuters													
Part-timers between X and CBD													
% of infowkrs	0.03	0.0519405	0.0898549	0.1552298	0.26753	0.4591933	0.7827208	1.3188079	2.1804031	3.4994467	5.3757263	7.7834636	10.495648
# of home wkrs	16008	28278	49914	87982	154712	270947	477900	833208	1425445	2367309	3763009	5522623	7548423
days/wk (average)	1	1	1	1	1	1	1.1	1.1	1.2	1.3	1.5	1.8	2
hours/wk	8	8	8	8	8	8	8.8	8.8	9.6	10.4	12	14.4	16
% of infowkrs	0.025	0.0372041	0.0552997	0.0820511	0.1214258	0.1790079	0.2624276	0.3816444	0.5487463	0.7767086	1.0764698	1.4521415	1.8955767
# Reg'l ctr. wkrs	13340	20255	30719	46505	70220	105623	160228	241119	358745	525429	753529	1030342	1363290
days/wk (ave)	0.8	0.8	0.8	0.8	0.9	0.9	1	1.1	1.2	1.5	1.9	2.4	2.9
hours/wk	6.4	6.4	6.4	6.4	7.2	7.2	8	8.8	9.6	12	15.2	19.2	23.2
Part-timers between X & Regl Ctr													
% of infowkrs	0.05	0.067434	0.0909191	0.122533	0.1650485	0.2221508	0.2987114	0.4011222	0.5376855	0.7190365	0.9585412	1.2725574	1.6803665
# of home wkrs	26679	36713	50505	69450	95447	131080	182382	253425	351514	486415	670979	902921	1208512
days/wk (average)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6
hours/wk	4	4	4	4	4	4	4	4	4	4	4	4	4.8
Full-timers													
% of infowkrs	0.02	0.0329507	0.054262	0.0892884	0.1467394	0.2406597	0.3933689	0.6394896	1.0305879	1.6383016	2.5505092	3.8510849	5.5755204
# of home wkrs	10672	17939	30142	50607	84859	142001	240176	404022	673750	1108280	1785357	2732471	4009889
% of infowkrs	0.1	0.156577	0.2449388	0.3826188	0.5963607	0.9263099	1.4312163	2.1936158	3.3219504	4.9432174	7.1764844	10.080327	13.585444
# of reg ctr wkrs	53359	85246	136062	216862	344875	546568	873847	1385902	2171736	3343993	5023540	7152323	9770591
Total Telecommuters	120058	188431	297342	471406	750113	1196219	1934533	3117676	4981190	7831426	11996414	17340680	23900705
as % of infoworkers	0.2%	0.3%	0.5%	0.8%	1.3%	2.0%	3.2%	4.9%	7.6%	11.6%	17.1%	24.4%	33.2%
TCing days/wk	360175	578764	930762	1497256	2414304	3874393	6347224	10258092	16544215	26370218	41456193	62288973	88677894
Total Home TCers	53359	82930	130561	208039	335018	544028	900458	1490655	2450709	3962004	6219345	9158015	12766824
as % of infoworkers	0.1%	0.2%	0.2%	0.4%	0.6%	0.9%	1.5%	2.4%	3.7%	5.9%	8.9%	12.9%	17.8%
Average Home TCing hrs/wk	4.4	4.5	4.6	4.7	4.8	4.9	5.5	5.6	6.2	6.7	7.7	9.1	9.9
Ave. home-CBD mi. (round-trip)	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4
Ave. home-RC mi. (round-trip)	9	9	9	9	9	8.4	8.4	8.4	8.4	8.4	8	8	8
Annual passenger - miles saved													
Home workers	69978438	119011162	202389491	344017950	584102262	989584378	1.742E+09	2.962E+09	5.124E+09	8.695E+09	1.47E+10	2.381E+10	3.546E+10
Reg. Ctr. workers	150747808	240222845	382515046	608320471	969201100	1.621E+09	2.596E+09	4.122E+09	6.467E+09	1.003E+10	1.576E+10	2.269E+10	3.134E+10
TOTAL PASSENGER-MILES/YR SAVED	220726246	359234008	584904537	952338421	1.553E+09	2.611E+09	4.337E+09	7.084E+09	1.159E+10	1.872E+10	3.046E+10	4.65E+10	6.68E+10
Telecommuters' transport choice (%)													
Priv. auto	93.5	93.2	92.9	92.6	92.3	92	91.84	91.68	91.52	91.36	91.2	90.78	90.36
Bus	5.4	5.62	5.84	6.06	6.28	6.5	6.64	6.78	6.92	7.06	7.7	8	8.3
Rail	1.1	1.18	1.26	1.34	1.42	1.5	1.42	1.34	1.26	1.18	1.1	1.22	1.34

1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
128801603	130094320	131400012	132434787	133477711	134528848	135588262	136656020	137466349	138281483	139101451	139926281	140756002
72898974	73891734	74898007	75819454	76752238	77696498	78652375	79260492	79730483	80203260	80678842	81157243	81638481
13.136653	15.367688	17.037065	18.176233	18.905558	19.353597	19.621888	19.78009	19.87253	19.926257	19.957388	19.975393	19.985795
9576485	11355451	12760422	13781121	14510439	15037067	15433081	15677796	15844464	15981508	16101389	16211478	16316100
2.3	2.5	2.7	2.8	2.9	2.9	3	3	3	3	3	3	3
18.4	20	21.6	22.4	23.2	23.2	24	24	24	24	24	24	24
2.3834535	2.8803919	3.3483525	3.7575624	4.0928546	4.3532371	4.5471501	4.6871028	4.7858404	4.8543883	4.9014474	4.9335061	4.9552315
1737513	2128372	2507849	2848963	3141358	3382313	3576442	3715021	3815774	3893378	3954431	4003898	4045376
3.4	3.9	4.2	4.4	4.6	4.7	4.7	4.8	4.8	4.8	4.8	4.8	4.8
27.2	31.2	33.6	35.2	36.8	37.6	37.6	38.4	38.4	38.4	38.4	38.4	38.4
2.203487	2.8640021	3.6815533	4.6688947	5.826484	7.1374638	8.565163	10.055192	11.542775	12.963554	14.264253	15.409653	16.384301
1606319	2116261	2757410	3539931	4471957	5545559	6736704	7969795	9203110	10397193	11508234	12506050	13375895
0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.9	0.9	1	1	1	1.1
4.8	4.8	4.8	5.6	5.6	5.6	6.4	7.2	7.2	8	8	8	8.8
7.6543896	9.8912953	12.022258	13.829336	15.216608	16.202416	16.865116	17.294147	17.56517	17.733731	17.837554	17.901121	17.939897
5579971	7308850	9004432	10485327	11679087	12588710	13264814	13707426	14004794	14223030	14391132	14528056	14645859
17.455621	21.330143	24.846714	27.765472	30.013564	31.647425	32.785434	33.554794	34.064498	34.397664	34.613523	34.752582	34.841834
12724969	15761213	18609693	21051629	23036082	24588941	25786523	26595695	27159789	27588048	27925790	28204237	28444344
31225257	38670147	45639806	51706971	56838923	61142590	64797564	67665733	70027931	72083157	73880976	75453719	76827574
42.8%	52.3%	60.9%	68.2%	74.1%	78.7%	82.4%	85.4%	87.8%	89.9%	91.6%	93.0%	94.1%
120421951	153309350	184711176	211285308	233236735	249274512	263754569	273553909	279954821	286085321	290378280	294020659	298530604
16762775	20780562	24522264	27806379	30661483	33171336	35434599	37355017	39052368	40601731	42000755	43245584	44337854
23.0%	28.1%	32.7%	36.7%	39.9%	42.7%	45.1%	47.1%	49.0%	50.6%	52.1%	53.3%	54.3%
11.0	11.4	11.8	11.8	11.8	11.5	11.7	11.6	11.4	11.5	11.4	11.3	11.5
19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4	19.4
8	8	7.2	7.2	7.2	7.2	7.2	6.6	6.6	6.6	6.6	6.6	6.6
5.037E+10	6.55E+10	8.017E+10	9.181E+10	1.014E+11	1.075E+11	1.136E+11	1.166E+11	1.186E+11	1.201E+11	1.213E+11	1.223E+11	1.233E+11
4.127E+10	5.17E+10	6.58E+10	7.486E+10	8.24E+10	8.828E+10	9.274E+10	1.008E+11	1.03E+11	1.048E+11	1.062E+11	1.073E+11	1.084E+11
9.163E+10	1.172E+11	1.46E+11	1.667E+11	1.838E+11	1.958E+11	2.064E+11	2.173E+11	2.216E+11	2.249E+11	2.275E+11	2.296E+11	2.316E+11
89.94	89.52	89.1	88.68	88.26	87.84	87.42	87	86.7	86.4	86.1	85.8	85.5
8.6	8.9	9.2	9.54	9.88	10.22	10.56	10.9	11.08	11.26	11.44	11.62	11.8
1.46	1.58	1.7	1.78	1.86	1.94	2.02	2.1	2.22	2.34	2.46	2.58	2.7

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