Managing Teleworking
Final Report

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Jack M. Nilles
Center for Futures Research
Center for Effective Organizations

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The project reported here had the support of many organizations and individuals. Foremost among them were the corporate sponsors of the project: ComputerLand, General Telephone of California, Honeywell, IBM, Northwestern Bell and Pacific Bell. Much of the survey questionnaire work for the project derives from a prior project involving the author and the extensive efforts of Omar El Sawy, Monty Mohrman and Thierry Pauchant. Dr. Pauchant also was heavily involved in the survey aspects of this project. Particular thanks for invaluable support, aid and advice also go to Dennis Acebo of GTE, Rick Higgins of Pacific Bell, Frank Miller of IBM and Donna Stubbs of Honeywell.

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[1]Adapted from Jack M. Nilles, *Exploring the World of the Personal Computer. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1982. Copyright 1986 by Jack M. Nilles.*

EXECUTIVE SUMMARY

Purposes

The research reported here had two major purposes. The first purpose was to develop and test a set of techniques that would be effective for managing work situations in which the members of the work group were physically separated for significant periods of time. In particular we emphasized the management issues of telecommuting.

Telecommuting is defined as the partial or total substitution of telecommunications, with or without the assistance of computers, for the commute to/from work.

The second purpose of the research was to estimate the rate at which telecommuting might become adopted by businesses in the United States and to assess key events that might alter the course of acceptance of telecommuting.

The basic premise of the research was that, although telecommuting might have a number of inherent attributes that would make it attractive to organizations, its acceptance in the near term (that is, over the next decade) would be decided largely by the attitudes and experiences of middle managers; managers of telecommuters. Further, it would take a significant amount of empirical evidence to convince managers that the rewards of telecommuting are as promised and that the risks are mostly illusory.

The Plan

Six corporations agreed to support the project when it began in June 1985[1]. They were: ComputerLand, General Telephone of California, Honeywell, IBM, Northwestern Bell and Pacific Bell. The original plan was to spend the first six months of the project developing background materials and selecting a set of telecommuters in each of the supporting organizations. The background materials were to include training documentation and a system for analysis of the impact of telecommuting on the participants. We at USC asked that a total of at least 100 telecommuters be selected from the participant organizations; each of whom would telecommute for at least eighteen months. This would enable us to assess "before" and "after" performance. We also requested similar tests for a set on non-telecommuters with similar jobs as a further gauge of the relative impact of telecommuting.

At the end of the test period, in June 1987, we were to analyze the test results and subsequently present them to the sponsoring organizations.

The Reality

One of the support organizations dropped out of the project entirely after a few months because of changes in its management structure. Two other supporters declined to take an active part in the project.[2] Another two supporters did not make use of our background materials, nor did they set up internal pilot projects. However, toward the end of the

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[1]For details of the initial project plan, see *Managing Teleworking*. Los Angeles: University of Southern California, CFR Publication F55, 1984.

[2]The reasons given for their change of heart were precisely the ones we wished to demonstrate were invalid. Both corporations were experiencing reductions in their middle level forces at the time, a process that made the potential participants in the project (and/or their supervisors) excessively edgy about the effects of participation on their career plans.

project they did locate employees who were already telecommuting, or who had been telecommuting, to participate in answering one round of evaluation questionnaires. The last organization set up a series of pilot projects and subsequently was active in developing telecommuting opportunities throughout the company[3]. This organization, too, has had difficulties in getting a critical mass of management support for telecommuting as a consequence of continuing changes in the management structure. In no cases were we able to get cost or benefit data from the participating organizations.

For these reasons--marginal financial support and significantly reduced, abridged and delayed field testing--the project fell short of our expectations. However, we have acquired sufficient data to be able to assess the impacts of telecommuting in a quantitative way.

In particular, we were able to get extensive data on 77 project participants from the 3 companies. Of this total, 44 were telecommuters, the rest were individuals with similar jobs in the same organizations. The two groups were similar in several other respects, such as age distribution, experience in the company, the size of their work units, etc. Each answered a questionnaire that went into considerable detail about his/her job and performance. All but one of the participants were mid-level employees.

Conclusions

There are 9 key conclusions that can be derived from the survey data.

1: Telecommuting can be successful for a large variety of job types.

2: Telecommuters are sociologically and psychologically very similar to non-telecommuters.

3: Telecommuters are more likely to be professionals than managers or routine information workers.

4: Telecommuters tend to be better supported by the corporate information infrastructure than either the controls or the members of our previous national sample of mid-level workers.

5: Telecommuters, at least at this stage of diffusion of the underlying technologies, are more likely to be in relatively "high tech" organizations.

6: Telecommuters tend to reserve their critical, thought-intensive work for their home or satellite offices.

7: The self-rated effectiveness of telecommuters is higher than that of comparable non-telecommuters.

8: Telecommuters are not significantly different from non-telecommuters in most aspects of personality, job characteristics, motivation and performance.

9: The socio-psychological experiences of long-term telecommuters are moderately to significantly more positive than for non-telecommuters.

10: Most telecommuting is part-time.

[3]Unfortunately, this company was only able to administer the evaluation questionnaires after their test group had been telecommuting for more than a year. Therefore we were unable to get any "before" data.

In addition, we make the following forecasts concerning the growth of telecommuting.

1. **Telecommuting will grow at least 25% per year for the next 5 years.**
2. **The public sector may overtake the private sector in promoting telecommuting.**
3. **Growth in information technology familiarity will act to accelerate adoption of telecommuting.**

A ONE MINUTE, PERSONAL HISTORY OF TELECOMMUTING

I coined the word *telecommuting* in 1973 to describe the basic concept that *telecomm*unications technologies, possibly with the aid of *com*puters, could effectively substitute for *commuting* to work--at least for some people, some of the time. The occasion for this was a research project at USC that was funded by the National Science Foundation as part of a program to stimulate more research on telecommunications policy issues. Shortly after that definition was expanded to *teleworking* to broaden the idea to include all kinds of travel substitution (such as video conferencing) during the work day/night. In all cases the focus was on bringing the work to the workers rather than the workers to work.

At the time the concepts weren't new, just the words for them. I first began exploring the idea in 1970, finding that spending one week per month in Washington, D.C., the rest of the time, usually, in Los Angeles, was getting old fast. But it took three years and a change of employers to get the formal research started. Actually, a colleague of mine at TRW Systems was the first telecommuter I knew personally; he had a Teletype KSR-33 terminal in his den so he could work out ideas on the company mainframe in the wee hours of the morning. That was in 1967.

About the same time our research began, several others were exploring the concept of decentralized work via telecommunications. Richard Harkness was writing his Ph.D. dissertation on the topic at the University of Washington, from an urban planning perspective. The Communications Study Group at University College, London, under the leadership of Alex Reid, was doing a number of field studies with government workers in and around London. Peter Goldmark, inventor of the LP record and head of CBS Laboratories, was beginning experiments in his "New Rural Society" project in Connecticut until his untimely and ironic death in an automobile accident. Murray Turoff had started his computer conferencing research while at the Office of Emergency Preparedness, continuing it, with Starr Roxanne Hiltz, when he returned to New Jersey Institute of Technology to develop the Electronic Information Exchange System (EIES). In short, there was a ferment of research on telecommuting related topics in the early to mid-1970s.

So what happened then? Not much. The research community, having found to our satisfaction that teleworking in its various forms was feasible and had significant benefits, both economic and psycho/sociological, went on to other things. No other federal government agencies (specifically, NSF, the Departments of Transportation, Housing and Urban Development, and Energy) were interested in supporting follow-on research. Our 1973 conclusion, that the biggest barrier to telecommuting was in the minds of middle managers, was proving to be quite accurate. A few companies and federal agencies tried telecommuting; some, but not all, still have active telecommuting programs. Often the programs failed to expand because their champion was promoted or otherwise went somewhere else. Meanwhile, the pressures that tend to encourage telecommuting have been building all over the globe. Research started in Japan in the late 1970's, partly as a result of the translation into Japanese of our book on the topic. Similar research efforts began in Europe in the early 1980's, particularly in West Germany.

Our USC team concluded in 1974 that telecommuting would develop on its own in the U.S., as a grass-roots movement, as the technology improved and as more non-techies became confident in its uses. A particular and major influence in that expansion has been the personal computer. After ten years I decided that the technological, economic and sociological conditions had changed enough (in the directions forecast) that it would be worth another look to see how matters were progressing. This report gives an overview of the environment for telecommuting from the present time to the next decade or two. The emphasis is on the various environmental factors that will have the strongest influence on telecommuting in the future.

PART 1: A FIELD TEST OF TELECOMMUTING

PROJECT DESIGN

Objectives

The focus of the project was on testing four main premises:

1. many, if not all, types of information *work* are amenable to some form of telecommuting;
2. not all information *workers* are suited to telecommuting, they and their jobs should be selected according to some sort of success criteria;
3. successful telecommuting managers may or may not be born, but they can be made; and
4. the benefits of telecommuting--to both the employer and employee--significantly outweigh the costs.

Testing the first three of these premises constituted the initial phase of the project. During this period we developed a set of criteria for selecting telecommuters and their managers. We also developed a set of training guidelines that emphasized the management style issues and the practical aspects of telecommuting from home.

This material was given to the sponsors of the project in the form of briefings to the sponsor representatives and as outlines for user manuals. The latter were to be customized by the individual sponsors to match their own organizational policies.

The emphasis of the project design was on exploring the techniques that would make telecommuting successful. This is in contrast to the more passive approach of just getting some people to telecommute and watching what happens. Our approach was in the philosophy of action research: implementing what was believed to be positive change, then adjusting and tuning the action process as working experience dictates.

For example, at the outset of the project we recommended that each participating sponsor appoint/choose a champion--a representative who was personally motivated to make the project a success. This would help to ensure that as problems arose there would be someone on the spot with a 'fix-it', not a 'tsk-tsk' attitude.

Forms of Telecommuting

Two main forms of telecommuting were tested during the project: home-based and satellite center telecommuting. In home-based telecommuting the telecommuter works from home part or all of the time. In satellite center telecommuting the telecommuter goes to an office location that is closer to home than the office at which the telecommuter would otherwise work.

There is a practically infinite variety of combinations and permutations of these two possibilities, ranging from the occasional home telecommuter, the part-time satellite telecommuter, combinations of the two, or the full-time variant of either of these. One secondary objective of the project was to get a feel for the ratios of home/satellite/main office work that might be optimal for different types of jobs, individual telecommuters, or work situations. In all cases we wanted to see what situations were most successful, how successful, and for whom.

Participant Selection

Our telecommuter selection process recommendations were based on the philosophy that successful telecommuters, particularly those working from home, would have certain characteristics not necessarily shared by everyone in their work groups. Two of the most important of these characteristics are self-motivation and a high level of job skills. But before we got to those personality and background considerations we posited that it was necessary first to examine the nature of the prospective telecommuter's job.

Job Considerations

The key issue in *job* (as contrasted to individual *telecommuter*) selection is the extent to which the tasks and activities constituting a job are independent of the physical location of the job performer[4]. For example, a machinist in a factory needs to be where the machine is in order to properly perform the job. A receptionist (in a traditional office) needs to be in a specific location where the visitors come before being sent off to another location. Participants in a meeting (without benefit of teleconferencing technology) need to be in a specific, common location during the meeting. All of these activity examples show location dependence.

On the other hand, many common information activities are location independent. For example, report preparation can be done anywhere, provided the background materials and writing implements are at hand. Telephone contacts can be made from any place that has a telephone. Thinking, reading and similar mental activity tend to be unconstrained by place.

Hence the first step in job analysis for potential telecommuters reduces largely to making a fairly comprehensive inventory of work activities over a period of one or more weeks, lumping them into location-dependent and location-independent categories. The next step in the process is to evaluate the likelihood that the location-*dependent* activities can be lumped together into fewer than five days per week. If so, then the possibility exists that the job holder can telecommute.

It is important to distinguish here between satellite and home-based telecommuting. Satellite offices generally encompass a broader set of options that may be location-dependent (that is, they should be performed in company facilities) but not main-office-dependent. For example, data entry activities might in principle be performed at home. But physical security considerations (such as the need to protect sensitive data) might dictate that a satellite center is a wiser choice.

Personal Factors

The next step in the selection process is the assessment of individual telecommuters whose jobs appear to be suitable for some form of telecommuting. The key personal selection factors are : prior experience with *this* organization, job skills, motivation, relationships with supervision, and attitudes. The ideal telecommuter might be someone who knows in intimate detail how his/her organization works, has complete competence in all the skills needed for his/her job, is highly performance oriented, enjoys a deep bond on confidence and trust with his/her supervisor and is very proactive about the work of the organization.

In the real world some of these factors may be less than 100% for most supervisor-telecommuter combinations. Note that we stress both the supervisor and the telecommuter. Key to successful telecommuting, in our opinion is a suitable comfort level on the part of both manager and telecommuter. [The definition of 'suitable' may vary

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[4]For a distinction between jobs, tasks and activities, see Nilles, El Sawy, Mohrman and Pauchant: *The Strategic Impact of Information Technology on Managerial Work*, referenced later.

among organizations.] Our approach to these issues was to outline a background survey technique for use by the sponsors in estimating the relative levels of these factors. This, combined with the job activity analysis, would allow a sponsor to make a relatively informed selection of candidates for telecommuting. In all cases this would involve selection of manager-telecommuter pairs (including, possibly, telecommuting managers).

The project plan called for this analysis and selection process to occur in the first six months. That is, in the second half of 1985. We hoped to have selected more than 200 telecommuters of various sorts, at least 40 from each sponsor company, by the start of training.

Training

We felt that it would be necessary to orient both managers and telecommuters to the particular issues of the telecommuting relationship. Foremost among these is the emphasis on product- rather than process-oriented management. The reasoning behind this is simple: it is not possible, particularly in home-based telecommuting, to completely monitor the activities of a telecommuter--unless fundamental freedoms are violated. Hence telecommuting must rely on individual telecommuters internalizing the discipline that would be imposed by the cop-manager in a stereotypical office environment. The role of the manager shifts from administrator to leader; a role that may be both unfamiliar and uncomfortable to many managers.

The primary purpose of training, then, is to inculcate these attitudes in both the managers and the telecommuters themselves. A secondary objective is to familiarize telecommuters with the environmental changes they are about to encounter. This is particularly important for home-based telecommuters. In their case it is important first to ensure that the home office they set up is at least suitable, and preferably superior, for job performance. Then it is necessary to ensure that they and their supervisors establish communications patterns that substitute adequately for the loss of face-to-face encounters. Clearly, the severity of the latter depends on the frequency and duration of home-based telecommuting.

We did not plan to do the actual telecommuter training in this project. Rather we provided the sponsors with training guidelines, under the assumption that each sponsor would have its own training style, personnel and techniques.

Evaluation

In a previous project, cited in the footnotes, we developed a survey instrument, in the form of a fairly extensive questionnaire, for assessing the effect of information technology on managerial work. Since almost all of the sponsor telecommuters involved in the project were managers or professionals, we needed only to add a set of telecommuting specific questions to that instrument in order to use it for this project. The instrument is designed to be administered to the individual telecommuters. The plan was to administer it at three points during the project: 1) just prior to initial telecommuting; 2) at the project midpoint, and 3) at the end of the formal pilot period. This would give us estimates of the changes produced by telecommuting on the nature of the jobs performed as well as on job performance.

In order to get other views of performance we planned to get manager's evaluations of their telecommuters as well as a set of quantitative cost and benefit data. Each participating sponsor was given an extensive list of the data to be gathered. These ranged from the details of equipment, administrative, training, maintenance and operational costs to the dollar equivalents of performance improvements, changes in health insurance claims,

absenteeism, turnover rates, and the like, in quantities sufficient to satisfy even the most compulsive cost-benefit analysts.

RESULTS

Bad News. Good News

First, the bad news. Only one of the sponsor companies selected telecommuters and trained them, generally in accordance with out guidelines. One company dropped out of the project entirely by the end of the first year. One continued financial support but enlisted no telecommuters. One set up a telecommuting satellite office but declined to furnish any performance data. The remaining two companies provided data on pre-existing telecommuters but did not do any new selections. None of the companies administered the series of questionnaires to their telecommuters, although the three actual participants did administer the 'final' round performance evaluation questionnaire. None of the companies provided cost or quantitative benefit data. The Center for Futures Research discontinued operations before the project could be completed. "Other than that, Mrs. Lincoln, how did you like the play?"

The good news is that we did get actual "snapshot"[5] data from three of the companies on 44 live corporate telecommuters, if only on 20% as many as we had hoped. We also were able to obtain simultaneous data from a slightly smaller number (33) of 'control' employees: people with similar jobs, but who were not telecommuters, in the same companies. In addition to the single round of performance oriented questionnaires, Terry Pauchant interviewed a sample of the telecommuters to get a more qualitative evaluation. The following summarizes the results.

The Survey Instruments

Two survey questionnaires were used in the study. The first was a screening questionnaire, designed to elicit attitudinal information from prospective telecommuters as part of the selection process. Emphasis in that questionnaire was on exploring attitude towards oneself and one's job, supervisor and co-workers. The questionnaire was 4 pages long and contained 140 multiple-choice questions, 104 of which were Wil Schutz's FIRO-B series.

The second questionnaire was a revised form of the performance oriented questionnaire fro CFR/CEO's prior study: *The Strategic Impact of Information Technology on Managerial Work*. The purpose of this questionnaire was to see what had changed in the organization's information infrastructure and in the respondent's roles, activities and tasks--from the respondent's point of view. This questionnaire was more extensive than the screening questionnaire, including more than 400 questions and requiring more than an hour to complete. The questionnaires were administered in late 1986 and early 1987.

Screening Questionnaire Results

For the reasons mentioned above the "screening" questionnaire was not used for screening. That is, it was not administered to prospective telecommuters prior to their selection and training as telecommuters. Instead, the questionnaire was administered to the existing group of telecommuters, 44 in all, all of whom had been telecommuting for at least several months. The questionnaire was also administered to a group of 33 non-telecommuters with similar jobs.

Because of the situation a major imponderable exists: are the telecommuters' answers different now than they would have been prior to starting telecommuting? Unfortunately,

[5]That is, at one point in time rather than the three points over 18 months that we hoped for.

there is no way to resolve this dilemma. In any case, there are differences between the telecommuters' answers and those of the non-telecommuters.

Job Characteristics

The first group of questions dealt with possible location dependence aspects of the telecommuters' work: need for quick turnaround, access to special resources, and physical security (of information). Telecommuters responded that they needed to participate in quick reaction tasks more frequently than the control group; 65% of the telecommuters, as compared with 46% of the control group, were required to participate at least several times per week. Access to special resources, such as copying equipment, was needed at least several times per week by 55% of the telecommuters and 85% of the control group. 36% of the telecommuters needed daily access to information that required strict protection, as contrasted with only 23% of the non-telecommuters, although only 30% of the telecommuters and 31% of the non-telecommuters reported that physical protection (in the form of locked files, etc.) was required. 27% of the telecommuters, and 23% of the non-telecommuters, did not have those security requirements. Presumably most of the remaining telecommuters were able to maintain suitable confidentiality without special precautions.

The respondents were also asked to rank their jobs in terms of opposite characteristics such as boring-fascinating, unstructured-structured, etc. The telecommuters responses were more positive than the non-telecommuters in terms of fascination, visibility, satisfaction and challenge. On the other hand, telecommuters rated their jobs as less well defined and less structured than the non-telecommuters. None of these differences was major; most were less than 10% and the largest (amount of job structure) was 24%

Conclusion 1: Telecommuting can be successful for a large variety of job types. Selecting telecommuters by excluding those whose jobs seem to dictate the needs to be in the office appears to be a reasonable precaution. However, the data from this survey do not seem to support that restriction *provided* that the telecommuters either work in satellite offices, confine their special access tasks to the relatively frequent occasions that they are in the office, or are able to suitably protect information (such as by encrypted files or the like) by non-physical means. That is, special job requirements do not seem to be a major barrier, at least to part-time-home- or satellite-based telecommuters. Similarly, emphasis on requiring a relatively high level of structure in one's job is not supported by these data.

Attitudes Towards Telecommuting

A further reasonable selection criterion is the prospective telecommuter's attitude towards telecommuting. The respondents were asked their opinion of the potential usefulness of telecommuting. The responses were as follows: None thought that it would have any sort of negative effect; none of the controls, but 5% of the telecommuters thought it would have no effect; 54% of the non-telecommuters and 18% of the telecommuters thought it would improve things somewhat; and 46% of the non-telecommuters and 77% of the telecommuters thought telecommuting would improve things significantly. We did not specify what "things" meant in the questions, leaving that to the respondents to decide. Subsequent interviews with the respondents lead us to believe that the answers might be slightly, but not materially, different if we distinguish between one's organization and oneself in these questions.

The telecommuters were also asked what their experience of telecommuting had been thus far. 95% replied that it had been strongly positive, 5% answered that it was somewhat positive.

Attitudes Towards Co-workers

Telecommuters generally ranked their supervisors lower than did non-telecommuters when it came to traits such as organization, clarity, communicativeness and availability--as might be expected in a situation where supervisors were given no special training to enhance these capabilities. On the other hand, telecommuters rated their supervisors higher in responsiveness, flexibility, supportiveness and confidence in the telecommuters' ability. Telecommuters also felt, relative to non-telecommuters, that their supervisors trusted them more, were less controlling and were significantly (24%) better at evaluating their work.

Telecommuters' co-workers fared less well. They received the same or worse ratings from telecommuters than from the non-telecommuters in all the characteristics listed. However, in all cases and for both groups the co-workers were rated better than average.

Attitudes Towards Self

A set of questions from a psychological self-inventory created by Wil Schutz also indicated some slight differences between telecommuters and non-telecommuters. In only two areas were the telecommuters' answers more than 20% higher than the non-telecommuters: the feeling that others felt free to confide in them (a 25% difference) and that they wanted more to be included in group activities (a 29% difference). At the same time, the telecommuters felt more that they were included in things--12% higher than the non-telecommuters! The telecommuters also felt that they had a higher level of self-knowledge (13%) and a greater amount of self-liking (also 13%) than did the non-telecommuters. There was no significant difference among the two groups in areas such as: feeling "together", spontaneity, feelings of importance, competence, belonging, control--or being controlled, or their confiding in others.

Conclusion 2: Telecommuters are sociologically and psychologically very similar to non-telecommuters. The differences lie primarily in their levels of self confidence and independence, although in the latter there is a stress between being independent and wanting to belong.

The General Performance Survey Results

This survey is broken into eight subcategories: demography, information infrastructure, job roles, job activities, technology uses, telecommuting specifics, implementation characteristics, and task effectiveness. All but the telecommuting specifics section were developed in our prior study of the effects of information technology on mid-level personnel.

Demography

Both the telecommuters and the non-telecommuters came from a variety of organizational sources. Table 1 gives the breakdown of functions, by percent.

FUNCTION	CTRL %	TCers %	FUNCTION	CTRL %	TCers %
1. Marketing	2.9	7.9	11. Office systems	0	0
2. Sales	0	2.3	12. Engineering	26.5	14.0
3. Operations	0	7.0	13. Production devel.	8.8	7.0
4. Finance	2.9	0	14. Accounting	0	2.3
5. Research & development	2.9	9.3	15. Legal	0	0
6. General administration	0	4.7	16. Human resources	2.9	2.3
7. Production	0	0	17. Information services	11.8	23.3
8. Customer service	5.9	4.7	18. Program management	0	0
9. Field services	2.9	2.3	19. Planning	5.9	2.3
10. Office services	2.9	0	20. Other	23.5	11.6

Table 1. Participants' Job Functions

Most of the respondents (74% of the control group and 82% of the telecommuters) considered themselves to be professionals. The control group also had 17% managers and 9% secretaries while the telecommuters had 16% managers and no secretaries. The average age of the control group was 38, as contrasted with the very slightly younger (37) telecommuters. Two-thirds of the control group and three-fifths of the telecommuters were males. Both groups had between 10 and 11 people in the group of those with whom they regularly communicated. The members of the control group had worked slightly longer for the company (13.0 vs. 12.8 years for the telecommuters), had been in their present work unit about 7 months longer (4.0 vs. 3.4 years) and in their current job assignment about 6 months longer (3.8 vs. 3.3 years). Hence the control group is well matched to the telecommuters, although there are slight differences among them.

Conclusion 3: Telecommuters are more likely to be professionals than managers or routine information workers, as would be expected at this stage of development of telecommuting.

Information Infrastructure

The information infrastructure of an organization comprises those elements of the organization that support information flow both within and external to the organization. For example, the telephone system, both internal and external, interoffice mail, electronic mail,conference facilities, the company newsletter, electronic bulletin boards, conversations in the bathrooms and hallways are all part of the information infrastructure. The purpose of this section of the questionnaire is to see how effective the infrastructure is in getting information to its users. The point of view is the user's, not the information system manager's.

The dimensions of effectiveness of the information management infrastructure are the dimensions of the organizational environment that make the manager's capability of using information technology effectively easier or more difficult. In defining the dimensions of infrastructure there are two essential features we have taken into account. First, we have characterized them in a task-independent way. Second, we have characterized them from an information management perspective.

We have identified thirteen effectiveness dimensions. For facility in exposition, the dimensions will be referred to simply as "infrastructure" dimensions in the rest of this section. Figures 1a and 1b show the results of the survey for the telecommuters, the control group, and for our 1985-86 survey of more than 900 middle managers and professionals in large corporations.

1. Coordination of Information Among Groups

This characterizes the degree of uniformity among different groups concerning: 1) methods of providing information, 2) frequency of updating information, 3) procedures for handling information, and 4) the coordination of information between groups.

2. Expediency of Access

This covers: 1) the speed with which a person can deliver a message, 2) the speed with which the person can have a face to face meeting, 3) the speed with which the person can get back a response to a message, 4) the speed with which members of *ad hoc* teams or task forces can share information, and 5) the speed with which internal communications systems (e.g., mail, telephones) can respond to changes in the organization (such as physical relocations, reorganizations).

3. Formalization of Information

This dimension includes: 1) the number of rules and procedures governing how the person handles information, 2) the number of rules and procedures governing how the person communicates with others, and 3) the extent of use of standard formats.

4. Information Quality

This refers to the accuracy and the completeness of information that reaches the person.

5. Ease of Communication with Others

This is the ease of communication with others in the organization when the person is in the office, and when the person is away from the office.

6. Information Capacity

This dimension comprises the extent of backlog in unprocessed or unfinished paperwork, and the amount of extra work-load that can be absorbed at peak times.

7. Fragmentation

Fragmentation refers to the extent to which the work flow breaks down if one of the involved individuals or subunits has a major problem, and the extent to which individuals or subunits operate independently of each other.

8. Tempo

This dimension focuses on the amount of time the person has to get most of the information he/she needs.

9. Amount of Information

An easy one: how much information are you getting?

10. Restrictions on Access

This concerns the extent of restrictions on access to information.

11. Proximity

This refers to the extent of physical proximity between interacting groups.

12. Amount of Redundant Information

How much redundant information are persons getting?

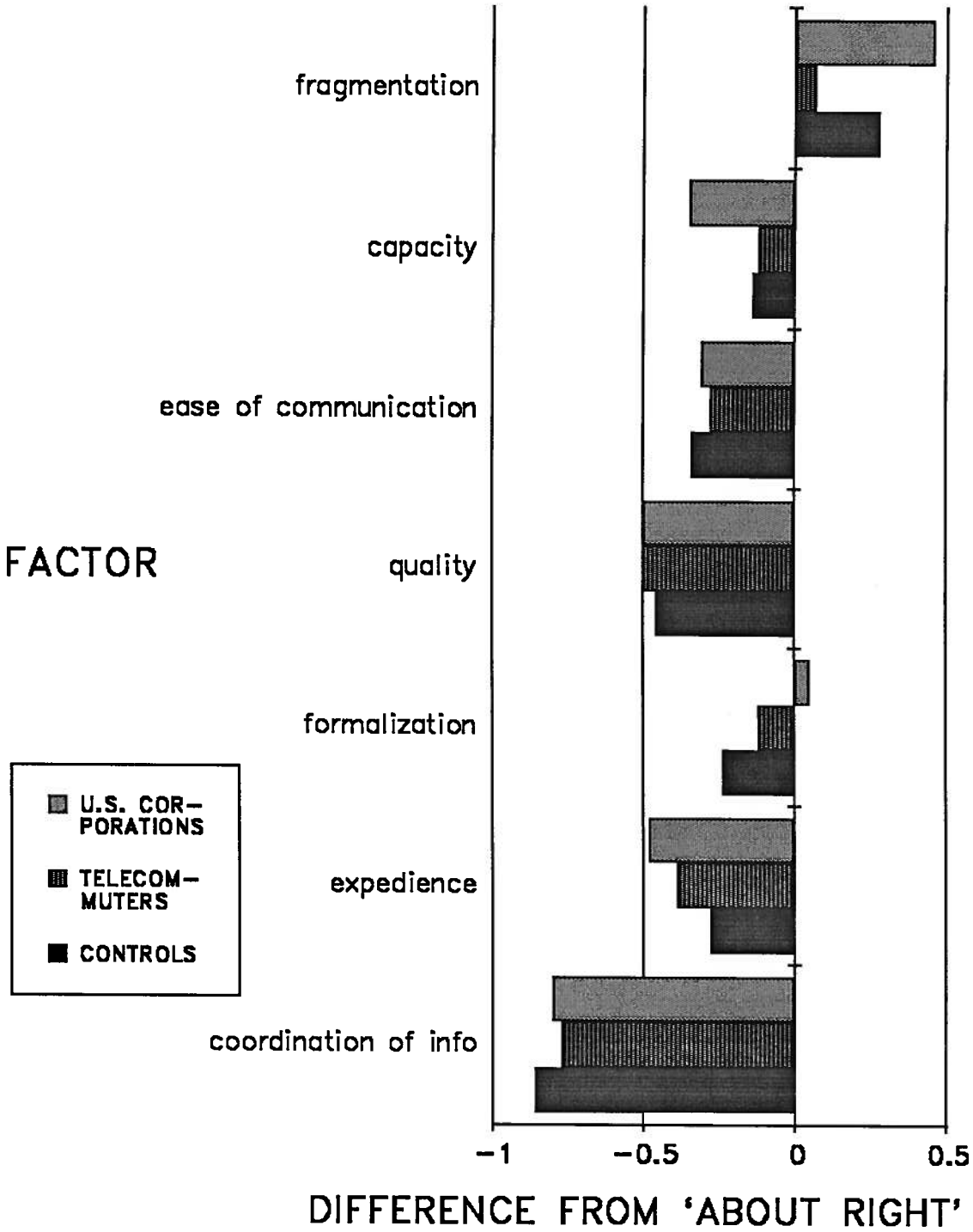

Figure 1: Information Infrastructure Factors

13. Deadline Tolerance

Finally, how tolerant is the organization, from the person's point of view, for missed deadlines.

All of these dimensions are characterized in relative terms--not enough, just right, too much--rather than in bean counting numbers. This is because the quantities themselves, such as tolerance in days or hours for missed deadlines, change meanings between organizations, or even between groups in the same organization. More important is the information user's view of the dimensions in terms of their appropriateness for his/her particular job.

Conclusion 4: Telecommuters tend to be better supported by the corporate information infrastructure than either the controls or the members of our previous national sample of mid-level workers, with the exception that the telecommuters are somewhat more concerned about missing deadlines and feel a little more distant from their fellow workers, as would be expected at the current levels of telecommunications technology.

Information Technology

We asked the participants a series of questions about their uses of information "technology," ranging from face-to-face conversation to such esoterica as video and computer teleconferencing. In our previous work we discovered, through factor analysis of the data, that these technologies can be grouped into a relatively small set of categories, as follows:

1. **Telephone.** A class containing only this all-purpose member; cellular telephone may eventually end up here;
2. **Traditional Internal Communications.** Internal mail, meetings and face-to-face conversation constitute the oldest and most revered forms of communications; we called this Internal because most of such activity takes place within the organization;
3. **External Mail.** The external half of the traditional media are here, including both forms of external mail (regular and express).
4. **CRT/Computer Technology.** In this class are technologies that involve a CRT display interface, are computer-based and essentially involve self-interaction (as contrasted to telematics, which is primarily oriented toward communication with others). This includes personal computing (on whatever size machine), specialized computer programs, spreadsheet analysis, graphics, and database development; outside database searching was not included for lack of respondents to this item;
5. **Telematics** Here we have computer-based communications technologies: text processing, computer conferencing and electronic mail;
6. **Non-CRT Electronic Communications.** This class includes telephone conferencing and facsimile; there are two further, single element classes;
7. **Answering Machines** and;
8. **Call Forwarding.**

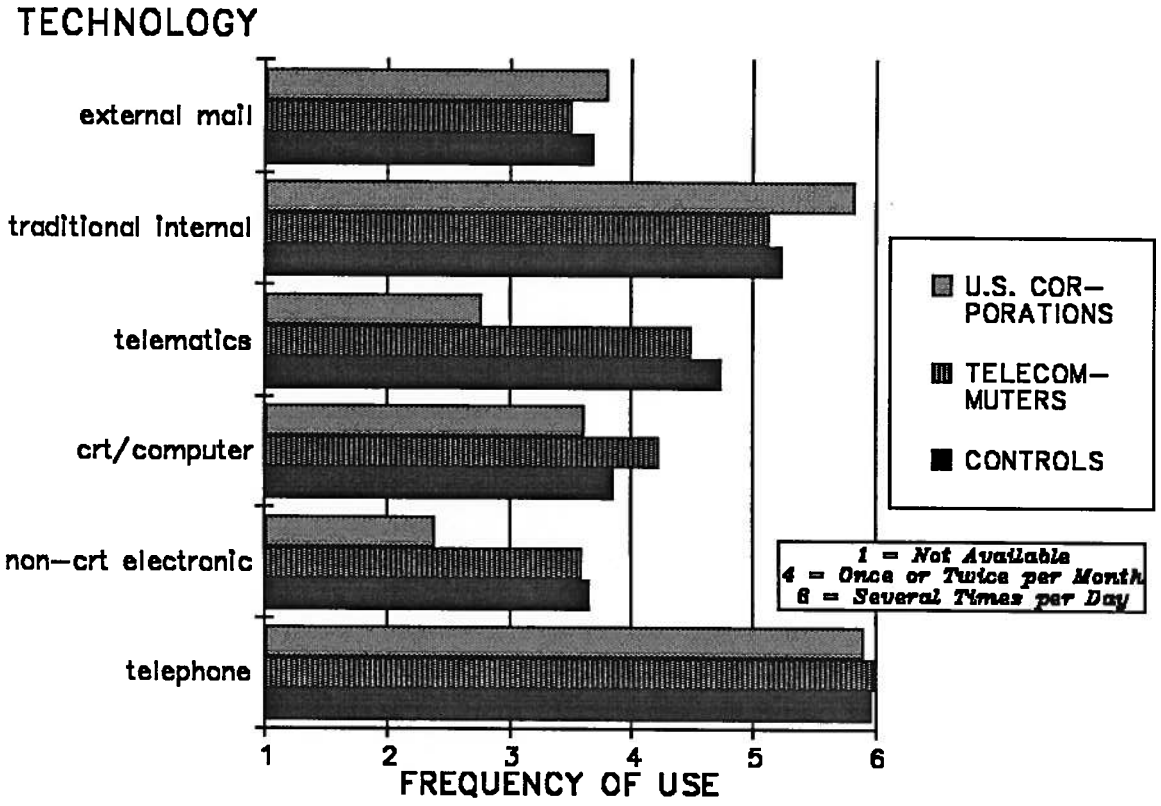

Figure 2a: Information Technology Usage Rates

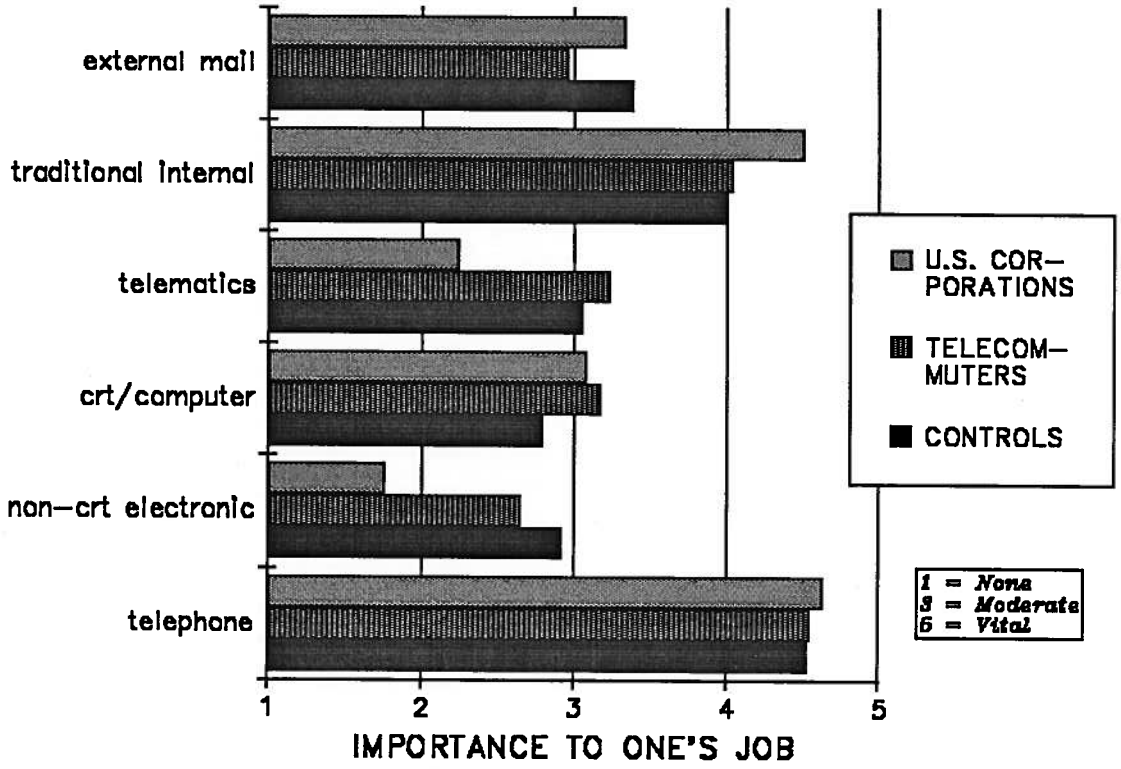

Figure 2b: Importances of Information Technologies

Figures 2a and 2b show the relative ratings of these eight technology groups for the telecommuters, the control group and our baseline set of corporate mid-level personnel. Figure 2a shows the frequency of usage of the technologies, while Figure 2b shows how important these technologies are to the respondents. For most of the technologies the telecommuters and the control group are closer to each other than they are to the more general set of U.S. corporate mid-level personnel, even though part of the telecommuter/control group comes from one of the companies in the U.S. general sample. Both the telecommuters and the control group are more involved with electronic forms of communication--and less involved in traditional internal forms of communication--than the general sample. The telecommuters are apparently more omphaloskeptic than the control group; telecommuters spend more time on, and attach more importance to, computer use and give less time and importance to telematics. Note, however, that telematics and non-CRT electronic communication are both given significantly more attention by controls and telecommuters than was the case in the earlier national sample.

In all cases the individuals constituting the control group were closely collocated with the telecommuters, in terms of organizational responsibilities, reporting structure, etc. Hence the telecommuters come from organizational cultures that, at least locally, are more dependent on non-traditional information technologies than is the case in a broader sample of U.S. corporations.

Conclusion 5: Telecommuters, at least at this stage of diffusion of the underlying technologies, are more likely to be in relatively "high tech" organizations. Clearly there is a significant element of self selection here. The companies that were involved in the project were already proactive users of information technology; in fact, all were either purveyors of information technology or sophisticated information services. The corporations that participated in our earlier survey covered a much broader spectrum of information technology intensiveness; all of them were given an opportunity to participate in the teleworking project.

Implementation

One uncertainty of telecommuting is the need for relatively expensive computer technology, as contrasted to "normal" office equipment. Thus the level of implementation of technology in the organization was assessed. The key areas of interest were how much the participants depended on technological aids and how they developed or maintained their proficiency with the aids they used.

Almost all of the participants, telecommuters and control group alike, had computers of terminals for their personal use in the office. At home 62% of the control group and 86% of the telecommuters had computers, as compared with 17% and 79%, respectively, in satellite offices. We asked both groups how many people in their work units worked at home with a computer. For the control groups 35% worked at home, while the fraction rose to 46% for the telecommuters' work units.

When it came to intensiveness of usage both groups answered about the same: 70% of their tasks were performed with the aid of information technology. The two groups also felt about equally dependent on the technology to do their work easily. Although the telecommuters felt slightly more able to do their work well without the technology, neither group felt they could work as well if the technology were not available.

Learning aids ranked as follows:

How do you keep current and expand your capabilities using the technology? (circle one)

SOURCE	CONTROLS %	TCers %
1. the manuals that came with it	37.5	33.3
2. an information center	4.2	12.1
3. periodic users' meetings	0.0	6.1
4. local "guru" or expert	50.0	27.3
5. telephone hotline/help desk	4.2	12.1
6. periodicals and trade journals	4.2	0.0
7. other _____	0.0	9.1

To whom do you go when you have problems using the technology? (circle one)

SOURCE	CONTROLS %	TCers %
1. the manuals that came with it	30.8	29.4
2. an information center	0.0	5.9
3. periodic users' meetings	0.0	11.8
4. local "guru" or expert	57.7	29.4
5. telephone hotline/help desk	11.5	14.7
6 .periodicals and trade journals	0.0	2.9
7. other _____	0.0	5.9

Table 2: Key Information Sources

Finally, we asked about the effects of telecommuting on career development. 22.5% of the telecommuters felt that it strongly helped, 25% felt that it helped somewhat, 30% did not perceive any affect, 20% thought that telecommuting somewhat hindered their careers and 2.5% (that is, one person in the sample) felt strongly hindered.

Activities, Tasks and Roles

The above areas of the survey deal with the *context* of the telecommuters' work: the surroundings, technological and organizational, in which the telecommuter must perform. This section treats the *content* of the telecommuters' work.

Each telecommuter has a *job*. To satisfy the requirements of that job the telecommuter plays one or more *roles*. In the performance of this/these role/s the telecommuter performs a number of *tasks* (such as preparing a report, conducting a meeting, planning a project, etc.). These tasks are accomplished via a series of *activities*, each of which consists of one or more *acts*. Our analysis of telecommuters and others examines the changes in these factors brought about by technology and/or telecommuting.

Activities

Acts are the fundamental things that people perform, such as striking keys on a keyboard, reading words and symbols, saying words, pressing buttons, and so on. Activities include such things as gathering or storing information, communicating, negotiating, working with others and making decisions. We have found in earlier work that information related activities can be lumped into two groups: *processing* information, mostly an inner-directed activity, and *using* information, which is mostly an outer-directed activity. In our sample there was almost no information activity difference between telecommuters and non-telecommuters. Telecommuters did slightly (1%!) more information processing.

Tasks

Emphasis on this aspect of work is on the worker's ability to distinguish between and accomplish critical and noncritical tasks and on the role of information technology in supporting both of those factors. The emphasis is on performance of critical tasks because the growing deluge of information presented to each worker makes it easy to lose sight of the key tasks to be accomplished. We postulated that it might be even more of an issue with telecommuters. They might not be assisted as well by the office environment in keeping on track.

There was very little difference between the control group and the telecommuters in their stated ability to identify and attend to critical tasks. The telecommuters showed a slight edge (3.5%) over the control group.

Conclusion 6: Telecommuters tend to reserve their critical, thought-intensive work for their home or satellite offices. The respondents' characterization of the nature of critical tasks is shown in Figure 3. Note that the primary difference between the two groups is in the location where the critical tasks are performed. The remaining responses are almost identical, except that telecommuters tend to feel slightly less stressed in performing their critical tasks.

We also asked how well they were supported by the technology available to them. The telecommuters felt that the technology supported them 19% better than the control group in identifying getting to, and accomplishing their critical tasks.

A key issue is that of productivity. Although we were unable to get direct confirmation of productivity by asking the respondents' direct supervisors, we did get self assessments by both groups of productivity changes over the preceding year. 9% of the controls felt less effective than the previous year (an average of 35% less effective!), while none of the telecommuters reported a loss in productivity. Roughly equal numbers of controls and telecommuters (about 47% of each group) reported no change in effectiveness. The remainder reported increases in productivity. The average size of the increase reported was 28.8% for the control group and 28.4% for the telecommuters. However, 54% of the telecommuters reported productivity increases, as contrasted to 44% of the control group.

Conclusion 7: The self-rated effectiveness of telecommuters is higher than that of comparable non-telecommuters. As a group the average change of effectiveness over the year of the non telecommuters was 10.6%, while the average change in the telecommuter groups' effectiveness was 15.2%. Clearly, the numerical values should be accepted with some restraint since there was no corroborating reporting from supervision. However, interviews with supervisors yielded similar comparisons.

Roles

The concept of roles played as the incumbent of a job is less concrete than that of activities performed. Nevertheless there are a number of distinct roles played by any information worker, 11 of them, to be exact. They are:

Innovating

Producing

Directing

Coordinating

Monitoring

Facilitating

Mentoring

Being 'Big Brother'

Supporting

Networking

Public Relations

Most of these are self explanatory, but some elaboration may be needed to distinguish among monitoring, supporting, mentoring and being Big Brother. Being Big Brother implies knowing everything that is going on in one's area of responsibility (at the very least). Mentoring refers to helping other people grow in their careers. Supporting refers to helping other people perform their work. Monitoring refers to the technical details of watching others' job performance.

Both the telecommuters and the control group scored about the same for most of these roles. There were significant differences in two areas: mentoring and public relations. The telecommuters felt that these roles were significantly less important and significantly more important, respectively, than did the non-telecommuters. The differences were about 17% in both cases. This seems to be a reasonable role shift since mentoring generally implies the need for more face-to-face communication than most of the other roles. Telecommuters, knowing they will have restricted contact tend to downgrade that role. On the other hand, that same situation increases the importance of public relations to help maintain the telecommuter's contacts with the rest of his/her work group.

Conclusion 8. Telecommuters are not significantly different from non-telecommuters in most aspects of personality, job characteristics, motivation and performance. What differences there are tend to be in favor of the telecommuters.

Telecommuting Specifics

In addition to the general, job-related issues discussed above we asked the telecommuters a number of detailed questions about the direct effects of telecommuting.

Basics

First, some basic statistics. 54.5% of the telecommuters were primarily home-based, 29.5% were satellite center workers and 16% shared time in both locations. The telecommuters lived twice as far from work, as measured in miles (30.2 versus 14.8 miles) but only 1.7 times as far as measured in commute time (40.8 versus 24.6 minutes). Both the home-based and satellite telecommuters were part-time telecommuters, telecommuting about 35% of their work days. The home-based telecommuters averaged 4.2 entire days and 3.9 partial days per month, while the satellite workers spent 7.2 entire days and 1.4 partial days per month telecommuting. The most popular home telecommuting site was an unused bedroom (25%), with the den and master bedroom(!) tied for second at 14% each. None of the group used the attic or kitchen as a telecommuting station.

The average telecommuter's home had 8 rooms covering 1900 square feet of which 158 square feet was used for telecommuting. 83% owned their own homes and 83% of all the homes were single family detached structures. 23% percent of the telecommuters held meetings with subordinates or supervisors in their homes.

Although the most popular working hours were in the conventional zones, between 8 AM and 5 PM, the group reported an average of 1.2 hours worked between 4 AM and 8 AM and 2 hours between 8 PM and midnight. As to permanence, 43% replied that they considered telecommuting to be a permanent work style, 24% thought that it would cover one period of their lives only, and 33% felt it to be an occasional (presumably *ad hoc*) option.

Socio-psychological Factors

Most of the remaining questions were phrased in terms of the situation now as compared with before the individual started telecommuting. The first set of questions dealt with the amount of change and the importance to the telecommuter of a series of largely psychological factors. These are summarized in Table 3.

QUESTION	HOME EFFECT	IMPORT	IMPACT	SATELLITE EFFECT	IMPORT	IMPACT	H-S IMPACT
Ability to get more done	4.30	4.30	4.29	4.20	4.11	3.73	2.39
Feelings of control of your life	4.20	4.43	4.12	4.10	4.42	3.76	1.46
Control over your own physical environment	4.30	3.95	3.84	3.70	3.81	1.97	7.16
Feelings of work related stress	4.20	4.19	3.83	3.80	4.19	2.55	4.88
Ability to concentrate on critical tasks	4.10	4.22	3.54	4.30	4.29	4.28	-2.60
Need to cope with traffic	4.10	3.57	2.83	4.20	4.37	4.04	-3.44
Available discretionary time	4.00	3.76	2.76	3.90	4.04	2.74	0.07
Quality of family relationships	3.80	4.19	2.55	3.90	4.36	3.02	-1.20
Creativity in your work	3.86	3.89	2.49	3.92	4.28	3.02	-1.32
Stress from environmental noise	3.86	3.85	2.45	3.63	3.36	1.49	2.36
Coping with interruptions	3.76	3.53	1.92	3.96	3.85	2.74	-1.56
Coordinating family and work time	3.62	3.86	1.77	3.96	4.11	2.99	-2.15
Avoidance of office politics	3.80	2.95	1.56	3.70	3.07	1.45	0.17
Developing self discipline	3.46	3.49	1.15	3.56	3.48	1.39	-0.28
Need to change environments	3.56	2.86	1.04	3.64	3.16	1.38	-0.35
Work-related costs to you	3.40	3.26	0.90	3.90	3.56	2.30	-1.27
Quality of working relationships	3.30	3.57	0.77	3.20	3.67	0.53	0.18
Involvement in community	3.26	2.56	0.41	3.27	2.38	0.37	0.01
Ability to bypass physical handicaps	3.30	2.15	0.35	3.20	2.21	0.24	0.04
Quality of meetings with supervisors/subordinates	3.03	3.36	0.07	3.07	3.62	0.18	-0.01
Uneasiness about equipment or software failure	2.94	2.78	-0.11	2.96	2.96	-0.08	0.00
Job stability	2.94	4.00	-0.18	2.96	3.88	-0.12	-0.01
Finding enough office space at home	2.92	3.11	-0.17	3.13	2.83	0.24	-0.07
Ability to separate home and work life	2.82	3.35	-0.42	3.26	3.67	0.69	-0.47
Feeling guilty about 'not really working'	2.78	2.76	-0.39	3.04	2.63	0.07	-0.18
Career advancement	2.75	3.81	-0.70	2.69	3.69	-0.83	0.09
Involvement in office social activities	2.55	2.24	-0.56	2.63	2.30	-0.48	-0.04
Amount of job-related feedback from colleagues	2.68	3.38	-0.76	2.78	3.48	-0.55	-0.16
Knowing when to quit working	2.55	2.92	-0.86	3.04	3.00	0.08	-0.82

Table 3: Psychological Impacts of Telecommuting

Some explanation is in order here. All the scales are 5 points, as follows:

EFFECT: 1 = Much Worse, 2 = Somewhat Worse, 3 = No Effect, 4 = Somewhat Better, 5 = Much Better

IMPORT: 1 = Not important at all, 2 = Slightly important, 3 = Moderately important, 4 = Quite important, 5 = Extremely important

IMPACT = (EFFECT - 3)X(IMPORT - 1); a 'No effect' or 'Not important at all' answer would produce a 0.00 impact score.

There are three impact columns: for home telecommuters, satellite telecommuters, and the differences between them. The entries are ranked in descending order of impact on home telecommuters. Note that there are nine areas of negative impact for home- and five negative areas for satellite-telecommuters. The latter are included in the former set. The greatest concerns are with workaholism, communications deprivation and career advancement. Yet, the greatest of these concerns is less than the sixteenth-ranked positive impact and is one-fifth the magnitude of the most positive impact, the ability to get more done. In short, the positive impacts seem to significantly outweigh the negative effects.

Interestingly, the satellite telecommuters seem to have the same concerns about communications deprivation and career advancement; they are even slightly more concerned about the latter than are the home-based telecommuters. The two largest positive differences between the home-based and satellite telecommuters are in control over one's physical environment and the ability to concentrate on critical tasks. The two largest advantages that the satellite telecommuters have over the home-based telecommuters is in the availability of discretionary time and in the decreased need to cope with traffic.

In this latter set we may be seeing evidence of a value shift. The improvement in both the need to cope with traffic and available discretionary time is about the same for both groups but the home-based telecommuters, having overcome the problem for almost two years in this study, have moved other factors into positions of greater importance.

We asked three other questions about communications behavior. The first concerned the amount of working time spent communicating with others. The control group average was 18% while the telecommuters reported 16%. The second question was: "How much of the time do you think it is important that your communications be face-to-face?" The control group averaged 43% against the telecommuters' 25%. Finally, we asked: "How much of the time do you think it is important that your communications NOT be face-to-face?" The two groups answered 40% and 47%, respectively. Clearly, the telecommuters down play the need for face-to-face communication but they are far from dismissing it entirely.

The factors that are more specifically job-related are shown in Table 4.

QUESTION	Much Worse	Somewhat or Less	About Same	Somewhat Better	Much or More
Quality of relations with co-workers	0.0	9.5	81.0	7.1	2.4
Quality of relations with supervisor	0.0	2.3	88.4	9.3	0.0
Feeling of job responsibility	0.0	2.3	34.9	41.9	20.9
Level of understanding of job requirements	0.0	4.7	69.8	20.9	4.7
Extent you see 'big picture'	0.0	2.3	76.7	20.9	0.0
Amount of job-related scanning you do	0.0	2.3	62.8	27.9	7.0
Amount of industry-related scanning you do	0.0	2.3	60.5	27.9	9.3
Amount you integrate new approaches in job	0.0	0.0	42.9	42.9	14.3
Your influence on department/company strategy	0.0	7.0	74.4	14.0	4.7
Level of understanding of rest of organization	0.0	9.3	62.8	25.6	2.3
How well your suggestions are received	0.0	7.0	81.4	7.0	4.7
Level of your work-related skills and knowledge	0.0	2.3	55.8	37.2	4.7
Level of your job versatility	0.0	0.0	34.9	37.2	27.9
Level of dependency on others	2.3	32.6	51.2	11.6	2.3
Scope of your job	0.0	7.0	44.2	32.6	16.3
How in touch with world outside work	0.0	2.3	53.5	30.0	14.0
Use of multiple perspectives in decision-making	0.0	2.4	64.3	31.0	2.4

Table 4: Job-related Impacts of Telecommuting

The only area where the telecommuters reported a 'much less' was in their dependence on others to help do their work, where 35% reported greater self reliance. The areas where the majority of the telecommuters gained were in increased: innovativeness (67%); job versatility (65%); feelings of job responsibility (63%); and job scope (59%); Even in the areas of little change (quality of interpersonal relations, receipt of suggestions) the balance is slightly in favor of telecommuting. In no area was there a net negative response.

Conclusion 9: The socio-psychological experiences of long-term telecommuters are moderately to significantly more positive than for non-telecommuters. Negative effects, while present, are not large and were not widely felt by the sample group.

Interviews

The author and Thierry Pauchant conducted a series of telephone and face-to-face interviews with the telecommuters at various points throughout the project. In these informal interviews the following general observations were made by the telecommuters.

Telecommuting is an enhancer of thinking style. Several individuals expressed the idea that they were able to think more freely and in modes more suited to their natural patterns than were possible in a conventional office. One individual, involved in work requiring a high degree of creativity and personal brainstorming, noted that the traditional office environment tended to stifle the nonconformism required for that process.

Telecommuting increases one's personal visibility in the organization. Contrary to our expectations and the survey intimations of concern for career advancement, some of the telecommuters felt that their promotional visibility had significantly increased as a result of their telecommuting. This may be a result of the nature of the project. Because it was a pilot, the participants tended to be more visible than the rest of their co-workers. Yet, at least one respondent said that the increased emphasis in telecommuting on objective job evaluation was a major plus for career advancement.

Telecommuting allows one to match one's work hours to one's metabolism. Although most telecommuters kept to fairly conventional work hours on average, most of the home-based interviewees also pointed out the times when they could immediately take advantage of an idea or continue an absorbing task outside of the normal work day.

Telecommuting allows greater work flexibility. The telecommuters frequently related anecdotes about their ability to interleave personal activities with their work. Foremost among these were the ability to quickly respond to home emergencies, such as sick children, car problems or malfunctioning appliances, or to attend special family events such as school plays and ceremonies. Late night telecommuters were better able to take advantage of lower loads on the company mainframe.

Telecommuting increases one's ability to manage time. This includes the benefits of greater amounts of available time (by not commuting) and the increased self-discipline developed by telecommuters as they juggle the time and location of task performance between the telecommuting site and the traditional office. Several telecommuters noted that the meetings they attended were shorter and more effective because the telecommuter participants had generally done their homework ahead of time instead of catching up at the meeting. As the level of preparation went up, including prior distribution by electronic mail of substantive agendas, the effectiveness of the meetings perceptibly increased. One telecommuter stated that this presented an additional problem for out-of-town meetings: meetings that once took all day were reduced to a few hours, leaving the telecommuter with an unfilled schedule for that proportion of the trip.

Telecommuting means self empowerment. There appeared to be unanimity in the opinion that telecommuting gives individuals more control over their own lives and life styles. Note that *all* of the telecommuters were mid-level managers or professionals; there were no entry-level or routine information workers in the sample. Hence the possibilities of the 'electronic sweat shop' were not seriously explored in this test. For these mid-level individuals, however, the desirability of telecommuting was clear.

The final comment made by one manager was: "Asking what jobs are suitable for telecommuting is the wrong question. You'll get a much shorter answer by asking what jobs *aren't* suitable for telecommuting."

PART 2: FORECASTING THE GROWTH OF TELECOMMUTING

BACKGROUND FOR THE FUTURE: WORKFORCE CHANGES

The Information Economy[6]

The United States is the most rapidly self-evolved society in the world today. Two hundred years ago, when the U.S. first officially existed as an independent nation, it and the rest of the world were primarily agrarian. The first census of the United States, taken in 1790, showed that 95% of the population was engaged in farming. The primary occupation of most Americans then was simple physical survival. The average life expectancy in 1800 was about 35 years. The average workday was 14 hours. Families were large, at least there were several children, but infant mortality was also high. Formal education was limited to a privileged small fraction of the population.

Although some manufacturing occurred in the United States during the formative years of the early 19th century, agriculture remained the dominant industry. One of the primary reasons given by the government for its import tariffs in the latter 18th and early 19th centuries was the protection of the infant U.S. industrial base. At the time, it would have been far less expensive to import all our manufactured goods from Europe, even though the costs of shipping were substantial. Partly because of the protective tariffs, partly because our physical isolation from Europe forced us to be more self sufficient, U.S. industry began to grow. Finally, about the time of World War I, the number of people employed in manufacturing industries equaled the number employed in agriculture. The move from the farm to the manufacturing town, then the city, had begun. The early 20th century saw the emerging dominance of manufacturing in our economy.

A fundamental necessity for this evolution was technology. The United States was in a chronic state of undersupply of labor. There weren't enough farmers to till the available land. There weren't enough skilled workmen to perform all the manufacturing tasks. Slaves satisfied the labor problems in the South, for a while. Immigrants from Europe ran the machines in the North. But advancing technology allowed the work to be done with fewer and fewer people. The cotton gin, the harvester, the disk harrow, the power loom, mass production techniques resulted in better, more uniform products with a smaller input of human labor. The consequence of these labor saving technologies was not general unemployment but rapid expansion of the economy and a continuing demand for more, better trained labor for the new ventures aborning. "Hand Made" became a label of distinction, if not of quality, as the cottage industries of the 18th century disappeared in the wake of the growing industrial society. The cities grew in population, the countryside declined.

Because of the immense productive power of the new, technology-based industries, the need grew for systems of efficiently controlling both the machines themselves and the supply and distribution processes that allowed the smooth flow of raw materials to the factories and finished goods to the consumers. As the variety and complexity of the products of our agroindustrial society grew, so, too, did the administrative infrastructure required to keep all the gears of the society meshing properly. The control problems of our great industrial society were increasing.

By the mid 20th century, after World War II, the amount of our economic effort spent in these control processes began to reach sizable proportions. The government supported educational system offered the promise of literacy to all the citizens. The government

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[6]Adapted from Jack M. Nilles, *Exploring the World of the Personal Computer. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1982. Copyright 1986 by Jack M. Nilles.*

influence in many areas formerly restricted to the private sector was noticed and criticized, or applauded, depending on the point of view of the critic. In the early middle years of the century major government actions toward control of the economy were started, in response to the pressures resulting from the great depression of the 30s. The Federal Reserve System, Social Security, the income tax were economic controls instituted in the second quarter of the century. All of these measures, as well as the needs for higher productivity in the agroindustrial sector, increased the need for improved information processing to keep the system in balance.

The momentum is continuing. Computers and telecommunications technologies play a large part in it. By 1970 just about half of the economic product of U.S. workers was information. From 95% in 1790, the agricultural population of the U.S. had shrunk to 5% by 1970 and to less than 3% by 1980. From 41% in 1943, at the peak of our manufacturing employment era, the fraction of our population directly engaged in the production of goods has declined to less than 19%. And even in these sectors of the economy which are thought of as solely "blue collar," the processing of information plays an increasing role. In California in 1980 almost 60% of the work force comprised information workers. Figures 1 through 3 summarize some of this history.

We are driven inexorably toward the thought that the reason for the dominance of *homo sapiens* over the rest of our physical world, our bigger and more differentiated brains and our ability to use tools, is putting us into evolutionary paths that increasingly act to emphasize that capacity. To continue that evolution, to increase our ability to survive in an essentially hostile (or, at best, indifferent) universe we must increase our ability to acquire and deal with information. That is the fundamental trend of development of the human race.

Lofty philosophical statements aside, the point is that, while about half of the work force in the U.S., Western Europe, and Japan is employed in information jobs, as much as two-thirds of our waking hours is spent in information activities, as a conservative estimate. We have become an information society. The next question is: how many of those waking hours are unrewarding? How many are dull, boring, or similarly unattractive? Would better information tools help, hinder, or have no effect?

The answers to those questions depend partially on the individual, partially on the available technology. Individual preferences dominate many information activities. What is dull, boring and frustrating to one person may be delightfully restful and soothing to another. The technology may not yet be properly developed to serve as a suitable aid to the problem. The technology may make it worse or have no effect at all. In any case, it is certain that the demands on people's time in the future will increase the pressures for more effective information handling. The following are some of the broad trends in our information society that emphasize this, with particular reference to jobs.

General Trends in the Information Society

Characteristics of the Workforce.

As the fraction of the population required to produce the basic necessities of life decreases, the proportion involved in other pursuits must necessarily increase. Most of this shift in jobs in the recent past has gone into the information economy. Factors tending to continue this trend in the types of jobs available include:

Increased Bureaucratic Influence. This includes new forms of regulation and extension of the level of detail of existing forms of regulation, government support of new ventures (such as new energy sources), together with the increased reporting and monitoring requirements that go with them, and increases in the size of existing "permanent" programs such as Social Security. Note that increased government influence does not necessarily mean increased government employment; the burden of compliance with regulations may

result mostly in new jobs in the regulated sectors of the economy, ranging from the home (personal income tax) to the large corporation (equal employment opportunities reporting),or the educational institution (more detailed accounting for research expenditures).

Pressures to limit the size of the government sector of the economy, such as California's Proposition 13, may only serve to reallocate the steady increase in information jobs resulting from government and administrative activities, although they do seem to be acting to reduce direct government employment. As in the private sector, government jobs which are not thought of as particularly information oriented may develop a high information content as the technological component of the job intensifies. For example, the Department of Defense operates the largest single educational system in the world; mostly oriented to developing and maintaining the proficiency of its personnel.

Bureaucracy (in its non-pejorative sense) is not confined to government by any means. The information component of the private sector has grown almost as rapidly as in the public sector. The "freeway effect" holds for information as well as for traffic: as new load carrying capacity is added it soon will be saturated and demand will once again exceed the supply. As more computers have entered offices to solve current information processing demands, new demands have invariably arisen for more and better information.

Changes in Composition of the Workforce affect the nature of the jobs to be performed. Many more women are now in the workforce than was the case in the 1950's. Women are moving into traditionally male-dominated jobs, (most of them information jobs) and vice versa. Secretarial jobs go begging for lack of qualified, or interested, applicants. Entry level workers (of whatever gender) are more likely to be functionally illiterate or marginally literate because of inadequate education. At the same time, entering workers are more likely than their older fellow workers to be accustomed to interacting with computers. For the past two decades the age distribution of the workforce has been shifting toward the younger worker, but that trend is starting to reverse itself in the eighties. The number of one-person households is dramatically increasing. The number of households with more than one full time worker is increasing, as is the likelihood that one of the jobs will not involve wages or salaries paid to the worker; that is, more workers are becoming at least part time operators of their own businesses, many of them information businesses.

The Effects of Technology on Jobs continue. The likelihood is steadily diminishing that a young entrant into the workforce will continue in his/her initial occupation or profession throughout his/her career; multiple careers during one's lifetime are becoming commonplace. As a consequence, the need for continuing refurbishment of one's educational background in the context of full time employment is increasing. Even within a single career, the influence of our technologies requires a continuous process of reeducation for many workers, particularly those in information jobs. Some jobs disappear or are drastically altered, beyond the capacity of some individuals, and beyond the willingness of others, to respond.

Changes in our Lifestyles are also important. Increased costs of gasoline and the threat of interruptions in the supply have changed our travel and automobile purchasing habits, increasing the importance of information transfer via telecommunications. Because the number of single-person households is increasing the number of tasks formerly shared among family members must now be handled somehow by the individual. The threat of violent crime is increasing (or is increasingly recognized), as is the threat of property crime. The "invisible economy," based on the ageless concept of barter, is increasing in activity to the point where the barter broker business has been growing, requiring computers to keep ahead of the escalating inventory control problems. Early retirement and increasing longevity of the population are changing the mix of demands for travel, education, and

entertainment as well as the supply of part time workers. We are more interested in physical fitness and preventive medicine. As the costs of routine services reach escape velocities, mostly because of the labor component, we are forced more into do-it-yourself operations on our homes and automobiles. Whether that is an economical alternative depends on how successful we are at quickly learning how to do it ourselves; a job which is also becoming harder as our homes and automobiles become more complex. We're not satisfied with the way our kids are being taught at school; the tests show they're not learning as much as they used to. Schools are equally dissatisfied with the low amount of parental participation in education and the high amount of apparent parental apathy. Consequent U.S. educational fitness is steadily declining in comparison with other developed countries. That decline is putting us in a permanent competitive disadvantage with those countries.

Potential Futures of Work; Some Views and Issues

All of this has major implications for the future of work; for the nature of work. The following are some speculations on possible impacts.

The Complexification of Society: Infocrush

The rate of generation of data today is probably at least proportional to the staggering rate of diffusion of information technologies. At least two decades of acceleration of this deluge of data faces each of us (see below). Society is becoming more complex as the human population increases, as our technologies become more sophisticated, as we become ever more interconnected, as the stresses and uncertainties of this accelerating change accumulate. How many of us chronically feel unable to cope with the flood of information reaching us, unable to sort out, or even recognize, the important from the trivial? How can we handle all of this without even better information tools? Or would it be better to destroy all the information tools we have and go back to that fabled simpler life? And how is all of this changing work?

General Impacts of Information Technology on Work

Although the picture is still blurred, it *is* clear that the consequences of all of this technological change are being directly expressed in structural changes in the economy and the work force. Some of these changes have been occurring for decades, others are just beginning to surface.

Agriculture

The labor force in agriculture is down to less than 3% of the total labor force, largely because of automation. This is comparable to the importance of agriculture in the economy; it accounts for about 2.5% of national income, even though the output of this sector is much more than enough to feed the U.S. Automation in agriculture, fishing and food processing is likely to continue its depressive impact on employment in the foreseeable future.

Manufacturing

A similar situation exists in manufacturing. Although this sector maintains its position in the GNP (about 24% of GNP), employment is steadily decreasing, to about 19% currently. Automation in the form of production point robotics and system-wide programmable automation is increasing less rapidly than the automation enthusiasts have forecast, but it is increasing nevertheless. Automation, as applied in some factories also has the effect of deskilling production jobs or, putting it another way, routinizing what were

formerly more diverse jobs. In 1977 Porat described the impact of computers on manufacturing as slightly negative, largely because of automation. This is an accurate description of the immediate impact. However, if automation makes the firm, or the industry more competitive, the longer term effect of it may be to increase job opportunities both directly in manufacturing and indirectly in related information services such as advertising.

Telecommunications plays a role as well. As (and if) telecommunications increases the overall efficiency of manufacturing, by such means as "just in time" inventory control, it acts to increase job opportunities as the market improves. To the extent that it allows firms to produce effectively in other countries, telecommunications has a negative impact on U.S. employment. One of the clear impacts of information technology is to make possible the globalization of manufacturing via multinational corporations and multinational alliances of corporations. Our continuing problems of a growing deficit in the balance of merchandise trade is at least partly attributable to the more effective use of automation on the part of Japan, and to our own seesaw shifts between onshore and offshore production in the semiconductor industry.

Secretaries and Clerks

Although we do not yet have comprehensive data to support it (except employment statistics over the past five years), our forecast is that secretarial and clerical jobs, as we know them today, will steadily decrease in relative terms as a consequence of: 1) managers/professionals and 2) customers, respectively, taking over the routine information processing tasks of secretaries and clerks. To some extent this will be offset by transfer of formerly complex (but now automated) tasks to routine workers. Some of these workers, those who have or develop high computer-related skills, may move upward. The rise of small entrepreneurial firms resulting from structural changes in large corporations may offset these losses in the workforce but it is clear that, in large private organizations at least, the losses will continue. Most of the incumbents in these jobs are women.

Managers and Professionals

Recent "belt tightening" moves in large firms frequently have resulted in large reductions in middle management ranks. These, too, are partially the consequence of increased automation of office functions. We expect to see an increase in the ratio of professional/specialist to generalist manager mid-level employees over the next twenty years as the necessity builds to cope with an increasing array and volume of information. Our survey data to date confirm this hypothesis.

The key to the employment issue in both management and secretarial ranks is a fundamental economic one, as diagramed in Figure 5. Increased use of information technology in an organization reduces the level of manpower required to do the information tasks previously performed. If the organization is in a mature industry and the automation merely serves to allow it to maintain its market share by cutting personnel costs, then there is a net loss of jobs, a structural change. If, on the other hand, the use of information technology serves to release human talents to increase the size of the market, or to diversify to other market areas, then there is a net increase in jobs, either just in the innovative firm or industry wide.

The Contracting of Services and Information Entrepreneurs

As some basic business services become automated, or computer-aided, they require fewer permanent staff, as just described. There is a growing tendency for large

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[7]Porat, Marc Uri. "The Information Economy: Definition and Measurement." Washington, DC: U.S. Department of Commerce, Office of Telecommunications, OT Special Publication 77-12, May 1977.

organizations, both public and private, to subcontract a growing array of services that they once maintained in house. This trend is, we think, accelerated by the conversion of former management and professional employees to independent consultants. New information technologies, providing steadily decreasing entry costs for budding entrepreneurs, are primary instigators of these changes.

Furthermore, as societal/business complexity mounts, new demand for information services is created. One of the findings of our research into the impacts of information technology on mid-level managers was that it increased their demand for more--and better--information. This demand is frequently expressed in the development of new types of information businesses, such as database services, specialized consulting, new media such as computer graphics, desktop publishing, etc. The dimensions of this area of growth are little recognized and even less well understood--except that growth frequently exceeds expectations of traditional conservative planners.

An Analysis of Telecommutable Jobs in the U.S.

All of the above listed sets of forces tend to increase the importance of at least some substitution of telecommunications for travel, whether work or 'leisure' (that is, non-work) related. As we then add telecommunications networks to the above list of available technologies we get teleworking. The fundamental societal impact of teleworking depends on its ability to make some jobs, and some tasks of other jobs, independent of the location of the worker. It gives us a possible way out of the global trend toward urban transportation autostrangulation. As Figure 6 indicates, teleworking is not confined just to a narrow array of job types. In fact, the range of jobs potentially encompassed by teleworking increases as the supporting technology becomes more powerful and sophisticated.

[8]Nilles, Jack M., Omar El Sawy, Allan Mohrman, Jr. and Thierry Pauchant. *The Strategic Impact of Information Technology on Managerial Work*. Los Angeles: Center for Futures Research Publication R16, July 1986.

Figure 6. A SAMPLING OF TELECOMMUTABLE JOBS

Job Title	Full Time Home-Based	Part Time Home-Based	Full Time Satellite or Local Center	Part Time Satellite or Local Center
Accountant		*	*	*
Actuary	* maybe	*	*	*
Advertising Executive	* maybe	*	*	*
Applications Programmer	*	*	*	*
Architect	*	*	*	*
Attorney		*	*	*
Auditor		*	*	*
Bookkeeper		*	*	*
CAD/CAM Engineer		*	*	*
Central Files Clerk			* maybe	
Chief Executive Officer		*		*
Chief Operating Officer		*	* maybe	*
Civil Engineer	*	*	*	*
Clerk-Typist	* maybe	*	*	*
Clinical Psychologist		*	*	*
Computer Scientist		*	*	*
Counter Clerk			*	
Data Entry Clerk	*	*	*	*
Data Search Specialist	*	*	*	*
Design Engineer		*	*	*
Economist	* maybe	*	*	*
Financial Analyst	*	*	*	*
General Secretary		*	*	*
Graphic Artist	*	*	*	*
Industrial Engineer		*	*	*
Insurance Broker	*	*	*	*
Journalist	*	*	*	*
Laboratory Director		*	* maybe	*
Laboratory Scientist			* maybe	* maybe
Lawyer	* maybe	*	*	*
Mail Clerk			*	*
Mainframe Operator			* maybe	
Maintenance Technician		*	*	*
Manager of Managers		*	*	*
Manager of People		*	*	*
Manager, Machine Systems	* maybe	*	*	*
Market Analyst	*	*	*	*
Marketing Manager		*	*	*
Natural Scientist		*	*	*
Office Machine Operator			*	*
Personnel Manager		*	*	*
Purchasing Manager	* maybe	*	*	*
Radio Newscaster	*	*	*	*
Realtor	*	*	*	*
Receptionist			*	*
School Administrator		*	*	*
Software Engineer	*	*	*	*
Statistician	* maybe	*	*	*
Stock Analyst	*	*	*	*
Stock Broker	*	*	*	*
Supervisor	* maybe	*	*	*
Systems Engineer		*	*	*
Systems Programmer		*	*	*
Technical Writer	*	*	*	*
Telemarketer	*	*	*	*
Telephone Operator	*	*	*	*
Theoretical Physicist	*	*	*	*
Traveling Salesperson		*	*	*
University Professor		*	*	*
Word Processing Sec'y	*	*	*	*

Access to the Labor Market

One major use of teleworking is that it gives employers access to human resources that otherwise would not be available to them: parents with young children, the mobility handicapped, workers with scarce or attractively priced skills who live out of town or are otherwise not physically available. This access can be on a local basis but is often international, such as the use of routine information workers in other countries to process data for firms in the U.S.

Dispersed Organizations and Competitiveness

As organizations become dispersed they can also become more competitive, responding more quickly to local market changes. In a very real sense teleworking allows organizations to be at once physically decentralized and logically highly integrated. New

kinds of organizations are possible with teleworking, such as evanescent organizations that are formed for single, ad hoc purposes and dissolve once the specific objective has been reached. It is increasingly likely that many of these organizations will be international in character.

Liberation or Exploitation?

Teleworking is viewed by most of its contemporary practitioners as a major liberating factor in their personal or organizational lives. This is the chief incentive for individuals to pursue it. The resultant productivity increases form a compelling reason for organizations to pursue it.

A chief perceived danger of teleworking is that it could also increase the exploitation of routine workers. The basic equation is simple: an oversupply of certain skills relative to demand leads to decreased compensation for the skills used. As these skills become automated, or telecommutable to other areas of the country or the world, the possibility exists that some workers will be steadily forced into accepting lower compensation for their work, either in avoidance or contravention of existing labor laws. This exploitation is felt to be more practical for home-based work because of the perceived difficulty of enforcing work rules via physical checks on the work places. One enforcement alternative, continuous monitoring of computer-based work, smacks of Big Brother and is equally poorly received. The AFL/CIO have issued strong warnings against all forms of home-based work because of the exploitative dangers. Nevertheless, there has been increasing pressure on Congress from employers and workers alike to eliminate current bans on home-based work. Home-based telecommuting is not currently banned by federal law.

There has been a legal test of telecommuting exploitation. Employees of Cal Western Insurance Company in Sacramento, CA sued the company, charging that they were exploited. The company allegedly had been treating a number of its claims processors as independent contractors, eliminating their employee fringe benefits and successively increasing output demands with no additional compensation. In short, they allegedly had been practicing all or most of the methods of exploitation that have been forecast by the unions. [Editor's Note: The case was settled out of court in May 1988, a few days before it was to go to trial. The results are secret under the terms of the settlement. Both parties claim to have been satisfied by the outcome.]

How Many Tiers?

An underlying possibility of the information age is that it will create a two-tiered society in the U.S. and elsewhere: one in which the middle class is substantially extinct[9]. This is produced by the continuing displacement by automation of formerly skilled workers into the unskilled class, and the displacement of the new information specialists, the information elite, from the middle to the highest income classes. Today's evidence points to exactly this phenomenon. Our optimistic nature, but no hard evidence to date, says that new, intermediate skill information jobs will be created at a rate such that the middle class will be maintained.

[9]For example, see Lester C. Thurow's article: "A Surge in Inequality" in the *Scientific American*, vol. 256, No. 5, May 1987, pp. 30-37.

TECHNOLOGICAL GROWTH

Fundamental Growth Factors

All of these changes are tightly linked to technological growth in general, and to the growth of information technology in particular. It is not clear, nor is it particularly important, which is the driver and which the driven. The fact is that information technology is growing in power at the highest rate of any of the extant technologies; the information component of our society is experiencing the highest rate of change of any component.

Microelectronics and Other Solid State Wonders

The growth in technology is typified by that of microelectronics. The general rule of thumb in the industry is that the information processing power of the latest, state-of-the-art microelectronics chip increases by a factor of ten about every seven years, as it has been doing since the mid-1960s. This increase in power is not accompanied by an increase in price, once the chips are in large-quantity production. As Figure 4 shows for microprocessors, this rate of growth in performance/cost ratio is expected to continue without substantial abatement until at least the mid-1990s.

Similar rates of growth in performance/price ratio are common to most of the other information technologies: mass storage of information via magnetic and optical techniques; fiber optics for massive increases in information transmission capacity; sophisticated satellite techniques for global data communications. New technological breakthroughs like high temperature superconductivity, nanotechnology and its micromachines, and gallium arsenide semiconductors simply act to sustain and diversify the growth to the point where there are few aspects of society that are unaffected by information technology.

Computers, Networks and Systems

All of these component and subsystem level changes make possible the next higher level of technological growth such as computers and telecommunications networks. In 1974 there were about a million general purpose computers in the world--of all sorts. A year later the first production quantity personal computers appeared. Now we are closing on a world total of 20 million operating personal computers, half or more of them in the U.S., with several million more being produced world wide yearly. There are many more millions of "smart" devices, from microwave ovens, to automobile ignition systems, industrial robots and brain surgery probe controllers.

The computers are increasingly beginning to communicate with one another over the developing telecommunications networks. The telephone networks themselves are becoming much more heavily computer controlled, to the point where, in the mid-1990s we expect to see much of the free world intensively digitally interconnected as a result of ISDN (for Integrated Services Digital Network--or I Still Don't kNow--as it's called in the trade) and similar developments. This provides the fundamental technological background for pervasive use of teleworking.

Key Technological Issues in User Acceptance

However, having fundamental technological capabilities and winning widespread acceptance are two different matters entirely, witness the majority of flops in new technological entries into the market. Teleworking is particularly vulnerable to technological hubris because it depends on a graceful and convivial, if not entire, substitution of technology for face-to-face communication. An issue that has preoccupied

researchers for the past two decades is *how much* does one need to emulate face-to-face communication in order to work effectively in situation X? [You fill in the X.]

Clearly, the answer to that question depends on a number of subissues, such as were covered implicitly in our telecommuting experiments (job characteristics, personality traits). Our experimental evidence involving both telecommuters and non-telecommuters leads us to believe that there are just a few technological factors that are key indicators of success in telesubstitution. The top two are:

* **Centrality** to the user and
* **Conviviality** of the technology.

Centrality refers to the closeness of fit between the supporting technology and the job its users have to perform. That is, if the hardware/software fulfills a central function for its users, even though the user may not consider him/herself to be an expert in its use, it will be used extensively. In contemporary terms what that means is that most high-level users of computer-based technology are either professionals or professionals turned managers. This is because most computer technologies to date are thinking/processing rather than acting/implementing tools. In short, it's what the technology does for the user that's most important. This should not come as a shock.

There is another aspect of centrality that is important (and untested thus far): *breadth* of applicability. A software package that is a very close fit to one particular aspect of the user's job, but does not cover many other aspects, may well be used effectively but will still not allow major changes in work style. For example, a spreadsheet or text processing program may be very effective for those times when the user needs to analyze costs or prepare a report. But if the user is spending most of his/her time trying to get in touch with other people, to arrive at detailed work objectives, to coordinate activities, etc., the package offers no support. This is of particular importance to managers, whose work day is usually *semper interruptus*, as contrasted with professionals, who tend to concentrate on one thing at a time. For managers the key software package may be a sophisticated communications/scheduling system that allows him/her to cope with a diverse and constantly changing information environment.

Conviviality refers to the ease/naturalness with which the user can interact with the technology. If it's easy to learn to operate, easy to remember for the casual operator and, most important, fits the user's thinking style, it is considered to be very convivial (as contrasted to surly or hostile). In short, if the technology fits like the old pair of slippers it's a winner.

The combination of these two characteristics determines the extent to which the technology acts as a natural extension of its user; a mirror or amplification of the user's thoughts. The better the technology fits that description, the more likely it is to be used effectively.

Applications to Telecommuting

Note that neither of these criteria are ordinarily monitored in typical product reviews, which tend to put great emphasis on general performance (a significantly less important factor in acceptance). Furthermore, while some software packages rank reasonably high in both centrality and conviviality, at least for professional users, telecommunications packages are generally not among that group. On the contrary, most computer-based telecommunications packages tend to be so surly that they do not get to the point of demonstrating centrality. They are rejected before reaching that point. Further, most telecommunications packages for microcomputers demand up front attention; they do not operate gracefully and unobtrusively in the background. The unadorned telephone is a counter-example of this failing. It ranks just slightly below face-to-face meetings in

importance and conviviality to most people. The telephone is invisible as a technology to most of its users.

The significance of this is that most practicing telecommuters today get their technological support primarily from basic telephone technology, except where they are relatively high on the scale of technological expertise. Where telecommuters use personal computers, and most of the home telecommuters seem to do so, they may not be transmitting their results over a telecommunications network. The fruits of their work may be more often taken with them, in the form of printouts or data on floppy disks, on the occasions when they do go to the office--or when a messenger picks up the results.

Thus the major technological *aid* to telecommuting is the proliferation of increasingly more powerful and versatile, and increasingly less expensive, microcomputers and their associated business software packages. The major technological barrier to telecommuting appears to be the general surliness of the telecommunications process. A good part of the latter is a result of the extreme diversity of interface configurations and protocols. Another part is the result of the general lack of multitasking operating systems for microcomputers.

To illuminate that last comment, consider a typical day at the (home or traditional) office. If our hero(ine) is using a typical contemporary microcomputer (s)he can either a) use a central, convivial applications package or, b) transmit or receive data from someone else but c) not do both at the same time. This is true in all but the most sophisticated traditional offices, where multitasking computers are available, and probably in at least 95% of contemporary home offices. If our hero(ine) is *not* using a microcomputer (s)he can write, read, talk on the phone and mail a letter, all at roughly the same time.

Technological Trends of Importance to Telecommuting

Technology is important to telecommuting to the extent that it can:

* effectively substitute for alternative modes of communication in objective terms;
* help overcome management concerns about access to, and effectiveness of, their directly-unsupervised employees;
* provide ready interaccess to members of work groups, regardless of their physical location; and
* generally fade into the background as the communications medium.

This list emphasizes communications technology because that constitutes the key difference between work-in-the-regular-office and telework. If the two of us could hold a conversation at will with all the aural, visual, olfactory and tactile clues that are available in a face-to-face conversation--yet be thousands of miles away from each other, then teleworking would be instantly accepted and adopted by us and by most people whose jobs would allow it. The more readily technological developments allow that ideal to be approached, the wider will be the acceptance of teleworking.

Furthermore, the greatest impact of computers on the work force has been among routine information workers and professional workers rather than among managers. The primary reason for this is that computer technologies (or, more precisely, software technologies) to date have focused on information *processing* rather than information *using*. The technological difference is that information using is much more communications focused than is information processing.

The key issue is how much of a gap can there be between this communications ideal and technological reality/cost for a given level of implicit acceptance. Note that there is almost always another gap between *im*plicit and *ex*plicit acceptance (between those who

could adopt it and those who *do* adopt it) that depends mostly on socio-psychological factors. At present the gap is quite large between the ultimate level of face-to-face substitution and contemporary technological capacity. Yet there may be 500,000 active telecommuters in the U.S. today, with the number growing annually; an indication that the gap is not infinite.

What does it take to narrow the technological gap? In particular, what seem to be the priorities for particular technological developments that will accelerate the pace of adoption of telecommuting technologies? The following are my own opinions, based on personal experience but not fortified by extensive explicit consumer research.[10]

The Graceful Interface

One major contemporary barrier to widespread use of intercomputer telecommunications is the bewildering array of telecommunications protocols in active use. This would not be a barrier if the computers themselves, or the networks interconnecting them, automatically resolved any protocol differences, making the various levels of computer handshaking instantaneous and invisible to the user. Such is not the case today. A first priority in setting up a telecommuting situation in an organization is to select and distribute a telecommunications software package that has built in protocols for most, if not all, of the situations the users are likely to encounter. Then the task to the non-techie telecommuter is simply to push the right function key or otherwise tell the machine to call the office--as contrasted to remembering the whole litany of baud rates, parity provisions, identification codes and passwords, file access commands, up- and down-loading protocols, and so on.

There are several trends at work here that promise to alleviate the situation. One is the growing movement toward some form of international data telecommunications standards that allow for a wide variety of forms of data transmission. ISDN (Integrated Services Digital Network) is the leading contender at present, although the first technological realizations of the standard are just now coming on the market. The rate of appearance of actual ISDN systems is influenced by the standards definition process, by alternate standards competition (generally driven by specific corporations), and by regulatory decisions at the national, regional and local levels. Our surveys of telecommunications experts from around the world indicate that ISDN will become a generally accepted reality in the U.S. around 1994. First approaches to ISDN, such as Pacific Bell's Project Victoria, may have an important influence on home telecommuting in the next few years, at least in California (currently successful attempts by competitors to derail it notwithstanding).

At the local level, an increasing number of telecommunications software packages are providing script capabilities that allow relatively complicated sets of commands to be packaged as files or associated with function keys on personal computers, so that typing one or just a few keys will effect connection to the desired machine. The increasing amount of implementation of CCITT protcol X.400 is a major step in that direction. I expect those capabilities to be essentially universal by 1995.

This still leaves the higher level protocol problems, such as the wide diversity of access commands for on-line services. This may not have a major influence on telecommuting, either because such services won't be used much or because individual telecommuters will tend to focus on a few such service, for which they will learn the appropriate rites. As on-line databases proliferate, however, simple expert systems that act as personalized translators may hit the market, probably in the early 1990s.

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[10]The emphasis here is on developments related to microcomputers because that is where most of the telecommuting action is likely to be. Clearly, local area networks in satellite offices, and microcomputer-to-mainframe communications in all cases are important, but the focus of the activity is on the intelligent workstations used by individual telecommuters.

Multitasking

The ability of personal computers to do more than one thing at a time--multitasking--is vital to the desired seamlessness of telecommuting technology. In many, if not most cases, telecommunications is seen as an adjunct to something else, or a something one wishes to do while also doing something else. Hence, the ability of telecommunications software to work in the "background" is very desirable. Some telecommuting software packages do this today, most do not. Some multitasking systems are available for personal computers today--UNIX/XENIX, Quarterdeck Systems' DesqView, the operating system for Commodore's Amiga--but are not very widely distributed in the business community. Microsoft/IBM's new OS/2 operating system for personal computers will significantly increase the rate and acceptance of multitasking when it finally appears late in 1988, but widespread telecommuting applications for the systems may not show up until 1989. By the early 1990's, multitasking capability should be essentially universal.

Communication Bandwidth/Richness

The controversy has been raging for years as to how much bandwidth is required to achieve certain interpersonal communications goals. Clearly, the more restricted the communication channel is, the more the communication message is limited. But the relationship is far from linear. Nor is it independent of the personal histories of the communicators. This issue is important because the cost of telecommunications is directly proportional to its bandwidth. In particular, most voice and intercomputer communications can take place over relatively narrow, hence low cost, transmission systems, while live motion visual communication requires at least an order of magnitude greater bandwidth and cost. The term bandwidth can be treated either as an electronic engineering term--frequency response--or as a communications versatility term--breadth of communications options. Our research over the past two decades, as well as common sense, has produced the following rules:

1. *Uncertainty is Expensive:* the bandwidth/richness required is directly proportional to the complexity of the communication; very delicate, ambiguous political negotiations, for example, need face-to-face quality communications while routine information transfer can be done with low bandwidth communications; similarly, unstructured work environments generally have higher uncertainty than highly structured environments, hence need more bandwidth for communication to be effective;

2. *Familiarity Breeds Conservation:* personal acquaintance of the communication participants with each other acts to reduce the bandwidth needed for effective communications; that is, visual and other cues that may be necessary for strangers to communicate effectively can be substituted for by aural, syntactic, or phraseological cues (often requiring significantly lesser bandwidths) between people who already know each other;

3. *The More Often You Get It, the Less Often You Crave It:* increased frequency of communication tends to reduce the required communications bandwidth, for reasons similar to Rule 2; and

4. *Time Is Money:* where action is needed in a hurry, two conflicting phenomena occur: it is psychologically more satisfying to have co-workers physically present in crisis situations--that is, the bandwidth requirement increases in accordance with Rule 1--while at the same time it can be exceptionally useful to have access to people who could not possibly be physically present. This latter case also applies to situations where it is necessary to communicate with large numbers of people in a hurry.

These rules govern most telecommuting situations. For the vast majority of moderately well structured office jobs, weekly (or two or three times per week) face-to-face meetings allow telecommuters to use low bandwidth telecommunications the rest of the time, as per Rule 2. Often, the required frequency of face-to-face meetings can be reduced by more frequent telecommunications (telephone conversations, electronic messaging, voice mail, bulletin boards) per Rule 3. Even in crisis periods or heavy negotiating sessions, escalation to video teleconferencing may be preferable to the difficulties of convening face-to-face interaction sessions, per Rules 1 and 4. For less well structured jobs the bandwidth and/or frequency of communications requirements increase. For these jobs the perceived gap between face-to-face communication and technological substitutes may be significantly larger.

In all cases the costs (if not the prices) of telecommunications bandwidth are decreasing at annual rates similar to those of microelectronics. The costs of information workers are not. Hence, the acceptance threshold even for video telecommunications is lowering annually. Further, as ISDN-like systems become available, with their adjustable communications bandwidth, it will be significantly easier to pick the bandwidth suitable for the situation. Telecommutability of even complex and unstructured jobs will steadily increase.

Telecommuting and Other Expert Systems

Finally, it is very likely that market pressures will spur the development of expert-system telecommunications secretaries. The first of these, appearing now, are relatively limited, following the push-a-function-key-and-I'll-connect-to-your-party system mentioned earlier. Later versions will respond to natural language inputs of the nature of "Call shipping and get the delivery figures on left-handed gizmos for the last 18 months. Then put the figures in this spreadsheet--right here." All of which will be done in background while the telecommuter is doing something else.

At the network level, ISDN-like systems have expert systems built into the network control software. Part of the market contest over the next ten years will be over the issue: "Where's the expertise?" Will it be largely at the CPE (customer premises equipment--telecommunicating workstations, local area networks and PBX's) end or will it be embodied in the network itself? The answer, of course, is: both. Teleconferences of various sorts, and other issues of optimal switching and bandwidth selection among customers, are best handled by the networks. Other value added services, such as providing smart databases (videotex), intercomputer protocol translation, personalized dialing and protocol libraries, etc., are more subject both to market and to regulatory influences. Each of the latter will affect the rate of appearance of more sophisticated expert systems.

Other kinds of expert systems also have an indirect on telecommuting. As more sophisticated decision/evaluation, scheduling, consensus-forming aids become available in forms tailored to the needs of managers, then the managers' needs for information using will be better served. They will consequently be more receptive to indirect (telecommunications-based) interchange with their subordinates and colleagues.

SCENARIOS FOR THE FUTURE

With this as background, here are four scenarios that depict the evolution of telecommuting under different conditions of environmental change. None of these scenarios will ever happen as explicitly stated. Their purpose is to illuminate some of the possibilities for future growth of telecommuting. The first, "Business as Usual," covers conditions under the assumption that no major changes occur either in the course of evolution of the supporting technology or in the other socio-economic environmental trends in operation today. The second scenario, "Energy Crises," covers different options for reacting to developments in the energy field. The third scenario examines the future as cities reach chronic gridlock conditions. Finally, a scenario of extraordinary technological growth completes the series. In each scenario the viewpoint is from the year 2002.

1 Business as Usual

The period from 1987 to 2002 pretty much followed the pattern of the previous 15 years. The international scene was dominated by concern for international competitiveness and with unstable power politics in the Middle East, with the Gulf States war grinding on, even after Khomeni's death. In the United States, it was a period of continued social consolidation marked by "meism"--my taxes, my health, my job, etc.--rather than public concern for the less fortunate or interest in foreign affairs. There was a growing number of 'less fortunate' fed by the declining numbers of middle class citizens as the division into a two-class society continued.

The U.S. government continued the shift toward more conservative attitudes with an emphasis on stronger defense and less investment in social needs. Deregulation of almost everything continued and there was more of a laissez-faire attitude toward economic growth. The economy experienced ups and downs including a major recession shortly after the new president took office in 1989. The U.S. continued to resist the pressures for protectionism resulting in increased Pacific Basin trade, particularly through Los Angeles.

Throughout the economy, "services" continued to grow, particularly those that were information-related. There was vigorous entrepreneurship throughout the United States and particularly in those urban areas where there was a major high tech component. The growing internationalization of the U.S. economy, together with the vigorously growing information industries, made the information sector outpace the national economy. The trends in the work force also continued as in the past decade--more women in the work force, an increasing average age of workers, many dual-earner households and weakening unions (down to 12% of the work force) as manufacturing continued its decline as a source of employment. Pressures grew for greater lifestyle flexibility and, in particular, more benefits for part-time workers and more worker participation in decision making. The gaps between the information-rich and information-poor widened, despite efforts to increase the funding available for retraining workers who had been displaced by structural unemployment.

In most urbanized areas the population continued to grow, with a shifting ethnic mix toward a greater percentage of Blacks, Hispanics, and Orientals and a decreasing percentage of Caucasians. Schools remain overcrowded and underfunded as the offspring of the baby boom generation filter through the system. Housing costs continued to increase, partly because of demands for reduced density and partly because of the need for increased developer fees to offset insufficient local government funding. City services deteriorated despite the attempt to establish more public/private partnerships and other experiments to improve the efficiency of service delivery.

In the area of urban transportation, the continued demand for office space in central business districts increased congestion on the freeways and city streets, and there have been occasional instances of gridlock, even in mid-sized cities, in which auto traffic was tied up for several hours at a time. Mass transit systems in all metropolitan areas have continued to deteriorate, highlighted by the frequent shutdowns in the Manhattan subway system. Mass transit in general has had very little impact on overall congestion in the cities.

On the other hand, computer and communications technologies have improved rapidly over this time span. Very powerful microcomputers are now available at moderate cost, and computer terminals have become much more convivial, especially since the perfection of voice input devices and telecommunications expert systems. The long awaited merger of computers and telecommunications occurred, beginning in 1987, and resulted in a proliferation of computerized data bases and relatively facile connectivity among all devices. However, government agencies at every level (but particularly among state Public Utility Commissions) have not become deeply involved in standard setting and the demarcations of authority over such matters as telecommuting are still ambiguous.

Partly as a result of these developments, people everywhere in the U.S. face heavier costs for residential phone use and there is a persistent shortage of spectrum and conduit availability. Despite the fact that little has been done to encourage telecommuting, workers and employers on their own initiative have conducted many experiments and pilot projects, resulting in a substantial increase in the number of telecommuters in the cities, and the impact on transportation patterns and urban form has begin to be substantial. Our most recent estimates are that there are about 25 million telecommuters in the U.S., with an annual growth rate of about 8%. About half of these telecommuters are part-time workers from home, the rest are now working at suburban centers, although some have begun to reverse-migrate and are now living and working in city centers (otherwise the Manhattan transportation failures would have reached crisis proportions several years ago).

2 Energy Crises

The period from 1987 to 1989 was much like the 'Business as Usual' scenario. But, with the death of the Ayatollah and his succession by even more radical elements, the Persian Gulf war erupted into cataclysmic proportions. There were a series of complete cessations of petroleum deliveries to Japan and most of Europe, one lasting several months. Although the U.S. was relatively untouched by the crises, the first one produced a permanent escalation in energy prices. Business was able to absorb this, much as it did in the 1973 crisis, but the second set of crises in the early 90's raised government concerns for long-term availability of petroleum. Hence, strict gasoline rationing was imposed--and is with us today. When rationing was first imposed the average driver was spending two to four hours per week waiting in gas lines. Although traffic congestion on the freeways was dramatically reduced, it was transferred to the side streets surrounding gas stations.

This produced a frantic demand for telecommuting by every type of organization that had many employees living more than a mile or two from work. Car pooling and jitney services also grew at great rates, but with less effect than telecommuting as employers discovered the productivity benefits of not fighting one's way to work. By 1997 almost 30 million telecommuters were telecommuting regularly, putting severe strains on many local telephone systems. This was partially alleviated as cable TV companies took advantage of the market opportunities and provided area-wide telecommuting networks for major organizations in their areas. Now, according to last year's survey, there are 50 million telecommuters in the U.S., about two-thirds of them working from small local centers that have sprung up in the past ten years. As the transportation infrastructure problems have become alleviated, growth of suburban areas--temporarily halted during the energy crises--has resumed, albeit at a slower pace than in the late '80s. We expect that pace to

accelerate in five to ten years as some of the technologies of superconducting power transmission are put in place, allowing more and more people to live economically away from major urban centers.

3 Urban Implosion

The period from 1987 to 2002 was a big improvement over the prior decade. The fears of all the doomsayers have turned out to be quite unfounded. For example, the decline in the value of the dollar soon led to a substantial reversal of the U.S. trade deficit and large surpluses became commonplace after the new president instituted a series of major reforms that greatly stimulated U.S. competitiveness. Internationally, the Iran-Iraq finally concluded, without victory on either side, and a major disarmament treaty was signed by the United States and Russia, greatly relieving economic pressures on both countries. One result of the improved economic circumstances for America was a virtual boom economy for Los Angeles and other west coast cities as Pacific Basin trade expanded at rates two to three times higher than the prior decade. As a result, many foreign companies and banks rushed to establish offices in Los Angeles, San Francisco and Seattle (in that order) and by now, Los Angeles and San Francisco have overtaken New York as the top two financial centers of the nation.

The economic boom in Los Angeles stimulated a great expansion of in-migration, causing serious problems for all city services. Congestion and even gridlock occurred not just in the city center, but also in most other pockets of high density throughout the region. Some employers tried to decentralize their work force but for every one that left the central business district, it seems as if there were three clamoring to get in. Many employers attempted to establish flexible work arrangements to ease the pressures on their workers, but these efforts are only partially successful. The great demand for workers brought still more women into the work force, creating greater demands for child care services and adding considerably to the daily mileage driven by such workers.

The economic and demographic growth caused housing prices to increase, forcing people farther and farther from the central city. Still, local authorities seemed to be able to do very little about transportation. The pressures for monorail and other mass transit solutions grew, but the systems are not in place or, if existing, do very little to ameliorate congestion in this time period. In their absence, the City tried to implement demand management techniques like ride sharing, metering of ramps, restrictions on vehicle use, and toll roads, but all to little avail. Even attempts to reduce density by restricting growth and industrial expansion or imposing high developer fees to pay for infrastructure improvements did not seem to deal adequately with the pressures of economic and demographic growth. There were simply too many people and too many cars overwhelming the transportation facilities that were built for much more tranquil times.

Meanwhile, technology continued to grow as in the prior scenario. However, all the improvements seem to have been concentrated in the information technologies. Air quality, for example, continued to degrade in the Los Angeles basin as little progress was made in the use of alternative fuels to combat air pollution. Finally, toward the end of the period, actions were taken to provide tax advantages for telecommuters, to stimulate telecommuting by including incentives in ride sharing ordinances and by forcing developers to pay for improved communications infrastructures.

4 Rapid Technological Growth

This scenario is much like the "business as usual" scenario as regards international and national developments. The big difference is in the speed with which technology is diffused throughout society and, in particular, its impact on the information industries. Partly this is

due to the government playing a direct role in stimulating the transition to a high-tech society by planning and investing in education and in technology itself, such as space exploration, teleports, and artificial intelligence.

Basically, this is a relatively benign economic time, not marked by runaway prosperity, but still moderately successful in historic terms. The federal government has moved toward some forms of protectionism which has greatly stimulated certain industries, particularly in information technologies.

Many of the technological developments that were anticipated in 1987 actually occurred earlier than most people had thought. By the early 1990's, many people were telecommuting to work or using teleconferencing extensively instead of traveling. The long awaited breakthrough in artificial intelligence had occurred with the successful completion of the fifth generation project in Japan, and expert systems were widely used throughout industry. By 1995, people had become quite comfortable with the use of computers and microelectronics applications were everywhere--robots in the home, electronic houses, low cost video phones, smart homes, voice input computers, smart cars, etc. Very cheap personal computers almost had become home appliances as smart, convivial software became available, and compact disc technology greatly expanded access to information. In response to the rapidly increasing demand for communication services, the telecommunications industry became highly competitive--with IBM ultimately becoming a true telecommunications services company as well. Network capacity exploded with virtually universal connectivity. Cable companies provided a full spectrum of services, especially two way data services.

In response to the technology explosion, the number of information workers greatly increased and millions of additional workers became highly computer literate. Employers restructured their jobs to take advantage of the new technologies and especially to permit (and even to encourage) telecommuting. Other adjustments were also made to favor telecommuting including workman's compensation for home workers, complete deregulation of the Regional Bell Operating Companies, active government involvement in standards setting, universal acceptance of electronic source documents and government action to solve problems of data security.

With telecommuting technologies easily available, thousands of Los Angeles residents found far distant suburbs much more attractive than the central business district and L.A. experienced a new wave of urban sprawl. Consequently, many of the problems that were previously concentrated in the central business district now appeared in suburbs, but the overall level of congestion and air quality in the city changed little from the mid-1980's.

KEY EVENTS AND INDICATORS

Preamble

What IS the Information Economy?

We are in the midst, maybe, of a fundamental transition in the basis of economics: the shift from trade being based on indivisible, tangible goods to that of much less tangible information. Neither our concepts of economics nor our legal structures are well prepared to cope with these changes.

The Indivisible vs. the Infinitely Clonable

The fundamental issue derives from the fact that information is infinitely clonable; what I transfer to you I still have. How do we account for that? How do I get compensated for that transaction? How do we decide its value? More specifically, how do we police further, unauthorized transfers of that information? Current cause celebres in copyright, patents, and international data flow highlight these issues.

No Ownership -> No Rights -> No Jobs?

All of the above gets to the core fact that our economy is based on the concept of ownership. If we don't really own something, how can we transfer it--or rights to use it--to others in return for some form of compensation? So far we can sell particular representations of that knowledge, in the form of magnetic tape, or paper with symbols on it, or microchips or electromagnetic waves but we still depend in each of these cases on some means of recognizing what we authorized to be transmitted and detecting illicit copies thereof. As piracy increases so does the worth of our products decrease. Taken to its extreme the draconian result is general unemployment except among the few remaining goods producers and the most clever and sophisticated encryptors. The rest of the world is unemployed, surviving at the sufferance of the overworked elite.

What Do We Know For Sure?

Very much and very little. We know that the information economy is upon us. We know/believe that, although it is in its infancy or teenagery, it is growing faster than any other sector of the economy. We know that it is transforming our basic concepts of the nature of work. That is, we think we know *generally* what is happening.

On the other hand, to emulate the proverbial ambidextrous economist, we have a great wealth of ignorance as to EXACTLY what is happening. It--whatever *it* is--is happening faster than the few of us who are watching can track it. Information technology, or more properly, our uses of it, can have either major liberating or repressing effects on work and leisure. Our *experience* has been that the ill effects of information technology that we feared in the past have not, on average, come to pass. The positive impacts have generally surpassed our forecasts. Information technology has become much more a mind aid than a Big Brother.

But then, the future is almost never "just like the past--only more so." Because of the enormous and growing quantities of unknowns about these impacts we need to spend much more time and effort on discovering and reviewing them. We need particularly to continue our exploration of the frontiers of information technology with the goal of creating *only* interesting and fulfilling work for everyone. We need to understand how all these pieces touched on above fit together. We need to reexamine our present, and invent new, scenarios of the information economy. We need to explore and activate the key factors that drive the future in the directions we want to go, not the ones we become compelled to go.

Events

The following are some key events related to telecommuting as derived from other USC studies.

From Telecommunications Outlook, June, 1987.

Telecommunications Outlook is an annual Delphi survey involving 229 experts from around the world, but 80% of them are from the U.S. Not all of the experts receive each questions; each expert gets a set of questions that is selected according to his/her areas of expertise. For each event described below we list the number of responses received, from all the experts (both U.S. experts and those from other countries), and a series of probability values: the minimum and maximum values and the lower quartile, median value and upper quartile of the responses. We feel that this is preferable to the more usual listing of mean and standard deviation because many of the response patterns are not normally distributed. The quartile response values give a better picture, in a small space, of the actual distribution of responses. The **median** value, that is the probability estimate separating the responses into two equal sets, is shown in **boldface**. *Where the U.S.-only sample differs from the total sample, the number of U.S. respondents and the U.S. median are also given in parentheses.* Each event description also includes the mean estimated time of its occurrence.

In summary, the experts expect telecommuting, now practiced primarily by mid-level employees, to be formalized by a Fortune 500 corporation (other than Blue Cross/Blue Shield, J.C. Penney, Aetna and others who are doing it now?) for entry level information workers by 1993. The odds are 4 to 1 in favor of seeing at least 10 million Americans telecommuting around 1993. The switch from freeways to fibers is given even chances of a substantial boost worldwide by an energy crisis around 1995. As a final test, two of our 'experts' gave only a 35% chance of having a Fortune 500 Corporation formally institute a company-wide remote (home or satellite center) working program for its middle managers and professional staff, sometime around 1996! This gives our sponsors 9 years more than they thought they had. In short, the Delphi survey shows telecommuting starting much later than is the case today, yet coming in large quantities in the mid 1990s!

TELECOMMUTE INCENTIVES. Preferential telephone rates are ordered in the 5 most populous states for companies using telecommuting.
NO. OF RESPONSES: 14
PROBABILITIES: 0.050, 0.800, 0.100, **0.200**, 0.500; TIMING: 1993. Note: this is being discussed in California in 1987.

INTERNATIONAL PROTOCOLS WIN. All of the non-Communist-bloc developed countries agree to and implement a uniform set of interconnect protocols to enable smooth telecommunications among their various networks.
NO. OF RESPONSES: 19
PROBABILITIES: 0.100, 1.000, 0.237, 0.600, 0.800; TIMING: 1995

VICTORIA DETHRONED. The FCC rules that Pacific Bell's Project Victoria is a protocol conversion technique--a value added service--thereby denying Pacific Bell the right to market the pre-ISDN (1B+D) technology.
NO. OF RESPONSES: 8
PROBABILITIES: 0.000, 0.500, 0.000, **0.100**, 0.300; TIMING: 1990

MICRO-OFFICES ARRIVE. Basic office equipment, such as desks, lighting, personal computers, printers, etc., become so small and well integrated that they easily can be stowed away in periods of non-use, such as for meetings, work-at-home, etc.
NO. OF RESPONSES: 24
PROBABILITIES: 0.000, 0.900, 0.100, **0.550**, 0.800; TIMING: 1995

MOST MICROS COMMUNICATE. At least 90% of all new personal computers sold, regardless of price, are equipped to communicate via the telephone.
NO. OF RESPONSES: 14 (12)
PROBABILITIES: 0.200, 1.000, 0.775, **0.900 (0.925)**, 1.000; TIMING: 1992

MULTICHANNEL HOMES. Devices like Pacific Bell's Project Victoria, in which twisted pairs are adapted for multi-channel simultaneous data and voice transmission, are installed in at least 20% of U.S. households.
NO. OF RESPONSES: 29 (26)
PROBABILITIES: 0.200, 1.000, 0.400, **0.500 (0.550)**, 0.800; TIMING: 1996

UNIVERSAL FORMAT MATCHER. Software is developed that allows interconversion of all major data formats, thereby allowing most computers to communicate with others, regardless of brand/model.
NO. OF RESPONSES: 13
PROBABILITIES: 0.030, 1.000, 0.350, **0.700**, 0.800; TIMING: 1995

TRANSPARENT DATACOMM SOFTWARE. Inexpensive (less than $100 U.S.) data communications soft/firmware is developed that allows microcomputers & data terminals to communicate with no intervention by the operators to set and monitor communications parameters.
NO. OF RESPONSES: 27 (24)
PROBABILITIES: 0.000, 1.000, 0.300, **0.700 (0.725)**, 0.800; TIMING: 1994

UNIVERSAL COMMUNICATOR. A major telecommunications company produces hard software that allows any communications terminal to telecommunicate with any other that is capable of handling the same type of information (i.e., data, pictures, voice).
NO. OF RESPONSES: 16 (15)
PROBABILITIES: 0.000, 1.000, 0.500, **0.775 (0.750)**, 0.900; TIMING: 1993

ANALOG TRANSMISSION GONE. All public telephone networks have converted to digital-only transmission.
NO. OF RESPONSES: 11
PROBABILITIES: 0.000, 1.000, 0.075, **0.700**, 0.800; TIMING: 1996

COMPUTER VOICE INPUTS. Low cost computers capable of accepting conversational voice inputs become commercially available.
NO. OF RESPONSES: 12 (11)
PROBABILITIES: 0.100, 1.000, 0.300, **0.850 (0.900)**, 0.900; TIMING: 1994

HOME COMM WIRING STANDARD. Most new homes are built with telecommunications cableways to each room.
NO. OF RESPONSES: 27
PROBABILITIES: 0.150, 1.000, 0.500, **0.750**, 1.000; TIMING: 1994

ISDN ACCEPTED IN U.S.. International Integrated Services Digital Network standard is accepted and put into operation in most states in the U.S.
NO. OF RESPONSES: 16
PROBABILITIES: 0.500, 1.000, 0.750, **0.800**, 0.900; TIMING: 1994

ISDN TRIUMPHS. At least 80% of newly manufactured Customer Premises Equipment worldwide complies with ISDN standards.
NO. OF RESPONSES: 8
PROBABILITIES: 0.250, 0.900, 0.700, **0.775**, 0.800; TIMING: 1996

OSI BECOMES A REALITY. The International Standards Organization Open Systems Interconnect (OSI) model becomes widely adopted in practice, allowing disparate computer systems to freely interconnect for messaging purposes.
NO. OF RESPONSES: 13 (10)
PROBABILITIES: 0.100, 1.000, 0.550, **0.750** (**0.725**), 0.875; TIMING: 1993

BUSINESS NET EXPERT SYSTEMS. Network-based expert systems are widely used by business for guidance in financial planning, marketing, product planning, R&D, etc.
NO. OF RESPONSES: 11
PROBABILITIES: 0.100, 1.000, 0.350, **0.750**, 0.812; TIMING: 1995

AUTOMATED SEARCH STRATEGIST. An expert system is developed that automates the search strategy formulation process for large collections of databases such as Lockheed's DIALOG system.
NO. OF RESPONSES: 12 (11)
PROBABILITIES: 0.300, 0.900, 0.500, **0.725** (**0.700**), 0.800; TIMING: 1993

FORTUNE 500 DECENTRALIZE. At least half of the Fortune 500 corporations establish work centers close to the residences of their employees in major urban areas, such that each employee works at the center closest to home.
NO. OF RESPONSES: 14
PROBABILITIES: 0.050, 0.900, 0.100, **0.200**, 0.350; TIMING: 1996

VIDEOCONFERENCING FINALLY GOES. Full-motion videoconferencing is adopted as a routine mode of communications at mid-level management levels by at least half of the Fortune 500 firms in the U.S.
NO. OF RESPONSES: 17 (14)
PROBABILITIES: 0.050, 0.900, 0.250, **0.500** (**0.450**), 0.688; TIMING: 1995

DATA PASSES VOICE. For the first time, intra-corporate data telecommunications traffic surpasses voice, in terms of gigabit-hours per year, for U.S. Fortune 500 firms.
NO. OF RESPONSES: 19
PROBABILITIES: 0.000, 1.000, 0.200, **0.400**, 0.625; TIMING: 1995

INFO ENTREPRENEURS UP. At least 10% of information workers become self employed, using micros in support of their entrepreneurial efforts.
NO. OF RESPONSES: 6
PROBABILITIES: 0.050, 0.850, 0.075, **0.400**, 0.600; TIMING: 1995

INFOSTARTUPS UP. The number of small, entrepreneurial information services companies exceeds the 1982 levels by 30% for at least four successive years.
NO. OF RESPONSES: 24
PROBABILITIES: 0.200, 0.900, 0.350, **0.500**, 0.700; TIMING: 1993

MOST EURO HOUSEHOLDS 2 LINES. At least 50% of the households in western Europe have at least two telephone lines.
NO. OF RESPONSES: 16 (14)
PROBABILITIES: 0.030, 0.600, 0.100, **0.300** (**0.275**), 0.400; TIMING: 1996

THIRD WORLD WIRED. At least 50% of the households in third world countries have telephones.
NO. OF RESPONSES: 17
PROBABILITIES: 0.000, 0.500, 0.100, **0.200**, 0.300; TIMING: 1997

MOST HOMES HAVE EXTRA SVCS. 90% of U.S. households subscribe to extra telephone services such as call forwarding, call waiting, calling number identification, call blocking, etc.
NO. OF RESPONSES: 13
PROBABILITIES: 0.050, 0.900, 0.425, 0.600, 0.700; TIMING: 1998

HALF HSHOLDS NETWORKED. Half of U.S. wired households have terminals or microcomputers connected to one or more interactive network information service(s).
NO. OF RESPONSES: 20
PROBABILITIES: 0.050, 0.800, 0.300, **0.500**, 0.500; TIMING: 1996

COMPUTERS LINK SALES. Virtually all sales of complex information products such as insurance, personal investments, estate planning, etc. are via computer links with customers.
NO. OF RESPONSES: 33 (26)
PROBABILITIES: 0.000, 1.000, 0.100, **0.300** (**0.325**), 0.787; TIMING: 1996

RESIDENTIAL CUSTOM SVCS WOW. At least 80% of U.S. residences subscribe to at least one custom phone service, such as call forwarding, waiting, blocking, screening, etc.
NO. OF RESPONSES: 15 (12)
PROBABILITIES: 0.100, 0.900, 0.300, **0.500** (**0.575**), 0.762; TIMING: 1996

TELCOS INTO DATANETS. Most major U.S. telephone companies offer a full range of data network planning, installation (including terminal equipment), integration, training and maintenance services for their medium- and big-business clients.
NO. OF RESPONSES: 17 (11)
PROBABILITIES: 0.200, 1.000, 0.750, **0.850** (**0.950**), 1.000; TIMING: 1992

TRANSIT TRASHES TCOMMUTING. Successful mass transit programs in the larger cities limit telecommuting to less than 3% replacement of the commute to work in those cities.
NO. OF RESPONSES: 16 (14)
PROBABILITIES: 0.100, 0.900, 0.100, **0.250** (**0.225**), 0.500; TIMING: 1995

ELECTRONIC YELLOW PAGES. Yellow pages are largely supplanted by smart, interactive database services that optimize response to customer queries.
NO. OF RESPONSES: 21 (15)
PROBABILITIES: 0.100, 0.900, 0.263, **0.500** (**0.400**), 0.600; TIMING: 1996

VIDEO CONFERENCING COMMON. Because of improvements in pricing resulting from fiber optics, data compression and new satellite technologies, video conferencing becomes routine at the department level in most Fortune 500 corporations.
NO. OF RESPONSES: 13
PROBABILITIES: 0.300, 0.900, 0.750, **0.800**, 0.800; TIMING: 1993

TELEMEETINGS DOMINANT. Teleconferenced (video-, audio- and computer-) meetings of groups larger than 4 people and smaller than 10 surpass face to-face meetings in number and frequency in Fortune 500 corporations.
NO. OF RESPONSES: 23 (17)
PROBABILITIES: 0.000, 1.000, 0.287, **0.600** (**0.500**), 0.825; TIMING: 1994

ELECTRONIC JUNK MAIL BANNED. At least half of Fortune 500 corporations put severe restrictions on employee use of electronic mail after studies show that it is a major time-waster because of the volume of "junk" E mail in the network.
NO. OF RESPONSES: 28 (21)
PROBABILITIES: 0.000, 0.950, 0.200, **0.500 (0.600)**, 0.700; TIMING: 1994

TELECONFERENCING PUSHED. At least half of Fortune 500 corporations urge managers to use teleconferencing more frequently after internal studies show it is a major time-saver.
NO. OF RESPONSES: 29
PROBABILITIES: 0.300, 1.000, 0.500, **0.700**, 0.838; TIMING: 1994

VIDEOCONFERENCING IS VAPOR. For at least 3 successive years, growth in the installation of new full-motion videoconferencing services is less than 5%.
NO. OF RESPONSES: 19 (18)
PROBABILITIES: 0.100, 1.000, 0.237, **0.700 (0.725)**, 0.912; TIMING: 1991

1ST ENTRY TELECOMMUTERS. A Fortune 500 corporation formally institutes a remote working program for entry level information workers.
NO. OF RESPONSES: 5
PROBABILITIES: 0.200, 1.000, 0.275, **0.900**, 0.938; TIMING: 1993

NLRB OKS UNION TELECOMMUTERS. A decision by the National Labor Relations Board allows unions to organize telecommuting employees as a group, rather than treating each work center as an individual entity.
NO. OF RESPONSES: 7
PROBABILITIES: 0.010, 0.750, 0.040, **0.500**, 0.562; TIMING: 1994

NLRB NIXES MASS UNIONZG. A decision by the National Labor Relations board requires that unions treat each telecommuting worker or local work center as a separate entity for organizing purposes.
NO. OF RESPONSES: 8
PROBABILITIES: 0.000, 0.600, 0.200, 0.375, 0.500; TIMING: 1994

TELECOMMUTER RIGHTS SET. A federal court decision, IRS ruling or act of Congress specifically guarantees that home telecommuters be given the same personnel benefits as in-office workers.
NO. OF RESPONSES: 7
PROBABILITIES: 0.400, 0.900, 0.475, **0.500**, 0.525; TIMING: 1994

OIL CRISIS SPARKS TWORK. A world oil crisis and ensuing gasoline rationing force at least 30% of U.S. businesses to adopt teleworking arrangements for most of their information workers.
NO. OF RESPONSES: 7
PROBABILITIES: 0.050, 0.750, 0.312, 0.500, 0.600; TIMING: 1995

INFOJOBS EXPORTED. At least 30% of all U.S. clerical and data entry types of jobs are performed by workers in other countries via computers and telecommunications.
NO. OF RESPONSES: 6
PROBABILITIES: 0.000, 0.700, 0.100, **0.225**, 0.325; TIMING: 1997

50% ENTRY TELECOMMUTERS. At least 50% of the entry level information workers in the U.S. work from home or in local work centers, using microcomputers and telecommunications for work and coordination.
NO. OF RESPONSES: 8
PROBABILITIES: 0.200, 0.800, 0.200, **0.300**, 0.500; TIMING: 1996

LOCAL TELECOMMUTING. Because of organizational decentralization and computer networking, at least 50% of all information workers work within 5 miles of home (as contrasted to a 1980 figure of 9.5 miles).
NO. OF RESPONSES: 8
PROBABILITIES: 0.050, 0.750, 0.100, **0.225**, 0.300; TIMING: 1996

GHETTO TELECOMMUTING. Telecommuting work centers succeed in several large U.S. cities as a means of bringing information jobs and training into low income areas and upgrading the local economies.
NO. OF RESPONSES: 8 (6)
PROBABILITIES: 0.100, 0.600, 0.200, **0.500 (0.375)**, 0.500; TIMING: 1995

ISDN ACCEPTED WORLDWIDE. International Integrated Services Digital Network (ISDN) standard is accepted and put into service in all the developed and some third world countries.
NO. OF RESPONSES: 220 (174)
PROBABILITIES: 0.000, 1.000, 0.300, **0.600**, 0.800; TIMING: 1995