JALA International, Inc.

Final Performance and Cost-Benefit Analysis

City of Los Angeles Telecommuting Project

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Contents

EXECUTIVE SUMMARY

This is the last of a series of three cost/benefit reports on the City of Los Angeles Telecommuting Pilot Project. This report covers roughly the last 6 months of the 18-month test of telecommuting in the City. It also includes detailed cost and benefit data and comparisons of active telecommuters and non-telecommuters with similar jobs.

Twenty-two City Departments have participated in the project to some extent as of this date. Of those, 19 Departments have approved telecommuters and supervisors for training[1], all of which have active telecommuters. JALA Associates has approved 540 City employees for telecommuting and has trained 429 employees plus their supervisors, department coordinators and some union representatives. Just over half of the employees in the project have been telecommuting for five months or less; a few have not yet begun.

The project includes a broad spectrum of individuals at the professional and managerial levels but only a few who are paraprofessionals or secretaries. This imposes some limitations on the cost-benefit analysis in that data on the effects of telecommuting on a major component of the City workforce will be minimal.

The average commute for southern California workers is 16.6 miles one way[2]; the present group of City telecommuters averages a 22.8 mile one-way commute; 37% farther! The group includes a mixture of employees on traditional 5-day-per-week and on modified work schedules. When the telecommuters do drive to their Civic Center offices they spend an average of 106 minutes per day commuting.

Although computer use may not be necessary for telecommuting, 74% of the telecommuters have their own personal computers at home (the same as at the time of the mid-term evaluation). The trend is clear that the use of personal computers is going to be an integral part of almost all "office" work, including telecommuting, in coming years. Our analysis of census data for California shows that three out of five Californians are now information workers. Forecasts by the Center for Futures

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[1] The City Clerk, because of shortages in public counter personnel and the need for rapid access to central, paper-based files, did not approve any of its selected telecommuters for training, although some personnel participated as members of the control group. The Mayor's Office did not progress past the application phase. The Fire Department withdrew from the project after its prospective telecommuters had been trained.

[2] As reported by Commuter Transportation Services in both their 1991 and 1992 surveys: *State of the Commute.*

Research at the University of Southern California show an expectation that essentially all information workers will be using computers by the end of the century. The use of telephones and personal computers outranks face-to-face conversation in importance to both telecommuters and non-telecommuters in our surveys.

The average telecommuter has been telecommuting for just under 13 months, and has worked at home 3.8 days per month over the last six months, compared to an average of 4.2 days in the first month of telecommuting. Analysis of the returns from the longer-term telecommuters indicates that those with one year of experience will telecommute almost exactly one day per week on average; two year veterans are likely to telecommute an average of 1.9 days per week[3] .

Twenty-three percent of the telecommuters said that the car was indeed used by themselves or someone else in their household when they worked at home (the remaining 76.9% maintained that it was not in use). Of those who stated that their car was available, 23.1% (5.8% of all the telecommuters) stated that there was an overall decrease in non-commuting car use in addition to the decrease due to telecommuting! To counter this, 23.1% (5.8% of all the telecommuters) stated that there was some additional car use, but not enough to counteract the telecommuting reduction. Analysis of the trip logs that were administered in March 1992 showed that some of this additional car use was the result of telecommuters performing chores that otherwise would have been carried out by other family members. ***At this point, to be conservative, we conclude that telecommuting produces exactly the car use reduction that equals the reduction in commute trips. Therefore, it completely satisfies the primary goal of the project: telecommuting-eliminated trips are not replaced by other trips.***

As was the case for the very early telecommuters tested in the baseline evaluation, the telecommuters have experienced significant quality of life improvements. In particular, their ability to concentrate on crucial tasks, get more done, be free from interruptions, and increase creativity are measurably higher than the non-telecommuters in the survey. This has an immediate impact on their work effectiveness. The telecommuters' self estimates of their effectiveness changes since telecommuting began average an increase of 28%, in comparison to the non-telecommuters' self estimates of a 16% increase.

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[3] As derived from a regression analysis of the data. Interestingly, the final survey results almost exactly match the mid-term results for this factor.

A complete benefit-cost model has been constructed. One-time costs include the project planning, administration and training (about $150 per telecommuter and supervisor). Benefits include the effectiveness changes (between $369 and $642 per telecommuter-month, depending on who is doinhg the estimating); parking space savings (about $22 per telecommuter-month); decreased energy consumption (about $10 per telecommuter-month); and increased employee retention (roughly $206,000 for the group of telecommuters who completed the final survey questionnaires). **If all the 432 telecommuters trained to date were to become active, and these effectiveness changes were maintained or increased for the entire group, then the annual benefit, from the effectiveness changes alone, would be between $1,914,000 and $3,327,800. Including the costs of City personnel involved in administration of the project, the project paid for itself, in terms of cumulative benefits beginning to exceed cumulative costs, in the third quarter of 1991 To put it another way, the current level of employee effectiveness increases pays for the entire project costs in about two months.**

The benefit-cost model takes the conservative approach and shows a cumulative project cost, by the end of 1992, of $590,000, including the project planning phase and all relevant City employee costs. Cumulative benefits, from the estimated 300 active telecommuters at the end of the year, are $3,722,000. The net benefit is $3,132,000.

The data demonstrate that telecommuting has a significant positive impact from every point of view: traffic and air pollution reduction; economic benefits; and quality of life improvements. The details are in the following sections.

INTRODUCTION

This is the final one of a series of three cost/benefit reports on the City of Los Angeles Telecommuting Pilot Project. This report covers the entire 18 month implementation phase of the project. It provides a comprehensive summary of the details of project, including costs and benefits. It does not compare the results of the two prior reports; that is done in the overall project final report. The data in this report supersede those in the two prior reports.

The final evaluation and recommendation report, to be delivered early in 1993, will also summarize additional reports on special topics. Included among the latter is a set of forecasts of the impacts of telecommuting and a report on implementation barriers and constraints.

The data presented here are taken from the third and final set of evaluation questionnaires administered by JALA Associates, the City's telecommuting consultant, to:

- the active telecommuters;
- those City employees who form a control group; and
- the supervisors of both groups.

Members of the control group are employees who would otherwise be eligible for telecommuting but who have volunteered (or have been told by their management) not to telecommute during the project in order to provide a means of comparison between telecommuting and non-telecommuting employees.

HISTORY

The City of Los Angeles Telecommuting Pilot Project began with a planning project in 1989. The project culminated in a formal plan that was submitted to the Mayor and the City Council in August, 1989. The plan recommended implementation of a formal test project that was to include 18 months of active telecommuting and include 250 telecommuters and a comparable number of members of a control group. The Mayor subsequently requested that the number of telecommuters be raised to 500.

The implementation portion of the project began in April, 1990, with a series of briefings on the project plans to senior City executives. The remainder of 1990 was

spent in briefing prospective participants in the project and in selecting the initial set of participants for training.

By the end of 1990, 426 City employees had applied or had been identified by their supervisors for possible inclusion in the project. As part of the selection process, both prospective telecommuters and their immediate supervisors were required to complete background questionnaires. Of the total number of people identified in 1990, 298 (and their supervisors) had completed all of the necessary forms. Of these, 279 were recommended by JALA Associates for training and subsequent telecommuting. Although JALA Associates recommended specific individuals, final selection decisions were made by the management of the participating departments. Eligibility to join the project was held open through March, 1992, in order to accommodate departments that were slow in making acceptance decisions.

Training of the telecommuters and their telemanagers began in January, 1991 and continued through March, 1992. Active telecommuting generally began shortly after the initial training sessions. The rule is that, once a telecommuter and his/her direct supervisor have attended the training sessions and have signed an agreement on their respective roles and performance expectations, they may begin telecommuting. A few of the participants had already been "guerrilla" telecommuters before they received formal training but most were neophytes. Some trainees' telecommuting was postponed because problems in securing equipment necessary to make their telecommuting fully effective.

The formal, data-taking portion of the project currently originally was scheduled for completion as of June 30, 1992. However, because of the late entry of a number of telecommuters, data collection continued through November, 1992 for the 39 telecommuters who were trained after January 1, 1992. This additional time was to ensure the inclusion of meaningful data from their telecommuting experience in the final evaluation.

DEMOGRAPHY

A primary goal of the project was to include as broad a spectrum of City employees as possible. The underlying premise is that telecommuting is feasible for most information or knowledge workers at least some of the time. One desired result is a better understanding of:

1. how broad the spectrum of jobs can be in practice, and

2. to what extent telecommuting is feasible for each element of that spectrum.

The demographic analysis provides the basic reference data on the participant group. Throughout the project, no specific goals were set for the number or job types of telecommuters to be supplied by the departments.

PARTICIPATION

Table 1: Participating Departments

Department	Total Applications	Forms Completed	JALA Approved	TCers Trained	Agreements Received	Baseline Evaluation	Midterm Evaluation	Final Evaluation
Building & Safety	44	37	37	40	21	11	16	13
City Attorney	60	30	29	22	14	14	21	15
City Clerk	44	38	35	0	0	0	27	16
City Planning	57	48	45	28	22	15	27	16
Community Development	10	8	8	10	5	3	5	5
Controller	13	11	9	10	11	2	10	7
Employee Relations Board	3	3	3	3	3	0	0	0
Environmental Affairs	3	1	2	3	3	0	1	1
Fire	37	30	30	10	1	0	6	0
General Services	10	10	10	10	5	5	7	1
Harbor	5	5	5	5	3	3	4	2
Information Services	100	65	55	48	21	24	43	34
Library	42	21	21	27	3	0	18	10
Mayor's Office	2	0	0	0	0	0	0	0
Pensions	9	9	9	6	7	4	6	4
Personnel	24	22	21	13	12	9	15	14
Police	208	141	140	115	82	67	95	54
Public Works	23	21	21	14	9	9	15	12
Recreation and Parks	23	22	19	8	8	7	18	11
Telecommunications	7	4	4	5	3	1	2	2
Transportation	22	21	21	12	9	6	14	7
Water & Power	49	23	17	43	0	0	12	11
TOTALS	**795**	**570**	**541**	**432**	**242**	**180**	**362**	**235**

Twenty-two City departments have been actively involved in the project at some point. The final status is shown in Table 1. The table shows, for each department, the total number of:

applicants of all sorts;
completed sets of applications;
positive recommendations, by JALA Associates, for some form of telecommuting;
telecommuters actually trained;
telecommuting agreements signed and returned to the Project Manager
baseline and mid-term evaluation questionnaires returned.

Note that some of these departments did not actively participate in telecommuting. For example, the Fire Chief decided not to have his employees participate after they had completed training. The City Clerk, because of staffing constraints, did not approve training for any of his employees, although they were allowed to be members of the control group. Some recommended (by JALA) employees in both of these departments volunteered to serve as members of the control group for the mid-term and/or final evaluations.

In general, the remaining departments approved only their very best people for telecommuting. Consequently, although JALA Associates has recommended more than the target of 500 telecommuters for training—and trained almost 90% of the target group—only about half of the number trained seem to have been approved by their department management (as estimated by the number of agreements received by the Project Manager). Of those who were trained, 55 had retired or transferred to non-participating units by the end of the project. Of the remaining 321 trainees, 156 (64% of those who had signed agreements to complete the questionnaires) had returned the final evaluation questionnaires by December 1st. "Questionnaire fatigue" is a common problem in evaluation studies. In this case the resolve of the participants was further tested by the length of the final questionnaire — more than 500 items.

This failure of departments to "activate" trained telecommuters is a serious issue since telecommuting's highest City priority is as a transportation demand management tool. If telecommuting is to become a significant means of reducing traffic congestion, then a fairly large percentage of City employees will eventually have to become at least part time telecommuters[4]. The Telecommuting Project was a primary way of giving City managers the opportunity of honing their management skills. Yet entire departments missed that opportunity. Others took only very tentative steps.

TYPES OF EMPLOYEES

The rest of this report deals with the results from the 235 final evaluation questionnaires that had been returned to JALA Associates as of December 1, 1992.

First, as a test of the breadth of the selection process, Table 2 shows the breakdown by the type of work reported by the participants.

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[4] Our analysis of City job titles indicates that about 16,000 permanent City employees could become at least part-time telecommuters. See the final evaluation report for details.

Table 2: Reported Types of Jobs

Job Type	% of Telecom-muters	% of Controls
Architect	1.9	3.9
Policy Analyst	1.3	1.3
Finance	1.3	1.3
Research & Development	1.3	1.3
General Administration	7.7	3.9
Public Safety	20.0	7.9
Customer Service	1.3	1.3
Field Service	0.0	2.6
Office Services	1.3	5.3
Office Systems	1.9	0.0
Engineering	9.7	13.2
Accounting	3.9	2.6
Legal	7.7	3.9
Human Resources	5.2	10.5
Information Services	16.1	22.4
Program Management	3.2	2.6
Planning	7.7	1.3
Other	8.4	14.5

TELECOMMUTERS AND CONTROLS

As of 1 December, 1992, we had received completed final evaluation questionnaires from 156 active telecommuters and 79 non-telecommuters in this group of respondents. This is a sufficient number to get a reasonable idea of the differences, if any, between telecommuters and non-telecommuters after more than a year of telecommuting.

Of the telecommuter group, 5.2% considered themselves to be primarily managers, 66.7% considered themselves to be primarily professionals, 19.0% claim both managerial and professional roles, 6.6% are paraprofessionals or secretaries, and 2.6% classify themselves in the "Other" category. Clearly, *it would have been more revealing if significantly larger numbers of paraprofessional, secretarial and clerical workers had been included in the project,* since the City employs fairly large numbers of people at these levels. Nevertheless, there is clearly a broad spectrum of job types represented in this group. The distribution of control group members

differs slightly, with 2.6% managers, 58.4% professionals, 24.7% as combined manager-professionals, 13.0% as paraprofessionals or secretaries, and 1.3% as "Other."

The average telecommuter is 38.9 years old[5] , has worked for the City 13.6 years, for his/her Department 5.1 years, in his/her particular job 4.0 years and has a gross annual salary of about $50,600. The average size of the unit in which the participant works is 12.3 people; the median work unit size is 8. Most, 84.2%, of the telecommuters in this sample work in or near downtown Los Angeles.

The telecommuters do not take much sick leave, except for maternity leave; the median annual number of sick days taken in 1989 was 6, with 5 days in 1990 and 4 as the median in 1991 during telecommuting. The telecommuters decreased the average number of sick days taken between 1989 and 1990 by 1.2, and between 1990 and 1991 by 1.8.

Most of the telecommuters own their own homes, averaging 1849 square feet. Their average electricity bill is $98, the gas bill is $23 and telephone charges average $73 per month. The apparent telephone bill increase[6] for telecommuters, since most departments are not paying for home telecommuters' phone charges, is only $3.59 per month. Even this $3.59 difference may be misleading, since the telecommuter data include one very large telephone bill ($860). The median telephone bill for the telecommuters was $51, making their bill $7.50 less than that of the control group. Therefore, we conclude that **there is no significant difference in the telephone costs between the two groups. Yet, telephone bills supposedly constitute the largest operational cost element for telecommuting.** This will be discussed further in the cost analysis section of this report.

The average control group member is 41.0 years old[7] , has worked for the City 14.5 years, for his/her Department 5.7 years, in his/her particular job 4.7 years and has a gross annual salary of about $47,800[8] . The average size of the unit in which the control group member works is 12.9 people; the median work unit size is 9. As with

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[5] The average age for males is 39.8, for females it is 38.2 years.

[6] As compared with the bills for the control group.

[7] The average age for males is 41.2, for females it is 40.4 years. In 1990, male and female federal workers averaged 43.6 and 40.5 years, respectively. as compared with 37.3 years for both male and female employees in the private sector. Hence, City employees are roughly comparable in their age demographics to other information workers.

[8] Men in the control group average $51,600 while women receive an average of $42,800 per year.

the telecommuters, almost all, 94.7%, of the control group members in this sample work in or near downtown Los Angeles.

Also like the telecommuters, the control group members do not take much sick leave; the median annual number of sick days taken were 6 in each of 1989 and 1991, 5 in 1990. On the other hand, the average telecommuter took 2 sick days (or 33.3%) less than the average non-telecommuter during the telecommuting period.

Most of the control group members own their own homes, about one office size less than the telecommuters', averaging 1918 square feet. Their average electricity bill is $94, the gas bill is $28 and telephone charges average $69 per month, with a median telephone charge of $58.50. In short, the members of the control group match the telecommuters fairly closely in their general characteristics. The major difference is a utility bill (including telephone charges) of about $3.09 per month more for the telecommuters.

Men have a slight majority among the participants, 53.3% of the telecommuters and 57.9% of the control group. About two-thirds, 66.7%, of the telecommuters and half, 51.3%, of the control group members live in dual earner households.

Forty seven percent of the telecommuters and 22.1% of the control group members are on a traditional work schedule: five 8-hour days per week. Only 5.8% of the telecommuters and 3.9% of the control group members work on the 4-10 schedule (four 10-hour days per week), while 45.5% and 74.0%, respectively, are on a 9-80 schedule (five 9-hour days one week; three 9-hour days and one 8-hour day the next week).

COMMUTING DATA

A primary goal of the Telecommuting Project is to reduce commuting. Hence, the commuting patterns of the participants are very important. As was mentioned earlier, most of the participants who have responded to the evaluation questionnaires commute to City Hall or the general downtown Los Angeles area.

RESIDENCE LOCATION

There is no particular pattern of residence locations for City employees. One hundred forty different residence zip codes were identified by the 235 employees who returned the final evaluation questionnaires.[9] The two most "intensely"

[9] As contrasted to the 161 different zip codes, with a maximum of 8 in a single zip code, identified by the 304 employees who returned mid-term evaluation questionnaires.

populated zip code areas have 5 employees living in them. This acts to complicate the problem of satellite telework center selection since there are no obvious, unequivocal locations that pop out of the data.

COMMUTE DISTANCES AND TIMES[10]

The average one-way commute distance for the active telecommuters is 22.8 miles[11] ; the median commute is 20.0 miles. The minimum one-way commute for a telecommuter is 3 miles, the maximum is 67 miles and the mode (the most common distance) is 15 miles.

The non-telecommuters' average one-way commute is 23.1 miles; the median and the mode are 23 and 26 miles, respectively. Their reported commute distances range from 7 to 60 miles.

Commute times from home to the office average 48.3 minutes for the telecommuters and 44.8 minutes for the non-telecommuters. The median morning commute times are 45 minutes for both groups. Afternoon commutes are significantly longer for both groups, averaging 58.1 minutes for the telecommuters and 57.4 minutes for the non-telecommuters, respectively. That is, the telecommuters average 106 minutes per day commuting, when they commute, and the non-telecommuters are on the road an average of 102 minutes per day, not much difference. ***If these people were to commute 220 days per year, each of these group members would spend about 9.6 work weeks (24 waking days) per year on the road***[12] .

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[10] Note: the commute times and distances are taken from the mid-term evaluation and trip analysis data. Through a clerical error, the commuting data portion of the final evaluation questionnaire was omitted from all but 40 of the questionnaires; only 15 of these were returned by the reporting deadline. However, since household moves were reported in a different section of the questionnaire, the mid-term data should be applicable to the final situation.

[11] The 31.9 mile average found in the baseline survey implies that the first group of telecommuters was biased toward those applicants who lived at greater than average distances. The mid-term survey had an average one-way commute of 24.9 miles and a median of 21 miles. The mid-term maximum was 170 miles.

[12] A work week is taken as 40 hours; a waking day is 16 hours, under the assumption that most people get about 8 hours sleep per day and that this does not occur while they are commuting. Waking days constitute potential disposable time for the telecommuters. Work weeks constitute potential productive time for employers.

COMMUTE MODAL CHOICES

Three of every five (61.4%) of the telecommuters drive their own cars to work at the rate of least four days per week when they are commuting, a slightly higher proportion than the 58.7% of the non-telecommuters who do so. Seventy-one percent of the telecommuters and 70.7% of the control group members do not belong to a car- or van-pool (ridesharing). Similarly, 26.7% of the telecommuters and 34.7% of the non-telecommuters do not drive their own cars at all to work. The average number of days per week each group drives to work is 2.6 days and 2.8 days per week, respectively for the telecommuters and non-telecommuters. Twenty-nine percent of the telecommuters carpool at least one day per week, versus 20.7% of the non-telecommuters. On average, the telecommuters carpool 1 day per week, as contrasted to 0.82 days per week for the non-telecommuters. The average days per week taking the bus are 0.31 and 0.63, respectively.

Of those who rideshare, 34.1% of the telecommuters and 52.4% of the non-telecommuters drive to their pickup point. Since each of these trips involves an engine cold start, the pollution reducing advantage of ridesharing is significantly diminished. The average trip time to the rideshare pickup point is 8.4 minutes for the telecommuters and 9.5 minutes for the non-telecommuters.

In short, telecommuters live slightly farther from work than do the non-telecommuters and they are about as likely to drive alone when they do commute. Overall, the commuting patterns of both groups are similar. Note that significant numbers of those using carpools and vanpools in both groups report driving their cars to the pool pickup location. Therefore, a high percentage of their telecommuting will result in real net trip savings and air pollution reduction.

TECHNOLOGY REQUIREMENTS

One of the common misconceptions about telecommuting is that it requires intensive computer use; that it is not possible to telecommute unless access to a computer is available. While this can be true for computer programmers and some other professionals, it is not necessarily so for many other people. The dilemma for computer professionals is illustrated by the composition of the non-telecommuter group of our sample; a large fraction of this group consists of individuals who either lack access to the mainframe or who otherwise need computers but do not have their own personal computers at home.

Part of our inquiry deals with the extent to which various forms of technology are useful to City employees. There are two aspects to this inquiry. First, what are the

minimum technology requirements for **any** form of telecommuting? Second, what is the effect of availability of a particular form of technology on *increasing the amount* of telecommuting?

We include in our list of "technologies" face-to-face meetings and other traditional forms of communication, since the effectiveness of telecommuting depends on the ability of some of the more electronic technologies to substitute for those traditional ones. Of the more "high-tech" technologies (computers, teleconferencing systems, etc.) 94.3% of the telecommuters and 93.7% of the non-telecommuters said these technologies greatly helped their work. We conclude that computers and sophisticated telecommunications are important to at least nine of every ten (up from four of every five at the mid-term evaluation) City information workers.

PERSONAL OWNERSHIP

A test of what technology products are personally important is that of personal ownership. Although this obviously has some cost considerations, Table 3 gives the breakdown of personal ownership of technology among the two groups. Over the period of active telecommuting, a significant difference has developed in technology ownership in the two groups, particularly in the ownership of personal computers and related equipment. It is interesting to contrast computer ownership by the participants of the survey, a 67.7% overall average, with the 46.2% personal computer ownership claimed by the applicants to the project.

Table 3: Technology Owned at Home by the Participants

Type of Technology	Telecommuters	Non-telecommuters
Personal Computer	73.7	58.2
Computer Printer	67.3	46.8
Computer Modem	39.7	19.0
Electronic Mail	10.3	6.3
Mainframe Access from Home	12.8	7.6
Photocopy Machine	9.0	7.6
Answering Machine	89.1	73.4
Facsimile Machine	18.6	12.7
Multiple Telephone Lines	30.1	19.0
Phone Line Used Only for Work	9.0	8.9
Voice Mail	3.2	1.3
Audio Conferencing	7.1	1.3
Call Waiting	42.9	25.3
Call Forwarding	14.7	7.6

One possible explanation for this disparity in computer ownership between telecommuters and members of the control group is that many of the telecommuters may have been on the verge of buying personal computers and their acceptance into the project triggered the purchase. Another possibility is that the internal departmental selection decisions were biased against prospective participants who did not own computers. As to the disparity in computer ownership between original applicants to the project and the members of the control group, it is possible that, since the project began, another 10% of City employees have purchased their own personal computers.

We also asked the participants how much *easier* various technologies made their work. Table 4 shows the results to date. It is clear that personal computers (with printers) and answering machines are key technologies for both groups. Interestingly, the non-telecommuters seem to prize technology slightly more than do the telecommuters. Figure 1 shows the same relationships in graphical form.

Figure 1: Relative Power in Making Work Easier

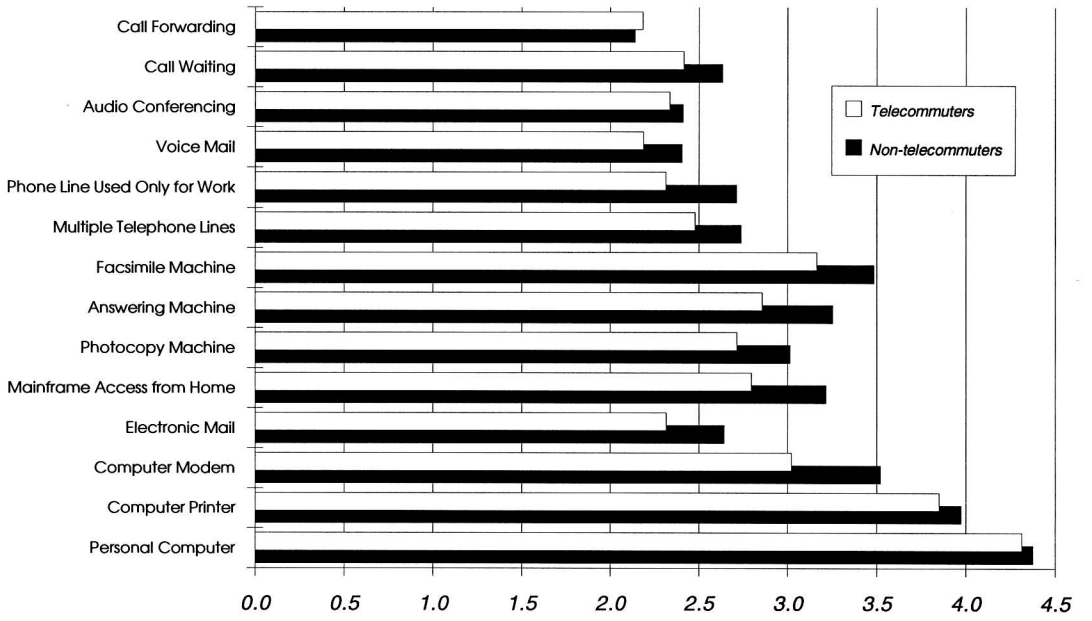


Figure 2: Power to increase Telecommuting (average days per month)

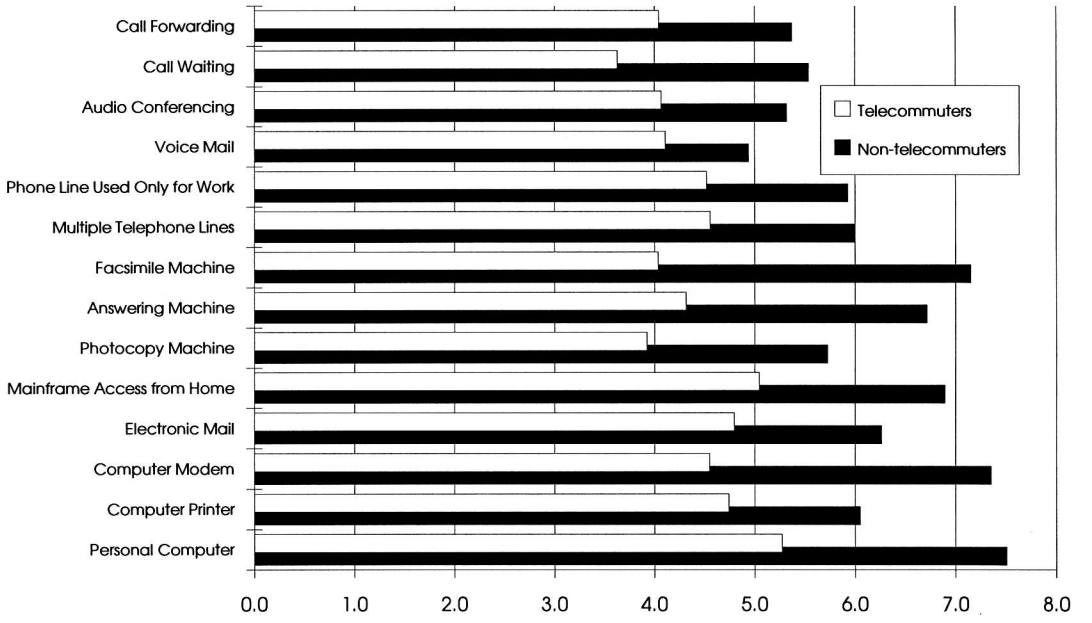


Table 4: Average Answers to:
How Much Easier Does This Technology Make Your Work?
(from 1 = No Effect to 5 = Very Great Effect)

Type of Technology	Telecommuters	Non-telecommuters
Personal Computer	4.3	4.4
Computer Printer	3.9	4.0
Computer Modem	3.0	3.5
Electronic Mail	2.3	2.6
Mainframe Access from Home	2.8	3.2
Photocopy Machine	2.7	3.0
Answering Machine	2.9	3.3
Facsimile Machine	3.2	3.5
Multiple Telephone Lines	2.5	2.7
Phone Line Used *Only* for Work	2.3	2.7
Voice Mail	2.2	2.4
Audio Conferencing	2.3	2.4
Call Waiting	2.4	2.6
Call Forwarding	2.2	2.1

In addition to the questions on the general power of each of these technologies, we asked the participants to estimate what effect the availability of the technologies might have on their ability to telecommute. Figure 2 shows those estimates, given as the average additional telecommuting days per months made possible by the

technology. Note that, for both of these questions, the non-telecommuters gave higher average estimates than did the telecommuters. This is particularly striking for the estimates of the ability of the technologies to increase the amount of telecommuting. Apparently, the telecommuters have a less optimistic (although still very positive) view of the ability of technology to increase the amount of telecommuting they do. In both cases, if all the estimates were added together they would total more days per month than are available.[13] Therefore, the estimates must be taken with a grain or two of salt. In either case, the highest ranked technologies are personal computers, their peripherals, and multiple telecommunications lines.

USE AT WORK

We also tested the relative importance to the participants' work of a broad array of technologies. We included traditional "technologies" such as mail, meetings and face-to-face conversation, as well as a variety of electronic and computer technologies. Since many fairly exotic technologies are included in our survey, the first task is to see how available the technologies are to the City employees participating in the project. Table 5 shows the results, listed in decreasing order of perceived availability. Note that these results depict the employees' *perceptions* about whether the technology is available to them at the workplace. Their perceptions may differ from reality to some extent. In general, there is little difference between the telecommuters and non-telecommuters. Apparently, a few employees believe that neither face-to-face conversation nor meetings are available to them!

[13] More than double the available days for the telecommuters, triple that available days for the non-telecommuters.

Table 5: Perceived Availability of Various Technologies

Technology	Percent Availability	
	Telecommuters	Non-Telecommuters
Full-Motion Teleconferencing	2.7	0.0
Slow-Scan Teleconferencing	2.7	1.3
Computer Conferencing	9.5	18.2
Voice Mail	11.4	7.8
Cellular Phone	17.6	11.7
Outside Database Searching	22.6	13.2
Electronic Paging	25.9	14.3
Electronic Mail	26.2	32.5
Call Forwarding	31.8	36.8
Phone Conferencing	55.6	63.9
Express Mail	63.5	61.8
Database Development	64.4	66.7
Computer Graphics	65.8	65.8
Spreadsheet Analysis	66.4	72.4
Text Processing	67.3	62.3
Facsimile	73.6	77.9
Internal Mail	73.8	77.9
Specialized Computer Programs	78.1	74.0
Answering Machines	79.9	61.0
Regular Mail	85.1	81.8
Personal Computing	86.3	85.5
Meetings	96.1	87.0
Face-to-Face Conversation	96.8	94.8
Telephone	100.0	100.0

We also asked the participants how often they used a particular technology and how important the technology was to performing their work. From these answers we derived a composite factor, we call *leverage,* that is a linear product of the other factors. Leverage values can range from 0 (meaning that the technology is either of no use or is not used) to 20 (meaning that the technology is used at least daily and is of immense importance to one's work). The leverage is computed only for those respondents who have the technology available to them. Therefore a technology that is not widely available can still appear as having high leverage if those few people who use it feel that it is important. Table 6 shows the rankings.

Although there are differences between the telecommuters and the members of the control group, none of the differences now appears to be statistically significant.[14]

It is noteworthy that personal computing ranks a close second in importance to the telephone for both groups, with text processing and internal mail alternating for fourth and fifth place. Although face-to-face conversation comes in third in both groups, it (and the telephone!) may be less important to the telecommuters than to the non-telecommuters. Figure 3 shows these results in graphical form. This leads us to conclude that personal computers, although not necessary for every job, have grown in importance for most City employees, whether or not they are

Table 6: Overall Importance or Leverage of Technologies to the Respondents

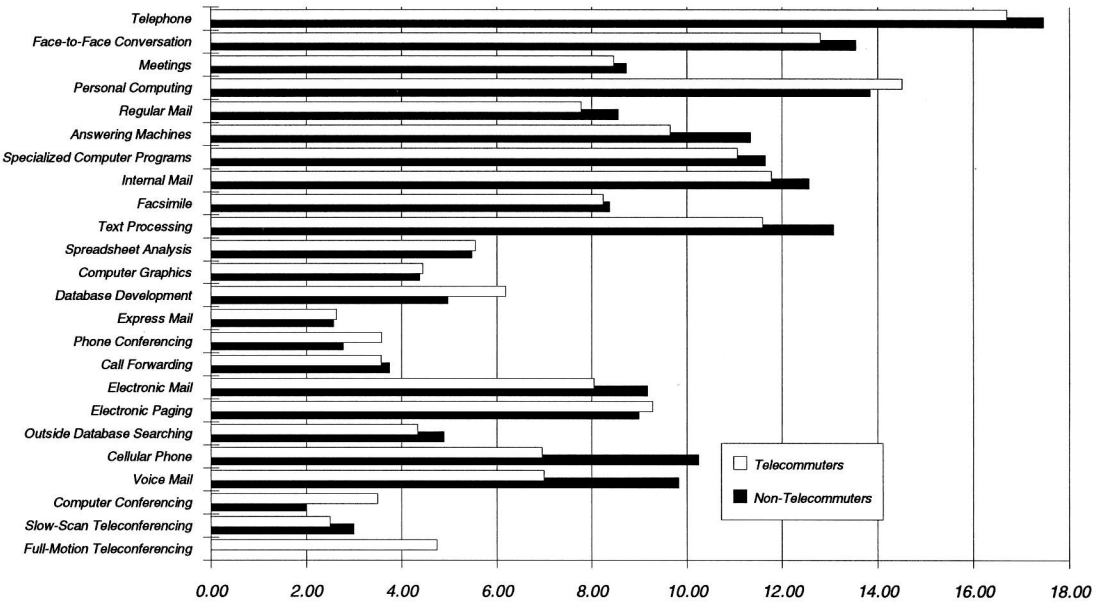
Technology	Telecommuters	Non-Telecommuters
Full-Motion Teleconferencing	4.75	0.00
Slow-Scan Teleconferencing	2.50	3.00
Computer Conferencing	3.50	2.00
Voice Mail	7.00	9.83
Cellular Phone	6.96	10.25
Outside Database Searching	4.34	4.90
Electronic Paging	9.29	9.00
Electronic Mail	8.05	9.18
Call Forwarding	3.57	3.75
Phone Conferencing	3.58	2.78
Express Mail	2.64	2.58
Database Development	6.19	4.98
Computer Graphics	4.45	4.39
Spreadsheet Analysis	5.56	5.48
Text Processing	11.60	13.09
Facsimile	8.25	8.38
Internal Mail	11.78	12.58
Specialized Computer Programs	11.07	11.65
Answering Machines	9.66	11.35
Regular Mail	7.78	8.56
Personal Computing	14.52	13.84
Meetings	8.47	8.73
Face-to-Face Conversation	12.81	13.55
Telephone	16.71	17.47

[14] The idea of statistically significant differences between groups reflects two factors: size of each group and the differences in their means and variances. Two small groups, with a difference in means comparable to, or larger than, that of a pair of larger groups, may not show that difference as being statistically significant because the expected variance of a smaller group is higher. There were statistically significant differences between the two groups in the baseline and mid-term surveys.

telecommuters. Note that meetings occupy ninth place in importance for the telecommuters and twelfth place for the non-telecommuters.

Voice mail, although not perceived as available to many participants, ranks higher than some of the computer capabilities in its leverage. On the other hand, some of the often touted "musts" for widespread telecommuting, such as computer, video and telephone conferencing, score near the bottom of the leverage scale. Full motion video conferencing is the most important of the three for those telecommuters who are aware of it or who have used it. However, most City employees are unfamiliar with either of these teleconferencing technologies.

Figure 3: Relative Leverages of Various Technologies



One interesting relationship that shows up in the non-telecommuter group is the growing importance of electronic mail (computer-based messaging) to telecommuters. In our baseline survey, the non-telecommuters felt that electronic mail was significantly more important, by almost a factor of five, than did the telecommuters. By the mid-term survey, the ratio of perceived importance had diminished to 1.5. It slipped to 1.1 by the final survey. The difference between the two groups was statistically significant at the 0.0002 level[15] for the baseline survey,

[15] That is, the probability is 0.0002 that the difference between the two groups is meaningless. To put it another way: the odds are 4999 to 1 against the difference being

but was significant only at the 0.0994 and 0.6117 levels in the mid-term and final surveys, respectively. In our opinion this, reflects considerable convergence in attitude of the two groups as they increased in size and diversity, and in knowledge and experience of electronic mail. We repeat our baseline forecast that electronic mail grows to be of comparable importance to the telecommuters as, and if, they gain experience with it.

PERSONAL INVESTMENTS

Ninety-six of the 156 telecommuters (62%) who responded to the final survey had made some sort of investment in work-related hardware and/or software during the past year. Of these investors, the average spent $2200 in computer hardware, of which $1800 was specifically for telecommuting. Software purchases accounted for $552, on average, of which $338 was telecommuting-specific. Maintenance costs accounted for $161 and $76, respectively; furniture costs averaged $385 and $253; and office machines took $775 and $353, respectively. Extra telephone services averaged $118, of which $88 was telecommuting-specific for 27 of the telecommuters. Total investments ranged from $5 to almost $15,000, with an average of just over $1400. Telecommuting-specific investments ranged from $10 to almost $8500, with an average of $668.

TELECOMMUTING PATTERNS AND IMPACTS

Now that most of the telecommuters in this survey have at least a year of actual experience with telecommuting, we can review their experiences with some degree of confidence. We have examined these experiences from three points of view:

1. Amount and distribution of telecommuting;
2. Quality of life effects; and
3. Work effectiveness changes.

BEGINNING TELECOMMUTING

Of the 325 individuals who had responded to our final survey by December, 156 were active telecommuters. Of the active telecommuters, 62.2% have been telecommuting more than 1 year, with only 7.7% who have been telecommuting less than 6 months.

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meaningless. By the mid-term survey, the odds against the difference being meaningless were reduced to 9 to 1. By the final survey, the odds had fallen to 0.6 to 1.

The nominal goal for the project was to have participants telecommuting at least one day per week, on average, with a nominal maximum average of two days per week. Some jobs are suitable for almost full-time telecommuting, in our experience, while others might encounter difficulty reaching the one-day-per-week goal. Some of the telecommuters found that they could not continue telecommuting at the same rate that they tried the first month. Others found that they could increase their rate of telecommuting. Still others have maintained their original rate. The overall average for the first month of telecommuting was 4.0 days, with median and mode also at 4 days and the range going from 1 to 23 days. For the first month of their telecommuting, 99% of the telecommuters worked at home 8 days or less.

In practice, the number of telecommuting days per month tends to increase over time. An analysis of the historic data for the project shows an expected average of 4.2 days per month for those who have been telecommuting for a year. Telecommuters with two years of experience are likely to be telecommuting about 8 days per month. For comparison, the State of California Telecommuting Pilot Project showed an average of 5.2 days per month at the end of the first year of telecommuting and 6.5 days per month at the end of the second year. A linear regression analysis[16] of the Los Angeles telecommuting frequency data indicates that the telecommuters will tend to telecommute about 2.4 days per week as they gain experience with telecommuting. Figure 4 shows the regression line. Note that the line begins only after a few months of telecommuting. This is indicative of the fact that beginning telecommuters tend to telecommute one or fewer days per week.

Although the training sessions for the telecommuters stressed that only full days of telecommuting would count, since the primary objective is to eliminate car trips, some partial day telecommuting was expected. In fact, 27 of the telecommuters also did some part-day telecommuting, one of them for 10 days in the most recent month before the survey. Half of the part-day telecommuters left home for the office between 7:00 and 9:00 a.m., the center of the time span proscribed by the SCAQMD in Regulation XV. Hence, this telecommuting had essentially no positive impact on the air quality problem.

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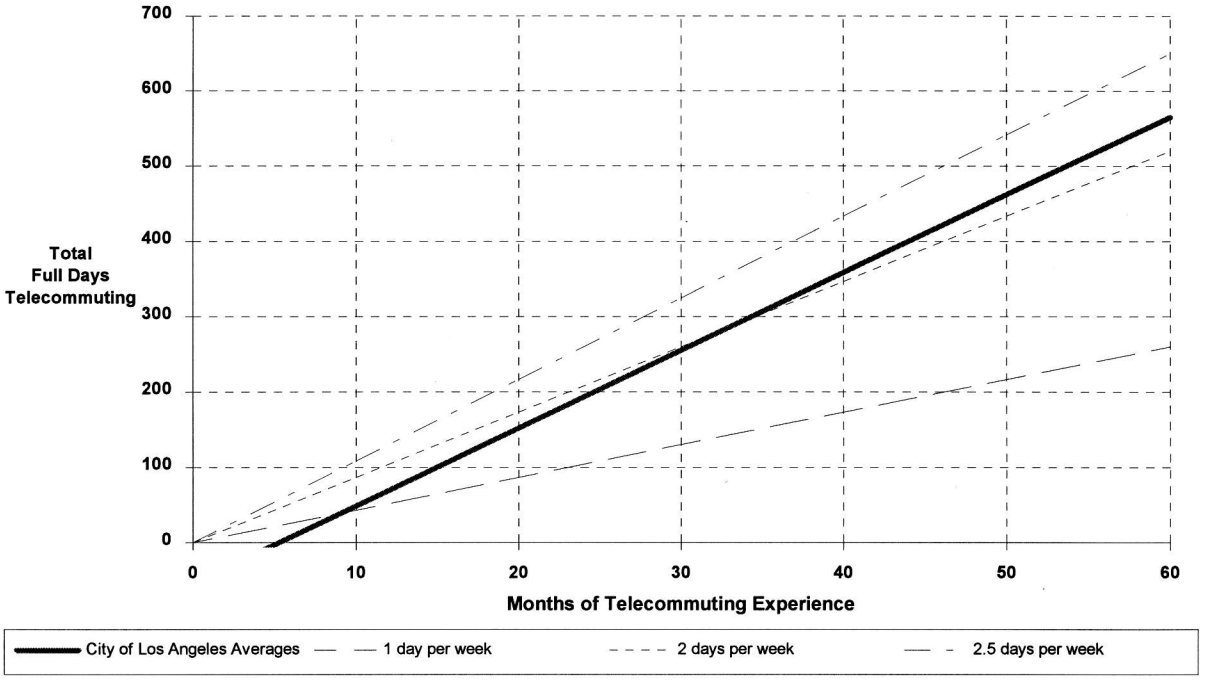
[16] Linear regression is a statistical procedure that fits a straight line to a set of data points. In this case the data points are length of time telecommuting and the number of telecommuting days during that period.

Figure 4: Projected Telecommuting Rates



One concern with telecommuting is whether it will increase car use, since an "extra" car may be available when the telecommuter is working at home. Twenty-three percent of the telecommuters said that the car was indeed used by themselves or someone else in their household when they worked at home (the remaining 76.9% maintained that it was not in use). **Of those who stated that their car was available, 23.1% (5.8% of all the telecommuters) stated that there was an overall decrease in non-commuting car use in addition to the decrease due to telecommuting!** To counter this, 23.1% (5.8% of all the telecommuters) stated that there was some additional car use, but not enough to counteract the telecommuting reduction. An additional 5% of the car-available group (1.3% of all telecommuters) said that their added non-commuting car use acted to cancel the reduction from telecommuting. In summary, only 8.4% of the telecommuters reported any erosion of the car use savings.

Analysis of the detailed trip logs[17] that were administered in March, 1992, showed that some of this additional car use was the result of telecommuters performing

[17] Cf. the project report: *Telecommuting Travel Impact Analysis: Los Angeles Telecommuting Pilot Project*, July 1992, by JALA Associates.

chores that otherwise would have been carried out by other family members. Hence, the slight additional use of their cars by some telecommuters may be overstated, since many of the "new" trips replace trips that would have occurred anyway. The net result of the actual trip measurements was an overall reduction in car use over and above the telecommuting reduction. ***At this point, to be conservative, we conclude that telecommuting produces exactly the car use reduction that equals the reduction in commute trips. Therefore, it completely satisfies the primary goal of the project: telecommuting-eliminated trips are not replaced by other trips.***

The most popular locations for the telecommuters' home offices are the den or study (20.8%), a spare bedroom (29.9%) and the dining room (13.0%). The average space used for telecommuting is 173 square feet (about 9% of their total floor space), with an average of 133 square feet used exclusively for telecommuting. Eighty-three percent of the telecommuters own their own detached-structure homes, 6.5% live in apartments and 7.7% live in condos or townhouses. The median home has 7 rooms.

The average telecommuter allocates about 37% of his/her weekly work tasks for the telecommuting period. *Given the overall average of 0.9 days per week telecommuting, that works out to 37% of the work being accomplished in 18% to 23% of the work week; possibly an average 100% productivity increase per telecommuting day.* Table 7 shows what the telecommuters are doing when they telecommute. While 17.5% of the telecommuters view telecommuting as a temporary or occasional thing, 82.5% (up from 77% at the mid-term survey) consider it to be a permanent change to their working ways.

Table 7: Activities Performed While Telecommuting

Activity	% who engage in it
Thinking/planning	69.2
Reading	68.6
Writing (without a computer)	55.1
Text/word processing	58.3
Research	55.1
Coordinating by telephone	44.9
Record keeping	17.3
Computer programming	20.5
Working with data bases	22.4
Other	20.5
Graphics/layout	10.9
Coordinating via computer	8.3
Having meetings	2.0

QUALITY OF LIFE EFFECTS

Aside from the quantitative effects of telecommuting, there is the issue of the socio-psychological effects of telecommuting. What is the impact of telecommuting on the telecommuters and their families? We do not develop direct evidence of the effects on the families, rather we asked the telecommuters about the impacts. We included a section in our evaluation questionnaires specifically oriented toward these impacts.[18] Common factor analysis of the questionnaires allows us to break a number of the work/social impacts into 11 categories, as follows:

1. *General Work Life*. This relates to changes in the individual's relationships with his/her supervisor, self assessment of job skills, feelings of job responsibility, influence, versatility and scope.

2. *Personal Life*. This factor includes changes in quality of family relationships, discretionary time, feelings of control of one's life, ability to separate work and home life, success in self discipline, coordination of family and work time, and knowing when to quit work.

[18] We developed this component (as well as the other components) of the questionnaire in studies of telecommuters and other information workers carried out over the past 16 years. It contains 50 questions about the extent and importance to the respondent of any impacts.

3. *Visibility*. Do telecommuters feel out of their supervisor's and co-workers' minds when they're out of sight? This factor includes changes in one's influence on organizational strategy, understanding of what others are doing, how well one's suggestions are received and self assessment of visibility in the organization.

4. *Environmental Influences*. This includes changes in home office space, stress from environmental noise, ability to match work and biorhythms, and feelings of self empowerment.

Table 8: Work / Social Factor Changes

Factor	*Telecommuters*	*Non-Telecommuters*	*Difference (T - non-T)*
Liberation	4.9	1.6	3.2
Continuity	3.1	1.3	1.7
Creativity	3.2	1.3	1.9
Personal Life	2.5	1.0	1.5
Environmental Influences	2.2	0.6	1.6
General Work Life	2.2	1.0	1.1
Stress Avoidance	1.2	0.3	0.9
Interdependence	1.0	0.5	0.5
Visibility	0.9	0.4	0.5
Belonging	0.6	0.3	0.3
Apprehension	0.7	0.6	0.1

5. *Belonging*. Do telecommuters feel themselves to be loners? Here we have changes in involvement in office social activities, amount of job-related feedback, career advancement, job stability and relationships with fellow workers.

6. *Creativity*. Changes in: creativity in one's work, the amount of flexibility in job performance and feelings of self empowerment, are in this factor.

7. *Stress Avoidance*. Changes in work related costs, ability to bypass physical handicaps and avoidance of office politics are grouped here.

8. *Liberation*. This factor includes changes in ability to concentrate on crucial tasks, the need to cope with traffic, and the ability to get more done.

9. *Apprehension*. Changes in uneasiness about equipment failure and feelings of guilt about "not really working" constitute this category.

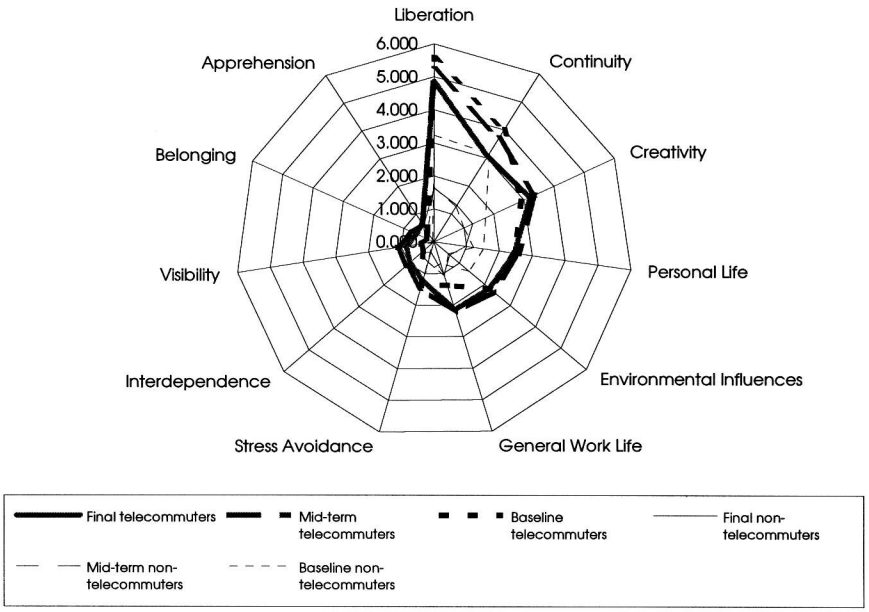
10. *Interdependence*. This factor relates to changes in the quality of meetings with colleagues and dependence on others to help perform one's job.

11. *Continuity*. The final factor calibrates changes in freedom from interruptions.

Note that the emphasis is on *changes* in these categories. We asked the participants what had changed since telecommuting began, whether or not they were telecommuters. We asked how much, if any, change there was and how important each issue was to them. We have developed composite values (amount of change multiplied by importance to the participant) for these factors, as shown in Table 8. The scales for *amount* of change are from -2 to +2, with -2 signifying much worse, 0 meaning no change, and +2 signifying much better. Importance ranges from 0 (not important at all) to 4 (extremely important to the participant). Thus, the composite factor can range from -8 (i.e., -2 × 4) to +8 (i.e., +2 × 4).

The surveys show clear differences between the telecommuter and non-telecommuter groups. There are three areas in which we might expect to see negative impacts from telecommuting: Visibility, Apprehension and Belonging. Yet, this group of telecommuters, on average, shows net positive changes for all three, although there are some individual negative responses.

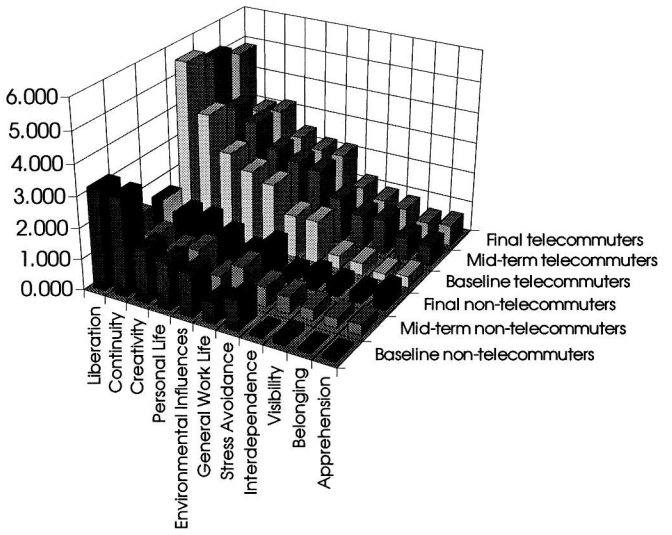
Figure 5: A "Radar" View of the Quality of Life Changes



Figures 5 and 6 show two different views of the elements of Table 8 as well as the comparable results from the mid-term and baseline surveys. Note that, with the exception of the liberation and continuity factors, both groups at mid-term appear to be more positive than they were during the baseline survey; then both groups tended to decline slightly from the mid-term to final surveys. In two of the key factors — continuity and creativity— the telecommuter group switched rankings between the mid-term and final surveys, while the non-telecommuters stayed about the same. This could arise from a possible increase in interruptions to the telecommuters as more people get used to contacting them while they are at home, coupled with a decrease in interruptions in the office as the on-site office population decreases. Interestingly, the telecommuters' responses to the liberation and continuity factors declined after the baseline measure, showing the effects of reality slightly modifying expectations.

In any case, the telecommuters show quality of life changes that are more positive in every respect than those of the non-telecommuters.

Figure 6: Comparative Quality of Life Changes



EFFECTIVENESS CHANGES

An important criterion in assessing the desirability of telecommuting is its impact on employee effectiveness. As a minimum acceptance criterion, overall work

performance should not degrade from its pre-telecommuting values. As is the case with the quality of life factors, we have concentrated on assessing ***changes*** in, rather than absolute values of, worker effectiveness. Several indirect measures of effectiveness factors are included in our evaluating survey questionnaire. However, the most numerically clear test is a direct question asking each respondent whether, and how much, their effectiveness changed since telecommuting began.

QUANTITATIVE ESTIMATES

Of the group of telecommuters, the range in their self-estimate responses ran from no change (twenty cases) to increases of 100% (five cases). The average response for all the reporting telecommuters was an increase of 29.9% with a median response of a 25% increase. In the case of the non-telecommuters, the range in responses ran from a decrease of 50% (one case) to an increase of 100% (three cases)[19] . The average response for the non-telecommuters was an increase of 23.8%, with a median response of 20%. The difference between the telecommuters' and non-telecommuters' average self-estimates of effectiveness change is 6.1%. The difference is significant at the 0.09 level.[20] About 13% of the telecommuters and 25% of the non-telecommuters indicated no change in their effectiveness since telecommuting began.

Note that the above figures are derived from the *employees'* responses. Typically, supervisors' estimates of employee effectiveness are lower than those of the employees themselves. Consequently, a parallel survey was made of the participants' supervisors. The supervisors' estimates of the telecommuters' effectiveness changes averaged 21.8%; their estimate of control group members' effectiveness changes averaged 9.3%, a difference of 13.5%. In this case, the difference is significant at the .008 level.[21] Twenty-five percent of the telecommuters' supervisors and 48% of the control group members' supervisors indicated no change in effectiveness. Hence, **the telecommuters are showing clear effectiveness improvements relative to the members of the control group, *particularly* in the estimation of their supervisors.**

There are some clear differences of opinion between supervisor and employee concerning effectiveness change. The telecommuters' self estimates tended to agree

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[19] Non-telecommuters can increase their effectiveness through such means as more experience or training, fewer interruptions from (telecommuting or other) co-workers, greater maturity in work attitudes, etc.

[20] That is, the odds are 10 to 1 that the difference is meaningful.

[21] Here, the odds are 127 to 1 in favor of a meaningful difference.

more closely with that of their supervisors. Nineteen percent of the telecommuters and supervisors agreed exactly on the effectiveness changes; 8% of the supervisors and control group members agreed. Twenty-six percent of the telecommuters received higher ratings from their supervisors than they gave themselves. Twenty-one percent of the control group members received higher than their self-ratings from their supervisors. The most interesting aspect of these results is that the supervisors' estimates have a much greater difference between telecommuters and non-telecommuters than do the individuals' self-estimates.

TRAINING INFLUENCES

One of the elements of the analysis is to see whether the initial training sessions for the project had any influence on the effectiveness outcomes. Table 9 shows the effectiveness estimates as a function of who was trained. A direct reading of the table can be slightly misleading, since there are only a few cases among the telecommuters where either no one or only the supervisor was trained. The overall evidence is that it is particularly important that supervisors receive training.

Table 9: Estimates of Effectiveness Increases by Level of Training

Training Received by:	Supervisors' Estimates		Self-Estimates	
	Telecommuters	Non-Telecommuters	Telecommuters	Non-Telecommuters
Neither	21.4%	6.0%	33.3%	21.3%
Telecommuter only	14.7%	11.0%	31.8%	21.2%
Supervisor only	38.3%	8.8%	30.7%	33.0%
Both	23.3%	12.5%	28.9%	26.9%

COST AND BENEFIT CONSIDERATIONS

A key issue in evaluating telecommuting, or any other change in organizational behavior, is whether the net result is positive, neutral or negative. Although some factors, such as quality of work life, necessarily must be somewhat subjective, other factors can be relatively readily quantified. We have also included actual measured costs and benefits to date. The costs include the time-plus-overhead costs of the City employees who have been participating in project administration. In order to remain conservative, the cost-benefit model reported here includes an assumption that the number of active telecommuters will remain at 300. The comprehensive

final report of the project will include costs and benefits under several different growth scenarios.

We have selected the following factors for analysis.

COSTS

DIRECT COSTS

Twelve main cost categories have been identified:

Additional Training;

Telecommunications;

Computers;

Moving;

Facilities Leasing;

Construction;

Furniture;

Insurance;

Miscellaneous Rental;

Project Administration;

Additional Travel; and

Liability

In most cases the costs are relatively easily quantifiable and are available routinely. In some cases the costs must be estimated. This approach of including quantifiable as well as estimated costs provides a conservative view of the project, so that the actual costs might be lower than those shown here.

ADDITIONAL TRAINING

This category deals with the costs for training that are specifically telecommuting related (for example, interpersonal communications and management instruction). Training costs may be computed as the total of time spent by the trainer and trainee, times their respective hourly rates (including indirect costs), plus costs of equipment and materials used for training. Training costs for the 432 employees (and their supervisors, etc.) who have been trained as of December 1, 1992, are

estimated at about $65,000, or $150 per trained telecommuter. This figure includes the costs of City personnel involved in administering/coordinating the training sessions, amounting to 34% of the total.

TELECOMMUNICATIONS

Telecommunications costs (such as equipment purchase/lease, software services, etc.) can be primarily telecommuting related or, as in the case of training costs, may be incurred as a normal part of office automation with telecommuting accounting only for some of the additional service charges. This allocation must also be made on a case by case basis. At the time of the mid-term report, the only costs we were been able to identify were the slightly higher average telephone bills of the telecommuters. These came to $3.17 per month, or $38.06 per year per telecommuter. The final survey shows that the telecommuters had an average monthly telephone bill of $3.59 more than the non-telecommuters, but a median telephone cost of $7.50 less than the non-telecommuters. We have not been able to determine the costs of additional calls from the office to telecommuters' homes, since the telephone billing system does not break out such calls.

For the sake of conservatism in the benefit-cost model, we will assume that the average telecommuter telephone bill increases by $4.00 per month ($48 per year) and that there is a corresponding $48 annual increase in office-to-home telephone charges for telecommuters.

COMPUTERS

Computer charges could constitute the largest portion of a telecommuting budget, depending on how they are allocated. These are the options:

- **Total Duplication**. These are cases where a computer is purchased solely because of telecommuting. Either there would be no computer use by an employee except for telecommuting, or there would be no duplication of computers without telecommuting. For these cases, all the computer costs should be charged to telecommuting.
- **Partial Duplication**. If the computer capabilities would be made available to an employee in any case, then only those costs peculiar to the telecommuting situation (such as equipment purchase/lease, make-ready costs, software, maintenance, etc.) should be charged to telecommuting.
- **No Duplication**. This covers cases where either the telecommuter does not use a computer while telecommuting, or where the necessary equipment and software

is already owned by the telecommuter (telecommuters' costs are analyzed separately), or where necessary software duplication is allowed without charge by the software providers and no computer communications software or hardware is used.

At present, we know of no cases of total duplication, and only a few cases of partial duplication, generally involving duplicate software packages for telecommuters' own personal computers at home. In general, almost no computer charges have been incurred. However, in many cases this is because employees who have been trained and need computers were not allowed to telecommute because they did not have computers at home and City-supplied computers were not available. Over 70% of the active telecommuters own their own computers and use them for telecommuting. Thus far these employees have invested a total of $103,511 in telecommuting-specific computer hardware, software, furniture, office equipment, telephone services and maintenance over the past year[22] . More than half, 56%, have made no telecommuting-specific investments in equipment. Note that, of those who have invested in equipment, about 85% of their total investment is specifically related to telecommuting. For conservatism, we estimate that the investment required for the average new computer-using telecommuter will be about $2,000, to be made either by the telecommuter or by the City.[23] For the purposes of the model, we have assumed that the City will make this purchase for 40% of the telecommuters added each year after 1992.

MOVING COSTS

This category includes all the costs of moving existing equipment from offices to either homes or satellite center offices. It also includes telephone installation costs. Also, costs of any interoffice moves by members of the control group are included here. So far, there have been no costs for moving telecommuters. We have not been able to assess costs of moving control group members. Therefore, this amount is zero in our current model.

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[22] The per-telecommuter cost for those who made telecommuting-specific investments averages $2052.24, split into $1839.45 for hardware and $212.79 for software that is telecommuting-specific. This is a significant increase over the amount reported for the mid-term survey.

[23] It is typically far less expensive for the telecommuter to buy the equipment, since the City generally pays a premium over the PC-compatible market prices for equipment of the same capability.

FACILITIES LEASING

Although the main group of the telecommuters are selected and the highest priority satellite site locations were identified, the administrative constraints on leasing facilities for the demonstration project have so far been impenetrable. Instead, we are using existing city facilities for satellite offices. The first two satellite office participants reportedly began telecommuting in late April 1992. Only one completed the final evaluation questionnaire.

ADMINISTRATION

There are several components of the administrative costs of telecommuting, some of which are difficult to assess. These include the special management costs of the pilot project itself (including evaluation), changes in the administrative system of the City, possible duplication of effort caused by telecommuting, and costs of system integration and coordination. Administrative costs include part of the salaries of the Project Manager, the Department Champions (coordinators) and consulting costs other than training. The estimated total administrative costs for the completed project is $307,000, including the planning phase of the project — about $700 per trained telecommuter.

ADDITIONAL TRAVEL

This category applies to two factors:

1. managers and professionals who find themselves traveling between their "home" offices and other centers during the day for meetings that would otherwise only require a short walk to a conference room; and
2. losses to car- and van-pools because of telecommuters who no longer use them.

None of these costs have appeared so far. Although some telecommuters are members of car- or van-pools, their participation as telecommuters does not appear to have disturbed the pools significantly, according to our interviews and the trip survey data.

LIABILITY COSTS

One largely unresolved factor is the possibility of increased exposure to worker's compensation claims resulting from work-related accidents in the homes of telecommuters. While experts say there have been no worker's compensation claims arising to date from telecommuting in any organization, this factor is included for

informational purposes. No participants in the project have claimed telecommuting-related worker's compensation claims.

INDIRECT COSTS

The following are indirect cost factors that are analyzed, since they relate to general support of office work.

INCREASED BUILDING ENERGY CONSUMPTION

Shifting work to homes, or to smaller buildings characteristic of satellite centers, may increase or decrease energy consumption related to space heating and cooling. To estimate this we check the differences in between average reported gas and electric bills. Telecommuters paid an average of $4.01 more for electricity and $4.51 *less* for gas than the members of the control group, for a net energy cost *de*crease of $0.50 per month per telecommuter. For conservatism we assume that there is no change in the energy consumption of City facilities when the telecommuters are away from those offices. The conclusion, then is that there is no significant difference between telecommuters and non-telecommuters in building energy consumption.[24]

INCREASED LOCAL TRAFFIC CONGESTION

By diverting automobile traffic from freeways to local streets, satellite center telecommuting may cause an increase in local traffic congestion, with associated energy and pollution costs. Since there are only two satellite center telecommuters so far, we have no way of assessing the cost. Therefore, it is set as zero.

BENEFITS

DIRECT BENEFITS

Although many of the cost elements are easily established, many of the benefits of telecommuting are less easily defined in quantitative terms. Most important of

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[24] As a counter example, the author's tele-office has two high-end personal computers and monitors running 24 hours per day, every day including weekends, plus a laser printer and other computer accessories, lighting, etc.. The office is electrically air conditioned. The total annual energy use of the office is about 1900 kWh. The annual cost of this (all in electricity use) is $176, or about $14.70 per month (about the cost of ten gallons of gasoline). Ten gallons of gasoline will suffice for about six round trips between the author's office and City Hall.

these benefits is employee effectiveness. The following are the benefit factors that generally appear in non-quantitative terms.

- *Increased Employee Effectiveness* including output quality and quantity. We compute the effectiveness impact by multiplying the estimated effectiveness change by the individual's salary. If we adopt the conservative view that the differential effectiveness change of the telecommuters (that is, the telecommuter estimates minus the non-telecommuter estimates) is that of the employees, then the monthly effectiveness-change-benefit per telecommuter at present is about $369 (as contrasted with $344 at the midterm report and $155 six months earlier). If we average the supervisor's and employee's estimates we get a monthly effectiveness-change-benefit of $642 (as compared to $508 at the mid-term evaluation and $295 in the baseline survey). If all the 432 telecommuters trained to date were to become active — and if these effectiveness changes were maintained or increased for the entire group — then the annual benefit would be between $1,914,000 and $3,327,800, depending on one's point of view.

  The average telecommuters' self-estimate of effectiveness change increased by 19% between the final and mid-term surveys, and by 22% between the baseline and midterm surveys, while the controls' self estimates increased by 41% between the final and mid-term surveys, and decreased by 7%. between the mid-term and baseline surveys. The supervisors' estimates of their telecommuters' effectiveness changes increased by about 28% between the final and mid-term surveys, while their estimates of non-telecommuters effectiveness decreased by about 2%. The mid-term estimates from the supervisors showed about the same amount (46% and 50%, respectively) for both groups over the baseline estimates. The conclusion is that the telecommuters' effectiveness is still increasing at the end of the project, while the non-telecommuters effectiveness is staying about the same, at least in the estimates of their supervisors.

- *Decreased Sick Leave* can be derived from employee records. Our conclusion from the data derived to date is that telecommuters will take two days less sick leave per year.

- *Decreased Medical Costs* are difficult to assess. For the time being, we assume this is zero. However, we expect long term medical costs to

decrease for telecommuters because of the clear reductions in stress stated by participants in our focus group sessions. These benefits are not likely to show up in statistically significant terms for several years, assuming that telecommuting continues beyond the pilot project.

- *Increased Organization Effectiveness* including output quality and quantity. An answer to this question requires a survey that has not yet been made and is not part of the project. Anecdotal evidence from the focus group meetings over the past six months leads us to believe that there is a slight overall increase in effectiveness of the telecommuters' organizations. That is, effectiveness is increasing among the non-telecommuting office mates of the telecommuters. For the purposes of the benefit-cost model, we are assuming that this improvement in dollar terms, amounts to 0.5% of the telecommuters' salaries (that is, about 3% of the supervisor-estimated effectiveness increase of the non-telecommuters).

- *Decreased Turnover* and attendant reductions in personnel search, hiring and training costs. Of the telecommuter respondents, 23% (as contrasted to 17% at the mid-term evaluation) replied that they had seriously considered quitting. Among that number, 74% (or 18% of all the telecommuters) said the ability to telecommute was a moderate to decisive influence on their decision to stay. We have not yet established a firm dollar value on the cost of replacing these individuals. However, our conservative estimate is that it would be about 25% of their annual salaries if they had to be completely replaced. We multiply this by an additional factor (ranging from 0 to 1) related to the influence of telecommuting on their decision to stay. The computed result is a 1992 benefit of about $206,000 for the group of 156 telecommuters who completed the final questionnaire.

- *Reduced Parking Requirements*. If advantage were taken of the fact that telecommuters are not using parking space part of the time, and the space were reassigned to, or used by, non-telecommuters, then the monthly savings would be approximately 0.245 × the monthly parking rate per telecommuter ($90), or about $22.

- *Office Space Saving* as telecommuters share office space. We have not yet tested office space saving methods. However, past experience indicates that organizations with large numbers of home-based telecommuters can achieve up to 33% reductions in office space. In the case of some City departments, telecommuting has allowed existing groups to work more

effectively with what was previously severe overcrowding. To be conservative, we have set this factor at zero for the cost-benefit model.

- *Increased Ability to Attract Staff* as prospective employees consider telecommuting an attractive work option. Although this is related to the turnover reduction benefit, it has not been tested since the City is in a hiring freeze position. This factor has been used successfully by other government agencies as a hiring tool.

INDIRECT BENEFITS

As with the cost elements, there are indirect benefits, some of which are most easily measured in dollar terms. These are largely related to reduced use of automobile transportation, as the following will indicate.

- *Decreased Energy Consumption* as commuter automobiles are *not* used. We estimate that the telecommuters' energy use reduction, assuming current telecommuting trends persist,[25] will run in excess of 6000 kilowatt-hours per year. At current gasoline prices ($1.30 per gallon), this amounts to an annual saving of about $214 per telecommuter.
- *Decreased Air Pollution*. The air pollution reduction is directly proportional to the overall decrease in automobile use. However, dollar costs of air pollution are difficult to establish and are not included here.
- *Decreased Traffic Congestion*. As in the air pollution case, it is difficult to make a firm estimate of the dollar costs of traffic congestion. An indirect measure is that of a primary impetus for the telecommuting project: if the City does not increase its average vehicle ridership to satisfactory levels, it may be liable for fines of $25,000 per day of non-compliance to Regulation XV of the South Coast Air Quality Management District.
- *Increased Access for the Mobility Handicapped* including disabled, working parents, retirees, etc.. The group of telecommuters includes individuals

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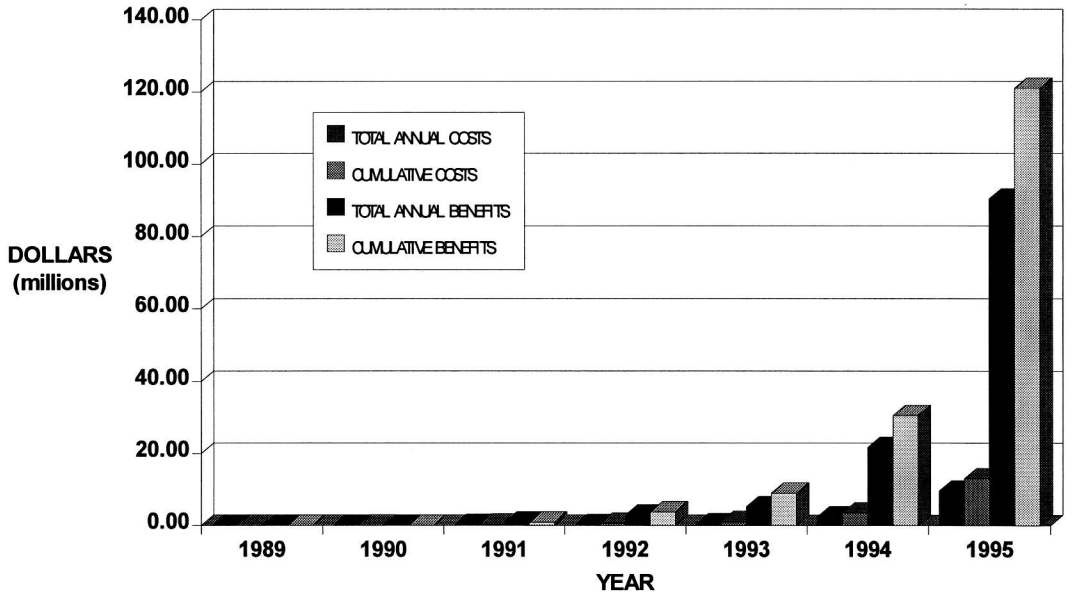
[25] That is, a continuing trend toward telecommuting an average of two days per week, replacing an average round trip of 45.7 miles, with 10% rideshare offset and an average car fuel efficiency of 24 miles per gallon. The average work week is 4.7 days, with an average of 49 weeks worked per year. This produces a total annual saving of 187 gallons of gasoline (or about 6800 kilowatt-hours) per telecommuter. We deduct 800 kilowatt-hours to account for any additional home energy use.

with mobility handicaps. Their reactions in this respect are included in the overall improvements in quality of life indicated by the telecommuters.

RESULTS

The factors above have been included in a cost-benefit model. The major one-time project costs are those of the project itself: planning, selection, training, evaluation and administration. These costs will cease at the end of the project[26] . Recurring costs are primarily those of telecommunications and training. All of the benefits are recurring. Figure 7 shows that historical and expected costs and benefits from the inception of the project in 1989 through 1995. The figure includes an assumption that telecommuting will increase in the City. The assumed growth shown here is to 600 telecommuters in 1993, 2400 in 1994, and 9600 in 1995. we have identified more than 16,000 "telecommutable" jobs in the City.

Figure 7: Summary of Project Costs and Benefits

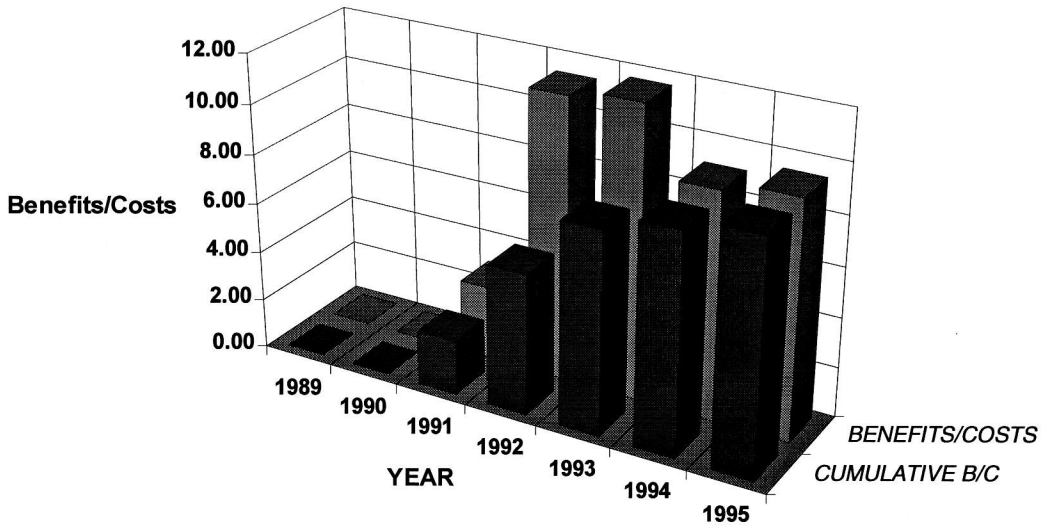


It is also informative to review the ratios between benefits and costs. Clearly, at the beginning of the project—during project planning, participant selection and training—there are no benefits, just costs. Once the participants begin telecommuting, however, the benefits begin to accumulate. At some point, if all goes

[26] Early in 1993.

well, monthly benefits begin to exceed costs. At some further point, the payback or breakeven point, cumulative benefits equal and begin to exceed cumulative costs. Figure 8 shows the historical and anticipated results for the project. *Note that the computer and software costs mentioned above are included in this analysis, even though those costs are currently being borne by the telecommuters, not the City.*

Figure 8: Summary of Benefit-to-Cost Ratios



Survey data through 1992, estimates thereafter, for City of Los Angeles Telecommuting Project

Table 10 show these results in numerical form.

The breakeven point in the project occurred in mid to late 1991. The drop in benefit-to-cost ratios in 1994 and 1995 is a result of training and computer purchases for the large numbers of new telecommuters assumed in the model. If future experience matches the data derived thus far, the post-project benefit-to-cost ratios could regularly exceed 100 to 1, once all of the telecommuters are trained and computer purchases are completed! However, we must be cautious at this point, since there may be cost data we have yet to uncover and the telecommuter effectiveness changes may yet diminish with time. For example, the current model assumes that only 40% of new telecommuters would have City-purchased computer equipment. This is felt to be conservative, since almost three-quarters of the telecommuters are now providing their own equipment. In a broader operational situation, those computer costs might be higher — or lower. Similarly, expansion of telecommuting to a broader selection of City employees might result in lower effectiveness

increases. In any case, the data at this point make it clear that telecommuting is working very well for City of Los Angeles employees and is far above a simple break-even situation.

Table 10: Summary of the Benefit-Cost Model
(Costs in $ millions)

YEAR	1989	1990	1991	1992	1993	1994	1995
NO. OF TELECOMMUTERS	0	0	211	300	600	2400	9600
TOTAL ANNUAL COSTS	0.05	0.06	0.30	0.25	0.44	2.39	9.57
TOTAL ANNUAL BENEFITS	0.00	0.00	0.90	2.82	5.19	21.65	90.37
CUMULATIVE COSTS	0.05	0.11	0.41	0.66	1.10	3.50	13.06
CUMULATIVE BENEFITS	0.00	0.00	0.90	3.72	8.91	30.56	120.93
BENEFITS/COSTS	0.00	0.00	2.96	11.36	11.68	9.05	9.45
CUMULATIVE B/C	0.00	0.00	2.18	5.63	8.06	8.74	9.26
DEVELOPMENT COSTS	0.048	0.041	0.086	0.157	0.034	0.810	3.240
OPERATING COSTS	0.000	0.020	0.217	0.092	0.410	1.581	6.325
BENEFITS minus COSTS	-0.05	-0.06	0.59	2.58	4.74	19.26	80.81

APPENDIX 1: QUOTES FROM SUPERVISORS

The following is a set of comments from the supervisors who completed evaluation forms in the final round of surveys.

GOOD NEWS

Even with an increased caseload, and the increased complexity of cases, [the telecommuter] has maintained his level of effectiveness. I believe this has been possible because of the quality time telecommuting affords him.

Telecommuting has allowed [the telecommuter] to keep pace with an increased workload, more complex cases, and specific projects.

This employee has a significant impairment (physical) to her performance. The telecommute day has helped compensate so that she is more productive, even though her overall performance is below her prior capability. (She has a degenerative disease that is also impairing her mental processing.) Telecommuting is a job saver for her and us.

I'm very supportive of telecommuting. Originally my support was theoretical. Today it is based upon actual practice. The "quiet" or undisturbed time available to telecommuters allows for very productive work on certain tasks/assignments.

Our work is difficult to quantify in terms of how long a particular part of it should take, and as everyone is at a different task at different times, it just is not clear if someone is getting more, less or no change in the work done. The only thing I can tell is that telecommuters are happy about telecommuting.

Telecommuting has helped [the telecommuter] as well as other employees I am familiar with in increasing productivity in that they can work on a project with no distractions such as phone calls and people dropping by to talk.

Telecommuting has forced [the telecommuter] to be a more organized worker. He has had to plan his work here and at home. He stated that the flexibility in work environment and work schedule has helped relieve the boredom that comes with doing repetitive tasks.

This individual has been on medical leave of absence. We attempted to use telecommuting to alleviate the degree of worksite pressures. While she telecommuted, her production record improved.

We are suffering a 50% staffing shortage at this time and are convinced that telecommuting has helped us to maintain an acceptable level of case processing.

I think the telecommuting program should be continued since the productivity, volume of work, increased for the engineers I supervised.

Due to required meetings, field work, employee unable to complete telecommute goal of once every two weeks. Excellent use of time the few times she did telecommute. Employee is very productive at the office and in the field and at home telecommuting.

For certain tasks/functions/projects and employees telecommuting is, in my opinion, vastly more effective than traditional methods. I would like to see it gain acceptance.

I am also convinced that **many** employees under my supervision could be more productive if they "telecommuted" (and did not have to contend with phone and other interruptions).

Telecommuting works very well with this motivated employee. When large complex projects need to be completed in a short period of time, she works from home without interruption. She makes optimum use of the phone for communication and for providing and receiving information. She uses her own computer equipment.

[The telecommuter] lives near [a City facility]; on several occasions, he was able to do field work "next door" without having to travel downtown and back. For him, [the facility] became a ready-made "satellite center."

Employee lives 29 miles from work. Effective use of employee's time. Special responsibilities of the job lends itself to telecommuting.

There is no doubt in my mind that all of our professional and most of our clerical staff could significantly benefit by telecommuting once or twice per pay period. Too many distractions in the office (much public comment telephone work).

[The telecommuter's] job performance is higher than the average engineer and that continued with telecommuting. He has outstanding PC skills which makes his telecommuting more effective and he has flexible approach to when telecommuting is done. He is well organized and plans ahead which also adds to his being very effective in a telecommuting program.

I have found that telecommuting works well when an employee is assigned a project that requires extensive reading and analysis.

MIXED NEWS

[The telecommuter] initially focused on reports and manuals. Later she had access to a main frame connection and devoted time to testing and trouble shooting new information systems. I had to limit the main frame access when I was pressured to keep the phone bill under $70.00 per month. For an effective program, the Dept. needs to solve the Telecommunications Cost Problem by placing low cost or toll free nodes near the telecommuting employees.

There has been a slight increase in my workload duties that [the telecommuter] would have handled had he been present, but at the same time this was offset by the greater productivity.

I believe that telecommuting is a very good program. But the effectiveness of the program is very much dependant upon "the employee" who participated in the program. Most of the participants are performing well but some would be kind of abusing the system (program).

The work was tailored to be effectively done at home. Because main frame accessibility was not available to [the telecommuter] , her work focused on reports, manuals and studies. She was able to accomplish almost two days work in one telecommuting day at home. This was a Win-Win for the Dept.

NOT SO GOOD NEWS

Employee lives one mile from work. More effective on job site as position already requires off site field work with branch libraries.

Employee lives two miles from work. Responsibilities of position more effectively carried out at work site since job has extensive field work outside of the office.

The city has chosen to operate its pilot program on the basis of telecommuters taking one day off per week. I'd like to see a more irregular schedule. [Note: See the comment on the next quote.]

We have removed all our telecommuters from weekly, fixed telecommuting days and have made the option available to any staff member, on a periodic basis, provided that there is justification. We found the practice of having fixed telecommuting days to be negative in that staff began to assume the day as an employment right rather than a privilege. [Note: Considerable time was spent during the training sessions and in subsequent focus group sessions about the relative advantages and disadvantages of fixed/variable telecommuting schedules, stressing the likely need for flexibility. One can lead a horse to water . . . .]

Due to personal problems and work related changes in duties and assignments the telecommuting option did not work out for [the telecommuter]. We both continue to be positive in attitude towards it and if situations change would re-implement.

On the plus side [the telecommuter] is very productive on his TC day. On the down side [the telecommuter's] work (we feel) must be reviewed. [Note: A major part of the training deals with the work definition and review process.]

BAD NEWS

Due to the assignments and upgrading of our work environment [the telecommuter] has not telecommuted in the past several months. There has been a significant decrease in productivity on two of her existing assignments. *Also, because our manager . . . is unwilling to commit his team to the program, it is no longer one of his top priorities to promote this program. He finds it easier not to support even if the participants are already enrolled in the program.* [Emphasis added.]

[The telecommuter] elected to stop telecommuting because of too many interruptions at home. [Note: We find this happens with less than 5% of home-based telecommuters.]

This program required more structure, training and monitoring to be effective. Passing out this questionnaire 5 mos. after we terminated the pilot project is ludicrous. [Comment by a supervisor who was trained but neither supervised a telecommuter nor attended subsequent focus group sessions. Only two of the active departments, accounting for 9 telecommuters, formally terminated their telecommuting as of July 1992.]