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Issues Related to the Emergence of the Information Superhighway and California Societal Changes, IISTPS Report 96-4

Jan L. Botha
San Jose State University

Roger Salstrom

R. Benjamin Knapp

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Norman Y. Mineta
International Institute for
Surface Transportation Policy Studies
Created by Congress in 1991

ISSUES RELATED TO THE EMERGENCE OF THE INFORMATION SUPERHIGHWAY AND CALIFORNIA SOCIETAL CHANGES

Mineta Transportation Institute
San José State University
San Jose, CA 95192-0219

IISTPS Report 96-4

ISSUES RELATED TO THE EMERGENCE OF THE INFORMATION SUPERHIGHWAY AND CALIFORNIA SOCIETAL CHANGES

December 1996

Dr. Jan L. Botha, Professor of Civil Engineering,
Dr. Roger Salstrom, Associate Professor, Organization & Management
Dr. R. Benjamin Knapp, Associate Professor of Electrical Engineering
Shirley Chan, Research Assistant

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16. Abstract: The Norman Y. Mineta International Institute for Surface Transportation Policy Studies (IISTPS) at San José State University (SJSU) conducted this project to review the continuing development of the Internet and the Information Superhighway. Emphasis was placed on an examination of the impact on commuting and working patterns in California, and an analysis of how public transportation agencies, including Caltrans, might take advantage of the new communications technologies.

The document reviews the technology underlying the current Internet “structure” and examines anticipated developments. It is important to note that much of the research for this limited-scope project was conducted during 1995, and the topic is so rapidly evolving that some information is almost automatically “dated.” The report also examines how transportation agencies are basically similar in structure and function to other business entities, and how they can continue to utilize the emerging technologies to improve internal and external communications. As part of a detailed discussion of specific transportation agency functions, it is noted that the concept of a “Roundtable Forum,” growing out of developments in Concurrent Engineering, can provide an opportunity for representatives from multiple jurisdictions to utilize the Internet for more coordinated decision-making.

The report also included an extensive analysis of demographic trends in California in recent years, such as commute and recreational activities, and identifies how the emerging technologies may impact future changes.

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The Mineta Transportation Institute
MTI
San José State University
College of Business
San Jose, CA 95129-0219
Tel (408) 924-7560
Fax (408) 924-7565
E-mail: mti@mti.jsu.edu
http://transweb.sjsu.edu

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EXECUTIVE SUMMARY

The Norman Y. Mineta International Institute for Surface Transportation Policy Studies (IISTPS) has been fortunate to receive funding, through the federal Research and Special Programs Administration (RSPA) and the California Department of Transportation (Caltrans), to conduct policy-related activities in the areas of research, education, and information-sharing to benefit the U.S. surface transportation industry. The project which is the subject of this report was sponsored by Caltrans as "Issues Related to the Emergence of the Information Superhighway and California Societal Changes."

The "Information Superhighway" or the Internet is emerging as a topic of significant importance to the economy and infrastructure of California, the nation, and the world. It involves important, and as-yet ill-defined, issues of the inter-relationship of technological development and societal behavior. The overall goal of this project was to develop an action plan for state and local transportation agencies related to the opportunities offered and challenges posed by the Information Superhighway.

It should be noted that the research for this project was conducted primarily during 1995. Given the remarkably fast-paced nature of change with this topic, readers are cautioned that some material may appear "out of date." It should also be noted that the research budget for this project was set at less than $50,000 and therefore the scope of inquiry was, of necessity, limited. Nevertheless, the information presented herein is useful as a summary of issues and ideas relating to how the Information Superhighway will be affecting individuals and transportation agencies in California.

The specific objectives of this project include:

- To identify information and emerging technologies, related to the Information Superhighway, that have potential application for public sector transportation agencies
- To document potential transportation-related impacts of these emerging technological changes on societal and behavioral aspects of California life
- To develop, over a longer-term basis, recommendations and propose an action plan for state and local decision-makers regarding further consideration of these issues.

The study found that there has been rapid growth in the development of communication and information technologies, and this development will probably accelerate. The existing Internet is really only the beginning of the development of the future Information Superhighway, which will provide significant opportunities for information sharing, communication, and computing. Opportunities will arise not only for dealing more efficiently and effectively with existing tasks, but may include the ability to undertake new or substitute activities which will further the attainment of the overall mission of transportation agencies. Since the functional activities of transportation agencies are, in general, very similar to all business organizations, the advantages of the Information Superhighway for businesses will also apply to transportation agencies. However, as technology continues to change, and change rapidly, institutional changes and adjustments will need to keep pace.

The major specific conclusions reached in this regard are:

- It will be advantageous for Caltrans and other transportation agencies to be pro-active in dealing with the emerging issues of technology. Caltrans had been a leader in this area and should continue that role.
- The improved information sharing and distributed computing offered by the Information Superhighway will create opportunities for Caltrans and other transportation agencies to deal more efficiently with internal units, other transportation agencies and other organizations located in

remote sites. Caltrans could provide leadership to establish priorities for the areas of information transfer and distributed computing which will benefit most from the opportunities offered by the Information Superhighway.

- The way in which transportation agencies deal with the public will probably also need to change over time. With the establishment of a World Wide Web presence, transportation agencies have introduced potential benefits and liabilities.
- The benefits or liabilities and the costs or savings associated with these developments will depend on the ability to have a policy established for hardware and software standards by which Caltrans and other transportation agencies can communicate.

Transportation/Communication Related Societal Changes

A difficult process for any firm is how to manage and facilitate change, and the Information Superhighway will be a major change for many organizations. Top management commitment is essential, but employees also need to be actively involved throughout the planning process. Improvements in communication/information technologies have great potential to transform the future workplace. Workers will be able to conduct their work outside the normal workplace and at hours outside traditional working hours.

Regarding societal changes related to transportation which may take place in response to the development of the new technologies, the study concluded:

- The implementation of improved communication information technology has had the effect, and will continue to have the effect, of making it easier for people to move and work in more remote locations. This could impact transportation facilities in rural and suburban areas significantly which will require additional funding and transportation management in those areas.
- Telecommuting does not significantly reduce vehicle-miles traveled (VMT). Although telecommuters will not be making the longer commute trips, they will be making an increased number of shorter trips. As a result, the alleviation of traffic congestion on commuter highways may only be modest, but the additional traffic in rural areas may be notable.
- It is difficult to predict the growth rate of telecommuting and the resulting transportation implications. The actual impact of telecommuting on transportation, air quality, and energy saving will depend on factors such as the degree to which telecommuting is adopted, the portion of peak hour trips eliminated, and future travel demand management related policies.
- The percentage of trips in the category of family and personal business (including social and recreational) is comparable to commute and work-related numbers. These trips could potentially be significantly affected by the new communication/information technologies, particularly if trip substitution occurs similar to telework alleviating the need for work trips.
- Training regarding the benefits and use of the Information Superhighway, as well as the impacts of implementing change, should be conducted for upper management through all levels of workers.
- The electronic age and the emerging communication and information technologies are raising new ethical questions about the use of information.

Some Opportunities and Challenges

There are many applications, spread over a wide spectrum, for the new communication/information technologies. Development is rapid, and will affect all transportation agencies. The following major conclusions were reached:

- There is an opportunity to make more information available on-line, and the image and functioning of the transportation agencies will be enhanced if centralized units could coordinate the information.
- In view of the rapid development and implementation of new technology, increased attention and funding should be given to education and training, particularly in areas relating to understanding of the underlying systems. Training will be necessary for technical personnel as well as for decision

makers to allow all affected parties to evaluate and use the new systems correctly. In addition, new technology, through distance learning, computer, and other electronic media, makes learning "on demand" more possible and/or less expensive.

- The concept of a Roundtable Forum, born out of concurrent engineering, can be extremely useful as transportation agencies learn to take advantage of the Information Superhighway. The new technologies can make the implementation of the Roundtable concept possible through electronic media, without having to meet physically. It will be easier to work with projects that transcend district or jurisdictional boundaries. In particular, there are several opportunities for Caltrans and other transportation agencies to utilize the new technologies in planning activities, such as making information available to the pubic and other agencies and in collecting and processing data.

Recommendations for Further Study

The following studies should be considered for future research and evaluation:

- As planned, evaluation of the "Smart Corridor" projects such as the Highway 17/880 area should be undertaken, once the projects are completed. Specific recommendations should be made regarding the coordination of the implementation as well as the integration of the traffic management and other functions across jurisdictional boundaries. In the case of the Highway 17/880 Smart Corridor, the "post-project" situation should be compared to the prior situation as much as possible.
- There is a potential for generating revenue from selling access to information, such as providing an opportunity for advertising and leasing space in publicly-owned Rights-of-Way for fiber optic cable or similar equipment. The desirability and legality of these issues should continue to be studied.
- A pilot project should be undertaken whereby Caltrans and other transportation agencies in a specific region coordinate, perhaps on a weekly basis, their construction and maintenance activities. This could be accomplished by establishing a regular video conference at regular times to resolve issues. Between meetings, proposed changes in schedule and other relevant information can be posted on message boards on the project's intranet, which can be accessed only by project members. An evaluation of this project should also be undertaken with the view of implementing long-term integration of overall traffic management.
- To further understand the impact of emerging technologies, a case study could be conducted on a suburban or rural area which has shown a population increase in recent years and has a significant number of telecommuters. The area can be selected from surveys of current telecommuting programs. The study should document the changes in lifestyle and travel behavior as a result of telecommuting, include a time use survey, and determine the potentials for telecommuting and trip substitution in the categories of family and personal business as well as social and recreational.

1. INTRODUCTION

Hardly a day goes by without mention of the "Information Superhighway" or the Internet. The federal government refers to the emerging Information Superhighway as the "National Information Infrastructure" (NII). In "The National Information Infrastructure: Agenda for Action." (1) the NII is envisioned as a "a seamless web of communications networks, computers, databases, and consumer electronics that will put vast amounts of information at users' fingertips."

The Internet is the world's largest computer network and is close to a working prototype of the Information Superhighway (2). There is a wide variety of information and services available on the Internet today. People with Internet access are able to retrieve and transfer files from remote computers, electronically send and receive mail around the world, download software, participate in discussion groups on various topics, or post news and information on public electronic bulletin boards.

The future Information Superhighway will include the Internet and more. Cable and television companies are fighting for control of who will build the Information Highway and hope to be able to connect all homes and businesses. The concepts of video-on-demand and interactive television are also part of the Information Superhighway. "Development of the NII can help unleash an information revolution that will change forever the way people live, work, and interact with each other" (1).

The Information Superhighway and the associated information and communication technologies are emerging topics of significant importance to California's economy and infrastructure. They involve important, and as-yet-ill-defined, issues of technological development and societal behavior. For example, it has been predicted that implementation of improved communication will reduce congestion and improve productivity. However, there has been no comprehensive policy-oriented review of the individual and societal impacts of these developments. The California Department of Transportation (Caltrans) funded a project, described in this report, that had the overall goal of developing an action plan for state and local transportation agencies related to the opportunities offered and challenges posed by the "Information Superhighway."

The specific objectives of this project are:

- To identify information and emerging technologies, related to the Information Superhighway, that have potential application for public sector transportation agencies;
- To document potential transportation-related impacts of these emerging technological changes on societal and behavioral aspects of California life; and
- On a long-term basis, to develop recommendations and propose an action plan for state and local decision-makers regarding further consideration of these issues.

The approach followed to meet the above objectives and the outline of the report are discussed in the following section.

2. RESEARCH APPROACH AND REPORT OUTLINE

2.1 Research Approach

As background to the discussion, it is useful to consider the dynamic interactions between technology and societal behavior. Most of the time an application is developed to meet a need or desire or to make an existing activity more efficient, then societal behavior is likely to change. If an existing application is made more efficient, then the user may have more time and/or resources to make use of another application or be able to afford to have another need or desire fulfilled, which in turn can lead to further development of technology. In the case of transportation agencies, the efficiency gains may allow them to provide more transportation facilities or be able to provide an adequate service with reduced resources.

The transportation related impact of these technologies may be direct or indirect. Introduction of these technologies into a traffic management system will directly impact transportation. There are, however, also indirect impacts since these technologies can make telecommuting more feasible. One of the effects of telecommuting may be to decrease certain trips during the peak hour, and another effect may be to increase trips in or from rural areas.

Another aspect of the dynamic interaction between the development and application of technology and societal behavior is the effect of pro-active technology development on societal behavior would be desirable, technology could be developed to make that specific behavior more feasible, more attractive, or more affordable. For example, developing technology to provide better information on public transportation may entice more people to use these services.

During the course of the discussion in the report, both aspects of information/communication technology applications (i.e., those leading to efficiency gains as well as pro-active applications) were considered. It should be noted that this report is principally a policy review, and the available resources did not allow for consideration of specific applications of these new technologies. Rather, the applications were viewed in terms of future directions of development and the associated opportunities and challenges.

2.2 Report Outline

To gain an understanding of these technologies, the various views of what comprises the "Information Superhighway" and the issues that are important for future use are presented in Chapter 3.

The opportunities and challenges presented by these technologies could be associated with the day-to-day operations of the organization or the products and services which the organization renders. The nature of public sector transportation agencies is discussed in Chapter 4 to determine how these organizations are similar to other businesses and whether the way in which the transportation agencies could respond would be similar to the possible responses of other organizations. Some opportunities for information and communication-related change are also described in Chapter 4.

Some documented potential transportation-related societal responses to, as well as emerging demands for, the development of improved information and communication described in Chapter 5. Some of the basic activities that a transportation agency, such as Caltrans, may undertake, are then discussed in terms of the background established in Chapters3 and 4, to make specific conclusions and recommendations. It should be noted that it is not the objective of this project to make recommendations regarding all possible opportunities for applying the new technologies on functions ranging from administration through maintenance of transportation facilities. Caltrans and other transportation agencies have conducted a significant amount of research in this regard. The focus of this report is rather on the application of the principles, established in Chapter 3 and 4, to the functional areas of administration through maintenance. An overall summary of conclusions and recommendations is presented in Chapter

7.

Commonly used terms associated with the Information Superhighway are defined in Appendix A. Appendix B contains a list of some Websites used to obtain information for this report as well as some other government- and transportation-related sites. Caltrans' Telecommunication Mobility Projects as of January 26, 1995 are listed in Appendix C.

The discussion presented throughout this report is based upon a review, primarily conducted during 1995, of literature available in conventional libraries as well as news publications and information made available on the Internet. Because of the rapid development of this field, a disproportionate amount of relevant information was available only in news publications and on the Internet. Great reliance was also placed on interaction with Caltrans personnel.

3. THE INFORMATION SUPERHIGHWAY

There are many technological issues of which Caltrans and other transportation agencies must be aware in order to deal with the challenges and opportunities forthcoming from the development of the Information Superhighway. Failure to recognize, understand, and respond to these issues could result in growing inefficiency, inability to adapt to increasingly complex transportation issues, little capability to respond to security problems, or worst of all, costly adoption of standards and protocols which Caltrans and these agencies were not involved in creating and which do not take into account the agencies' needs. Discussions of some of the critical issues are contained in the following sections. First, the Information Superhighway will be defined, followed by a discussion of the concept as it exists today. Next, the critical elements of the future Information Superhighway will be discussed. Conclusions will be drawn regarding the most critical of these issues and their impact on Caltrans and other transportation agencies.

The objective of this section is to discuss:

- Definition of the Information Superhighway
- Brief discussion of the present Information Superhighway
- Access to the Information Superhighway
- Components of the Information Superhighway
- Issues:
    - Distributed computing and information sharing
    - Standards
    - Privacy
    - Security
    - Cost
- Conclusions
- Recommendations

3.1 Definition

The term "Information Superhighway" is attributed to Vice-President Al Gore (3). He used the term to describe a communications network akin to a highway system. The system will allow everyone to be connected to everyone else, have a universal standard, and minimize bottlenecks. According to the searchable index on the World Wide Web on the Internet at Web site http://wombat.doc.ic.ac.uk/?information+superhighway, the Information Superhighway is "… the emerging high-speed global communications network capable of carrying voice, data, video and other services around the world. These services will use satellite, copper cable, fiber optics, cellular telecommunications and be accessible via set-top boxes or suitable equipped computers.

The term "Information Superhighway" has been used interchangeably with the federal government's proposed National Information Infrastructure (NII). The NII, when built, will be "a seamless web of communication networks, computers, databases, and consumer electronics that will put vast amounts of information at users' fingertips" (4). The two main goals of the Information Superhighway are: single form of "information" that can be easily accessed and wiring all households and businesses in the country so that everyone is connected to the network. But the most immediate challenge is "building" it. Many questions remain unanswered. Precisely what form will the information highway take? What is the best way to deliver information to people? When will this all happen? And most importantly, who will command it?

3.2 The Information Superhighway Today

The information highway is still more concept than reality. The Internet, a loosely organized computer communications network made up of many smaller networks patched together, is the nearest thing existing today to a working prototype of the Information Superhighway.

3.2.1 How It Started

The Internet emerged from the experimental network ARPAnet established during the 1970s, which was designed by the U.S. Advanced Research Projects Agency (ARPA) to support academic and military research (5). The agency wanted a network that could withstand partial outages, such as nuclear attacks and bomb attacks, and still be able to function.

3.2.2 The Internet Today

Today the Internet (the Net) is the world's largest computer network; it is a global connection of networks that links together the large commercial computer and communications services as well as the tens of thousands of university, government and corporate networks. Additional companies, organizations, and private citizens are connecting to the Net everyday. Although the number of people using the Net is unknown, it is estimated that 30 to 40 million people in more than 160 countries can at least send and receive e-mail (6). The Internet is predicted to grow at ten percent of its total base users every month (7).

The Internet has changed the way some people scan for information, process personal and business communications, and solve problems. It is a two-way medium which allows access to:

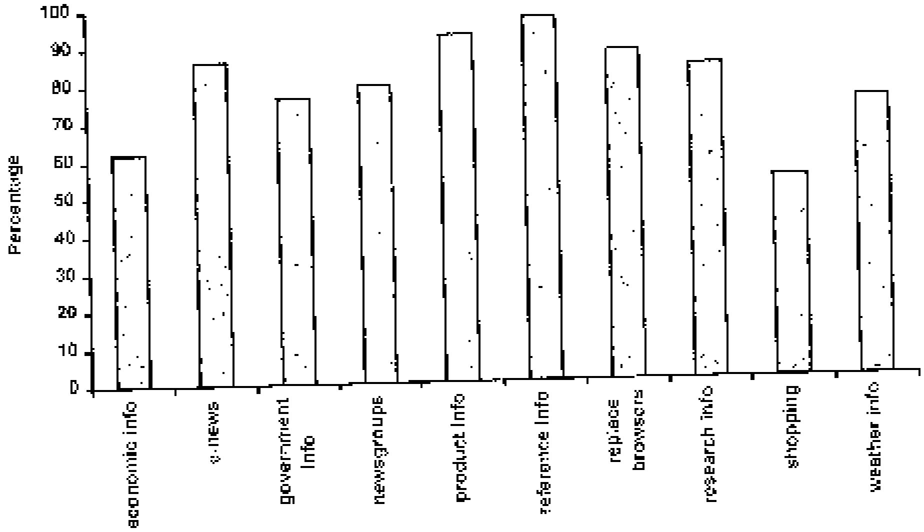
- people
- data
- computer software
- written documents
- and multimedia information such as pictures and sounds.

Current major features of the Internet include:

- Electronic Mail (e-mail)
- Talk
- Usenet
- File Transfer Protocol (FTP)
- Telnet
- Gopher
- Wide Area Information Servers (WAIS)
- World Wide Web (the Web, WWW, 3W)
- Netscape, Mosaic, MS Explorer, Lynx
- Video Conferencing.

These terms, in addition to other key terms, are defined in Appendix A of this report. In the Graphic, Visualization, & Usability Center's (GVU) Fifth WWW User Survey, users were asked how frequently they accessed each category for information, i.e. several times a day, once a day, several times a week, several times a month, once a month, a few times, and never. There were a total of 6,619 respondents for all categories. The percentages presented in Figure 3-1 were calculated by subtracting the total number of respondents who answered 'never' from 6,619. The category which almost all the respondents have used was reference information (99.69%). Other information categories frequently used include: product information (92.37%), replace other browser (87.61%), and electronic news (86.09%). The type of information least accessed was shopping (53.57%).

Figure 3-1: Information Access



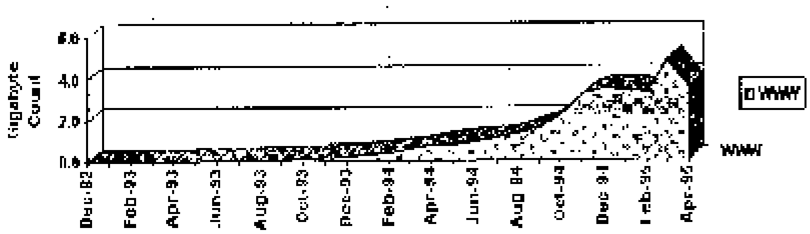
Source: GVU 's Fifth WWW User Survey (April 1996)
http://www.cc.gatech.edu/gvu/user_surveys

3.2.3 Growth of the Internet

From 1986 to 1992, the number of Internet users increased a thousand-fold and is now growing at a rate of ten percent per month. It will more than double itself in one year from 30 million users to more than 66 million (5). Research from SIMBA Information Inc. (8), an information services company that monitors, analyzes, and reports on the global market, reported that the Internet is expected to grow by 64 percent between 1994 and the year 2000. SIMBA estimates there to be 282,000 direct-dial access accounts to the Internet which are being paid by individual consumers in the United States, as of the second quarter of 1995. Total commercial on-line subscribers were anticipated to reach 10.7 million by the end of 1995 and 27 million by the end of the decade. California surpasses all other states in Internet usage at 13 percent. But while the growth rate is tremendous, there are some factors which will hinder future expansion. More than half of all Americans say they have never heard of the "Information Superhighway." Also, fewer than 30 percent of the people have home computers. This issue will be discussed further in the following section.

Figure 3-2: Growth of the World Wide Web (1992-1995)

Figure 3-2: Growth of the World Wide Web (1992-1995)



Source: http://www.cc.gatech.edu/gvu/stats/NSF/merit.html

3.3 Access to the Information Superhighway

3.3 Access to the Information Superhighway

"The introduction of the personal microcomputer in the mid-1970's began a movement that brought computer mediated communication to the masses" (9). However, in a survey of 2,000 adults, less than 30 percent of the respondents owned a computer in their home and of these people, 72.9 percent do not think they will ever own one. This becomes more apparent as the Nielson study reports that a quarter of the 24 million people on the Internet have annual incomes of at least $80,000 compared to only ten percent of the overall population who belong to this income level (10). The study also showed that nearly two-thirds of the users have a college degree and are male, while more than half are between the ages of 16 and 34. "In short, Internet users are young, well-heeled professional men" (10).

As the wealthy are hooking up to the network, the lower-middle and poor people may be left behind as they can not afford to have access to the Internet. The Clinton Administration hopes to be able to provide access to everyone. Vice President Gore told the *Wall Street Journal* that, "It is a priority for this administration that every classroom, library, hospital, and clinic be connected to the National Information Infrastructure by the year 2000" (11). Despite the Administration's goal, "information haves and have-nots", thus further enlarging the economic and cultural gaps between the middle and upper classes and the urban and rural population (11).

A 1993 survey by an interactive services trade group reported that about 20 percent of the U.S. population do not have access to most commercial on-line services by way of a local phone number (12). Commercial on-line providers are unwilling to add local sites unless there are enough customers in the area using their services. Adding a local access point incurs a large cost to the company because they need to pay for a secure location, phone lines, modems, ports, circuits, and hardware. As a result, people living in these areas need to call the nearest local access site, which then becomes a long-distance phone call. The phone bill adds up quickly as one user in Virginia was faced with a $205 phone bill after being on-line for a month (12). In addition to the long-distance cost, users often also pay an hourly charge to the on-line service provider. These extensive toll charges hinder the poor, even those with a secondhand computer, from gaining access to the Information Superhighway.

Another factor which prohibits the poor from accessing the Internet is that 7 million Americans do not even have telephones (13). Supporters of wider access are trying to lessen the economic and cultural gap by installing computers and Net connections into libraries, post offices, and other public places for people without home computers to use. For example, this is taking place in Santa Monica, California (13), where 15 public-access terminals have been installed in places such as banks, community centers, and grocery stores. Now, even the homeless are able to get on-line information about city services, send e-mail to city officials and local members of Congress, and participate in discussion groups.

In November 1994, future House Speaker Newt Gingrich, R-GA, emphasized the importance of making documents available on-line to the public. He said, "We will change the rules of the House to require that all documents and all conference reports be filed electronically … and that they cannot be filed until they are available to any citizen who wants to pull them up" (14). On January 5, 1995, Congress started the Thomas system, the main repository for documents such as the text of bills and electronic copies of the Congressional Record. Although unofficial printed copies of transcripts and records of committee hearings are available shortly after they are completed, electronic copies sometimes cannot be obtained for days or even months later (14).

In contrast to these intentions, the government has not placed great priority in providing staff and officials with the latest technology. Members of Congress, those with access to computers, work with outdated ones. "More than half the PCs are two generations old and aren't capable of running the Windows operating system, a de facto standard in most businesses" (14).

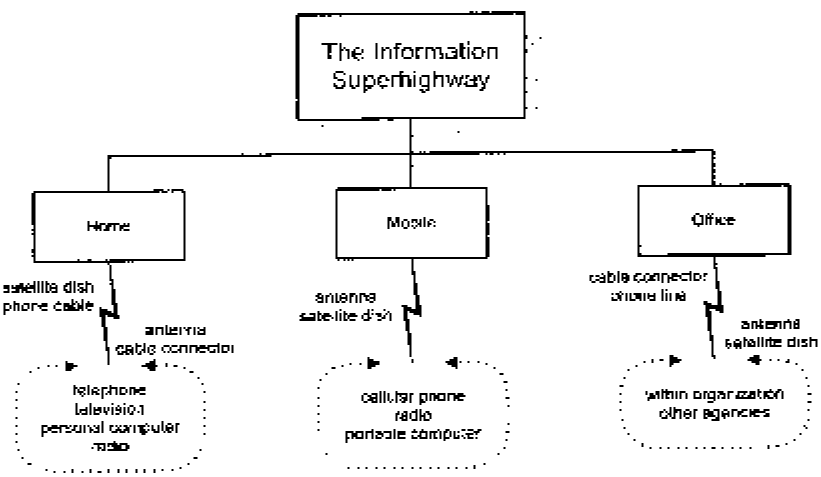
3.4 The Components of the Information Superhighway

The term Information Superhighway can be interpreted to mean the flow of information, both stored or actively created and modified, across locations. Presently this information can flow in two forms, analog or digital. Analog information exchange represents information in continuous form such as voice amplitudes or video color. Digital information exchange involves coding continuous values into a set of numbers. Due to the advent of high speed computers and the flexibility and noise immunity that it creates, information transmitted digitally is rapidly becoming the dominant form of communication devices. To see this impact on information flow, one must examine all levels of knowledge transfer.

The major hardware components of the Information Superhighway are depicted in Figure 3-4. Essentially, the Information Superhighway will be accessible from the home, vehicle, office or from anywhere outside of these three places. It will be accessed via wireless communication or various wired systems. The receiver may be a computer, a television set, a telephone, or other devices which resemble these well-known appliances. Many new devices will combine some of the functions of the aforementioned devices (15).

20 The Information Superhighway

Figure 3-4: Components of the "Information Superhighway"



3.4.1 Individual/Home

<u>*3.4.1 Individual/Home*</u>

There are essentially five ways of information flows to and from homes:

a) One-way Radio Frequency (RF) transmission (radio): This communication channel is presently analog only and is used predominately for audio information exchange. Due to bandwidth constraints, it is unlikely to become digital. It is, however, currently the most common technique for receiving automobile traffic flow information.

b) One-way VHF and UHF transmission (television): This transmission is presently one way and analog. This is, however, changing rapidly and dramatically. First, interactive analog transmission, while presently not very successful, does allow for real-time data exchange. More importantly will be the adoption of a digital television protocol (commonly referred to as High Definition Television (HDTV)). Once this occurs, computers can be used to receive the video information, and then it becomes possible, for example, to not only receive traffic information, but interpret routing patterns, etc.

c) Two-way direct connected narrow bandwidth transmission (telephone): This is presently a narrow bandwidth analog communication channel. However, through the use of modems, which convert digital data to analog form, two-way data communication is possible. This has become an exploding area for the Information Superhighway as individuals establish modem connections to sites on the Internet. Through establishment of data compression techniques and serial line interface protocol (SLIP) connections, complete two-way access to the World Wide Web is possible. The problem, however, is the limited bandwidth which, even with compression and error checking protocols, presently stands at 28.8 kBaud. With the advent of ISDN lines to homes, the speed can be improved to over 100 k Baud, but it is doubtful that it will ever achieve the capabilities of the two systems discussed below.

d) Direct connect broad bandwidth transmission: This is presently an analog protocol, but because of the broad bandwidth coaxial cable allows, it will soon be a high speed two-way connection to the internet. In France, experimentation with having one channel devoted to an internet connection has already begun. This high-speed connection opens the possibility for much faster video transmission as well as more complex compression and security features. This will, for instance, be important if car or driver's license registration were to become possible directly from home.

e) One-way microwave transmission (satellite): This represents the largest growth potential for home communications. GM Hugh's Direct Broadcast Satellite System (DSS) already has a 23 MB/sec band for two-way digital data communications, which opens the possibility for real-time audio and video in the future.

It is critical to realize that once home transmission is digital, then any system based on computer, microcomputer, and microprocessor can receive, exchange, and process information. Information transfer will become software dependent and much less hardware dependent. It will be this software that will enable individuals to access information on traffic information , etc.

3.4.2 Automobile/Mobile

Cellular communications systems now allow the individual to leave the home and still remain connected to their phone system and, in some limited cases, the Information Superhighway. While most of these systems are analog, with bandwidth constraint similar to home telephone systems, there has begun a move to digital cellular communications. Now, two-way data transfer to vehicles of any sort and to pedestrians will be quite common. This could be important to transportation agencies as it would enable traffic information to be transmitted to an automobile, bicycle, train, truck, ferry or pedestrian or a customer who stays at a point of origin. Unique automobile ID codes (similar to IP addresses) could be sent to transportation agencies and aid law enforcement, traffic routing, registration verification, and possibly even toll payments (tolls could be paid by debit from the car owner's bank account). It should be noted that some of the methods used to transmit information to and from the home also apply here, the predominant method being cellular network access to telephone communicating.

3.4.3 Office

Obviously, organizations including transportation agencies potentially have access to all Information Superhighway connections described above. Only the public, private, and government institutions that take advantage of this fact will maintain maximum efficiency, excellent customer relations and thus achieve a good probability of survival. It is believed that the number one use of the World Wide Web will eventually be commerce (16). Initially, static publishing has been the dominant way of using the Net. Corporations can display everything from products and services to job openings. This obviously has many applications for transportation. The next step is dynamic Web pages whereby the Web page is changed depending upon the query. Thus, information from thousands of databases can show up on one Web page. The third step is the ability to order goods and services on the Web, i.e. updating the Web site's base by query. The Web could be used to purchase toll passes, pay fees, etc. Finally, the ability exists to un applications across the Web. Simulations can now be launched at any time from anywhere, causing information to be then sent to other sites. Toward this end, based on the Asynchronous Transfer Mode (ATM) networks, which was initially developed for phone systems, ironically have been first implemented for data networks within corporations by some regional and backbone providers.

3.5 **Distributed Computed and Massive Information Sharing**

As discussed previously, there are many reasons for wanting to use the Information Superhighway. Fundamentally, however, it serves two purposes: information sharing and distributed computing. Information sharing includes activities such as traffic data sharing, video image distribution and response, and real-time site communication. For an organization as large as Caltrans, this becomes a massive information exchange structure.

Distributed computing refers to the ability to use many computers simultaneously, either for computation intensive activities, taking advantage of specialized computing hardware, or reducing the needed bandwidth for information exchange. Some examples of each scenario are:

- Large simulations require either enormous computing power within one computer or the distribution of parallel simulation tasks over many computers.

- A remote job site with only a laptop needs to take advantage of visualization software at a computer back at headquarters.

- Motorists want to get continuous traffic updates in their cars.

The last example could be misinterpreted as another example of data exchange. It is, however, an example of distributed computing over the Internet. With new remote program execution protocols such as JAVA^{TM}, an applet (a small program) can be transferred to a remote computer (either workstation or PC) and executed. This allows for reducing the bandwidth of information exchange by:

- Transferring an applet
- Remote machine executing the applet
- Occasional update of information

Continuous screens updates (HTML files) do not have to be sent.

3.6 Standards

When one computer stands alone, serving its intended function, it does not matter what particular hardware it uses or what software runs on it. The minute the computer is networked and becomes part of a distributed computing environment, software and hardware standards become crucial. Without these standards, data cannot be shared easily, computation cannot be distributed efficiently, and most importantly, human computer interaction becomes slow, tedious, and expensive, as the user must be retrained repeatedly. Network standards are essential. In the U.S. House of Representatives, there are a minimum of nine different internal electronic-mail systems, which makes it difficult for members of Congress to communicate with each other (17). To maximize the rewards from using the Information

Superhighway, transportation agencies must adhere to standards in both computing hardware and software.

3.6.1 Software Standards

Software on the Information Superhighway does not just refer to networking, mail, and other communications software. It also refers to the applications that each user is running and operating systems they run upon.

Software standards refer to two separate issues:

- Establishment of standards by which all software, both custom and commercial, to be used by the organization must adhere
- Stardardization of commercial software to be used by a transportation agency and its contractors.

3.6.1.1 Common Standards

Establishment of standards is critical if any information sharing and distributed computing is to take place. Standards must be set in the following areas:

1. File formats for data exchange. This includes all application generated files that will be exchanged across Caltrans and to outside contractors including text documents, databases, drawings, etc.

2. Reporting formats within common files. Although a file format may be compatible, if the data reporting within the file is different, communication is broken. A simplistic example would be a common database format that has a completely different field assignment than another database.

3. Distributed program communication protocols. Obviously, if a program is to communicate in real-time with another program, it must speak in the same protocol. This is critical for such thing as real-time traffic monitoring and management.

3.6.1.2 Common Applications

The continuing development of standards is important in the following areas:

- Operating systems
- Communication packages
- Applications that will be used at more than one site

This issue has an impact not only on ease of data exchange and distributed computing, but also on the cost of software purchasing, training, and maintenance. Software that is common across sites and across computing platforms can allow for volume discounts, common training programs, ease of technical support, and less time keeping software current and compatible. While having common software is not absolutely necessary as long as common standards are set, the monetary savings to agencies would be enormous.

3.6.2 Hardware Standards

As was mentioned previously, the Information Superhighway has eliminated the necessity for common computer hardware. A personal computer can talk to a UNIX workstation and talk to a mobile laptop at the job site without any problems as long as software standards are maintained.

It is very important, however, that hardware standards for communication be established. As discussed earlier, information exchange can take many forms and occur at many speeds. The method for communicating to a remote job site, or a car, or a home, must be established. It costs hundreds of thousands to millions of dollars to network buildings together. Real-time video data exchange from a job site or a traffic corridor, for example, requires high bandwidth networks. The choosing of appropriate hardware standards, as well as software standards will impact whether the money spent now will be wasted due to obsolescence.

3.7 Privacy

"Forging e-mail is notoriously easy," said Gary Jackson, director of academic computing at the Massachusetts Institute of Technology (18). Messages can be manipulated such that it looks as if someone else sent it, which makes verifying the origination of the message difficult. There is also a potential for the unauthorized opening of electronic mail; this would be considered misuse of Internet facilities. On the other hand, activities between two consenting adults are usually private and harmless (19).

Anyone who uses the Internet or puts any document out on the Internet needs to be concerned with the copyright law and intellectual property protection. "All works of expression have at least one thing in common: they are protected by copyright as soon as they are created and fixed in a tangible medium" (20). The copyright law grants authors the right of intellectual property and certain exclusive rights to their works for a limited time. This applies to Usenet postings and e-mail messages as well. Both are original works of authorship fixed in a tangible medium of expression (20).

There are two doctrines which will probably allow some copying of Usenet postings and e-mail messages: fair use and implied license. Appropriate fair use may be considered if it was not used in a commercial nature, the postings or message was not an artistic or dramatic work, only a short quotation was copied, and there was little or no impact on any market for the posting or e-mail message (20). With e-mail messages, one must also be concerned with other laws such as defamation, invasion of privacy, and trade secrecy when contents of a private e-mail message are revealed. Others support the idea of an implied license; they argue that anyone who posts their ideas to Usenet "is granting an implied license for others to similarly copy or quote that posting, too" (20). There has been little litigation testing these theories in court since most postings are not registered with the Copyright office. In order for the defendant to win, he/she must show actual damages. These cases do not usually result in any actual damages, and therefore it becomes too expensive to sue for negligible damages.

However, a copyright only protects an author's original expression and not the "ideas, system or factual information that is conveyed in the copyrighted work …" (20). It also does not apply to U.S. Government works. Works of the U.S. Government cannot be copyrighted and are considered public domain, thus becoming available to be freely used by anyone for any purpose.

3.8 Security

Security is always a key issue when data is stored and exchanged. At University of Southern California (USC), the Security Infrastructure for Large Distributed System (SILDS) project has the objective of developing infrastructure to support authentication, authorization, accounting, and related security services for the Internet. These services promote greater sharing of resources and enable electronic commerce. Through the SILDS project, the Information Sciences Institute in San Diego recently released NetCheque, an electronic payment system for the Internet. Users registered with NetCheque accounting servers are able to write electronic checks to other users. These checks may be sent through e-mail or as payment for services provided through other network protocols. When deposited, the check authorizes the transfer of network protocols. When deposited, the check authorizes the transfer of account balances from the account against which the check was drawn to the account to which the check was deposited. This kind of security will be an issue as Caltrans and other transportation agencies become greater players on the Internet.

Data security is also critical in other areas. For instance, security becomes critical when information is exchanged in areas of biometric record keeping, bids, proposals and employee records.

3.9 Cost

To understand the present and future costs of using the "Information Superhighway," one must understand the structure and cost history of the Internet as well as cost of Web sites. Much of the information from sections 3.9.1 and 3.9.2 is excerpted from the information infrastructure Web Site at the University of Michigan (http://www.umich.edu).

3.9.1 Internet Structure

How much different is the Internet from telephone networks? Most backbone and regional network traffic move over leased phone lines, so at a low level the technology is the same. However, there is a fundamental distinction in how the lines are used by the Internet and the phone companies. The Internet provides connectionless packet-switched may service whereas telephone service is circuit-switched. The difference may sound arcane, but it has vastly important implications for pricing and the efficient use of network resources.

Most of the network hardware in the Internet consists of communications lines and switches or routers. In the regional and backbone networks, the lines are mostly leased telephone trunk lines, which are increasingly fiber optic. Routers are computers. The routers used on the NSFNET (National Science Foundation Network) were modified commercial IBM RS6000 workstations, although custom-designed routers by other companies such as Cisco, Wellfleet, 3-Com and DEC probably have the majority share of the market.

The U.S. portion of the Internet is best thought of as having three levels. At the bottom are local area networks (LANs), e.g. campus networks. Usually the local networks are connected to a regional, or mid-level network. The mid-level backbone is an overarching network to which multiple regional networks connect, and which generally does not directly serve any local networks or end-users. The U.S. backbones connect to other backbone networks around the world. There are, however, numerous exceptions to this structure.

A few years ago the primary backbone was the NSFNET. On April 30, 1995, the NSFNET ceased operation and now traffic in the U.S. is carried on several privately operated backbones. The new "privatized Internet" in the U.S. is becoming less hierarchical and more interconnected. The separation between the backbone and regional network layers of the current structure is blurring, as more regionals are connected directly to each other through Network Access Points (NAPs), and traffic passes through a chain of regionals without any backbone transport.

3.9.2 Internet Cost

In January 1994, there were four public fiber-optic backbones in the U.S.: NSFNET, Alternet, PSInet, and SprintLink. The NSFNET was funded by the National Science Foundation (NSF); it evolved directly out of ARPAnet, the original TCP/IP network. The other backbones were private for-profit enterprises.

By summer 1995, there were at least 14 national and super-regional high-speed TCT/IP networks in the U.S. As interconnection proliferates, the distinction becomes less important. A map of the major interconnection points and the numerous networks that use them is available at the California Education and Research Federation Network (CERFnet).

MCI, which helped operate the original NSFNET, is probably the largest carrier of Internet traffic today;

they claim to carry 40 percent of all Internet traffic. However, this is a highly competitive market; Sprint, Alternet, and PSInet are also signing up many customers.

The NSFNET backbone shut down on April 30, 1995, when its NSF funding ended. NSF is continuing to fund some regional nets, but this funding steadily decreases to zero over five years. Instead, the NSF is funding NAPs near Chicago, San Francisco, and New York. The NAPs are interconnection points for backbone providers.

It is difficult to say how much the Internet as a whole costs, since it consists of thousands of different networks, many of which are privately owned. However, it is possible to estimate the cost of the NSFNET backbone, since it was publicly supported. In 1993, NSF paid Merit about $11.5 million per year to run the backbone. Approximately 80 percent of this was spent on lease payments for the fiber optic lines and routers. About seven percent of the budget was spent on the Network Operations Center, which monitored traffic flows and trouble shooted problems.

To give some sense of the scale of this subsidy, add to it the approximately $7 million per year that NSF paid to subsidize various regional networks, for a total of about $20 million. Based on estimates that there were approximately 20 million Internet users (most of whom were connected to the NSFNET in one way or another), the NSF subsidy amounted to about $1 per user per year. Of course, this was significantly less than the total cost of the Internet; this figure does not include all the public funds from state governments, state-supported universities, and other national governments. No one really knows how much all this adds up to, although there are some research projects underway trying to estimate the total U.S. expenditures on the Internet. It has been estimated–read “guessed”–that the NSF subsidy of $20 million per year was less than ten percent of the total expenditure by U.S. public agencies on the Internet. At present, there are many overlapping information networks (e.g., telephone, telegraph, data, cable TV) while new networks are emerging rapidly (paging, personal communications services, etc.).

Each of the current information networks was engineered to provide a particular type of service and the added value provided by each different type was sufficient to overcome the fixed costs of building overlapping physical networks. However, given the high fixed costs of providing a network is strong. Furthermore, now that all information can be easily digitized, separate networks for separate types of traffic are no longer a basic feature in most visions. The much publicized migration to integrated services networks will have important implications for market structure and competition.

3.9.3 Web Site

One of the critical costs for any company on the Internet is the establishment and maintenance of a World Wide Web site (WWW). Costs to set up, run, and maintain a WWW site can become significant. According to a panel of Internet marketing experts at a conference on marketing on the Internet, at COMDEX FALL 95, it would cost $6 million over two years to run a “large” site, $2 million for a medium site, and $500,000 per small site. Becki Walk, one of the panelists, stated that it was crucial to set up good links on a homepage and this may cost as much as $800 per month. The costs of a WWW presence will grow and become quite significant as the mission of the Web pages grows.

Discussion with Caltrans personnel indicated that the Caltrans WWW presence will be important in information exchange with the public. The benefits and liabilities associated with a Web presence also nee to be considered. Although Caltrans will be able to make more information available to the public and correspond more efficiently, they will need to be accountable for the information distributed as well as respond, in a timely manner, to queries/requests the public makes.

3.9.4 Future Costs

It is impossible to predict the cost of using the Internet and the Information Superhighway in the future.

It is clear, however, that adherence to hardware and software standards, as discussed previously, will be critical in keeping costs at a minimum. With an organization as large as Caltrans, securing agreements with Internet providers could also help keep rising access costs down. A coherent policy on Internet access and standards could put Caltrans in the best position to influence the future costs of being on the Information Superhighway.

3.10 Summary of Conclusions

There has been rapid growth in the development of communication and information technologies and this development will probably accelerate. The existing Internet is only the beginning of the development of the future Information Superhighway, which will provide significant opportunities for information sharing, communication, and computing. Opportunities will not only arise for dealing more efficiently and effectively with existing tasks, but may offer opportunities to undertake new or substitute activities which will further the attainment of the overall mission of transportation agencies. Along with the opportunities there will be challenges for transportation agencies in dealing with these changes, which will probably occur very rapidly. A summary of the major specific conclusions follows:

1. It will be advantageous to be pro-active in dealing with the emerging issues. The most important issues are:

    - Identification of which functions will be affected by the Information Superhighway as well as determining which additional functions could be advantageously dealt with through the Information Superhighway
    - Standards and protocols for computing hardware and software
    - Possible security problems.

2. The improved information sharing and distributed computing offered by the Information Superhighway will create the opportunity to deal with Caltrans units, other transportation agencies and other organizations located in remote locations in an efficient manner. Caltrans could provide leadership to establish priorities for the areas of information transfer and distributed computing which will benefit most from the opportunities offered by the Information Superhighway. This can be done within the context of Caltrans’ and other transportation agencies’ ongoing evaluation of their functional organization and operation.

3. The way in which transportation agencies deal with the public will probably also need to change over time. With the establishment of a World Wide Web presence, Caltrans and similar agencies have introduced potential benefits and liabilities.

4. The benefits or liabilities and the costs or savings associated with these developments, will depend on the ability of Caltrans to have a policy established for hardware and software standards and protocols by which organizations, which Caltrans deals with, could communicate.

3.11 Recommendations

Caltrans and other transportation agencies should develop a policy/strategic plan for dealing with the public, other transportation agencies, vendors and other commercial enterprises. In the short term, this policy should focus on issues related to the Internet. The specific issues for Caltrans to deal with are as follows:

- Establishment of a unit that will oversee and/or establish leadership for interagency communication and, most importantly, distributed computing

- Establishment of a unit that will oversee and/or establish leadership for communication with the public and contractors using the World Wide Web
- Establishment of protocols, of hardware and software standards
- Establishment of a training program for Caltrans and other transportation agencies for the purpose of electronic communication
- Establishment of a cost sharing formula for Caltrans and other transportation agencies for the purpose of electronic communication
- Establishment of a cost sharing formula for Caltrans and other transportation agencies for hardware, software, and training costs.

It is recommended that Caltrans establish a task force to initiate a policy/strategic plan for dealing with the above-mentioned issues. This task force should preferably include representatives from other transportation agencies and possibly also representative from other organizations, such as consultants, which Caltrans and the other agencies routinely deal with. An initial policy will probably have to be proposed by Caltrans. This should be a very worthwhile action since it will establish a cost-efficient and cost-effective direction for dealing with the opportunities and challenges presented by the emerging technologies.

4.
5. BASIC BUSINESS ORGANIZATION AND COMMUNICATION

It is often said that "Government ought to operate more like a business." The primary objective of this chapter is to discuss some opportunities for information and communication-related change potentially available for many organizations, including private businesses and public transportation agencies. Advances in communication, information, and computer technologies have impacted the way businesses operate. In just this past decade, the personal computer has, for many, become a tool which helps accomplish daily tasks, aids in the communication process, and retrieves information. It has improved the processes, efficiency, and accuracy of businesses (15). Business users can potentially use the Internet as a delivery medium for their products, information and services. Transportation agencies can potentially utilize the Internet and the future Information Superhighway in the same way that businesses can, and learn from businesses in this respect, given that there is a similarity in the fundamental operation of transportation agencies and private businesses.

In the following sections, the basic functions of organizations will be introduced, with a corporation of the functions of four typical transportation agencies, to address the fundamental question of whether-or-how transportation agencies operate in a similar manner as other businesses. The opportunities and general impacts that the Information Superhighway will have on all businesses (both internally and externally), and some of the specific applications to transportation agencies, will also be addressed. The subject of concurrent engineering will be presented, since improved information/communication technologies can yield substantial benefits in this area. A summary of developments related to the future workplace will be presented, followed by a discussion of how change will take place in an organization. Following this will be a summary of conclusions and recommendations.

4.1 Basic Organizational Functions and Transportation Agency Examples

To create and deliver goods and services, all organizations perform the functions of marketing, production/operations, and finance/accounting. Universities, churches, volunteer groups, and businesses all perform these functions (21). In addition to these basic functions there are other support functions that are important enough to be identified separately. For most businesses, the following major functional areas are commonly found (22).

Marketing. Concerned with the selling, promotion, and distribution of a product or service.

Production or operations. Concerned with converting raw materials into finished form, or with delivery of a service.

Finance. Concerned with developing sources of funds and guiding their internal and external investment.

Personnel. Concerned with attracting, developing, and maintaining the organization's human resources.

Accounting. Concerned with financial reporting for external and internal purposes.

Research. Concerned with discoveries that may be developed into useful products or processes for the future.

Legal. Concerned with protection of an organization from legal action, and maintenance of legal rights, which all organizations have.

Do these particular functions apply to transportation agencies? The assumption is that transportation agencies are (or can be) very similar to any business. The following organizations were reviewed, primarily from an analysis of their published organization charts, to determine how well they correspond to typical businesses:

State Department of Transportation (Caltrans)

Metropolitan Planning Organization (Metropolitan Transportation Commission)

Local Government (City of San Jose's Department of Streets & Parks)

Public Transit Agency (Santa Clara Valley Transportation Authority)

It should be noted that the analysis was carried out by examining published organization charts and noting the obvious functions performed in comparison to the generic business functions identified in the earlier discussion.

4.1.1 State Department of Transportation (Caltrans)

Caltrans is responsible for the design, construction, maintenance, and operation of the California State Highway System, as well as that portion of the Interstate Highway System within the California's boundaries. Caltrans is also involved in the support of passenger rail service in California and promotes the use of alternative forms of transportation. Overall, the major Caltrans functions correspond closely to the functions found in typical business. At the District level there is not an identifiable department of marketing, but there is a public information function.

4.1.2 Metropolitan Planning Organization

Since a metropolitan planning organization (MPO) is mainly a planning organization, its functions do not correspond to a typical business as well as the other agencies which were considered. The Metropolitan Transportation Commission (MTC), the MPO in the Bay Area, allocates a large sum of money each year to what it decides are needed improvements, although the MTC usually does not do the project work itself. However, these planning and allocation functions are performed in most businesses.

4.1.3 Local Government

The mission of the City of San Jose's Department of Streets and Parks is "to ensure that the City's investments within its street right-of-ways are effectively and efficiently maintained; to operate the City's traffic system in a manner that is sensitive to community concerns, minimizes accidents, and provides for the efficient movement of vehicles and pedestrians; and to effectively manage the City's parking enforcement and citation programs" (http://www.1pac.net/csj/street&traffic/sts&pks.html).

Again, there is a close similarity between the functions for the Department of Streets and Parks and the functions in a typical business.

4.1.4 Public Transit Agency

The Santa Clara Valley Transportation Authority (SCVTA), created under statue as the Santa Clara County Transit District, was established in 1972 and has the primary responsibility of operating and maintaining public transit services within the county. It has a fleet of approximately 461 buses and a 21-mile light rail system serving the county. These divisions are very similar to the divisions in a typical manufacturing company. The main difference is that the Santa Clara Valley Transportation Authority provides the transit system products and services, while a company such as NUMMI manufactures cars.

From the discussion in the preceding sections, it can be concluded that transportation agencies are very similar to other businesses, except that they provide transportation products and services and are government agencies. The difference between these organizations from private businesses is that they are also instruments of public policy and are more susceptible to political factors.

The traditional marketing function was not readily apparent in the agencies analyzed except in the case of the Santa Clara Valley Transportation Authority. Most public agencies do have an identified function of public information, but this is very often based primarily on disseminating information on the agency's own activities. It should be noted that the emergence on the Information Superhighway will provide the opportunity, but also a need, to increase activity in this area, especially in overall public relations and marketing.

4.2 Internal and External Uses and Impacts of the Information Superhighway

The underlying theme throughout the discussion is that the Information Superhighway can be used to complement and supplement other modes of communication rather than replace them. Whenever practical, people should be given a choice of modes of communication rather than being constrained to any single mode.

One of the frequently cited advantages of the Internet is institutional cost savings. For example, Jerry Neece, Internet Marketing Manager at Sun Microsystems, estimates that Sun has saved approximately $1.25 million from having an Internet connection (http://www.southcon.com/nethype.html). Although cost savings can exist, a significant WWW presence can involve large costs, particularly for a large company. IBM has spent several million dollars creating their site. IBM's site is extensive, containing over 10,000 documents across 30 Web servers (http://www.ibm.com). It should be noted that the start-up money is only an initial investment, while the on-going maintenance cost can be significant. IBM is also creating WWW sites which will be used to disseminate confidential IBM information to employees.

Although cost reduction obviously is an important potential advantage, this chapter will focus more on the quality of communication than on reduced costs for several reasons. First, it is both hard to generalize about cost savings and also difficult to accurately measure all the cost impacts, including less direct impacts. Second, given the rapid rate of change with many aspects of the Information Superhighway, including changing cost levels and structures, it is difficult to predict future costs of use. Quality-related communication advantages, on the other hand, will tend to be more stable over time.

The Information Superhighway will impact transportation agencies in a number of areas. It is important, however, to note that there are few models for integrating the Information Superhighway into core organization functions (23).

Internal uses will be discussed fist, followed by external uses.

4.2.1 Impacts of the Information Superhighway on Internal Activities

There are significant areas within a firm which can benefit from using the Internet and the Information Superhighway. In the following sections, the various areas of these benefits will be presented. They include internal distribution of information, operations, and production. In a later section of this chapter, the use of concurrent engineering in new product/project planning and development will be discussed.

4.2.1.1 Internal Distribution of Information

For much internal communication, the Internet combines the best features of telephone and paper communication. The written format used with e-mail tends to lessen communication misunderstandings that can arise with telephone communication. At the same time, information can be disseminated more rapidly and at a lower incremental cost through e-mail than with paper communication, particularly with large, multiple-site organizations.

The Internet can also contribute to significant hard-cost savings in the way firms distribute information. Schlumberger (23) identified the following advantages of using the Web rather than paper to distribute information:

- Lower cost of distribution
- Greater speed of distribution
- Ease of cross-indexing information
- Ease of using and reusing information by "cutting and pasting"
- Ease of correcting and updating information
- Ability to monitor who is interested in obtaining what information.

4.2.1.2 Operations

As a result of improved communication, there will be a reduction in purchase costs, product development and manufacturing cycle times as well as inventory levels. There is a large trend toward partnership arrangements with suppliers in order to reduce costs and implement just-in-time (JIT) systems rather than the old adversarial relationship. "A survey of North American companies revealed the average number of suppliers to be 1,096 prior to JIT. The number dropped to 759 after one year of JIT, to 656 after two years, and to 357 after five years" (25).

Part of the requirement in a partnership is much closer communication with suppliers. Some 40 percent of U.S. manufacturers are already electronically linked to suppliers, customers, and partners, according to the National Center for Manufacturing Sciences. The trend in the future will be the development of closer ties to suppliers since fewer suppliers generally result in lower costs and higher quality. Firms have found that a stable relationship with a small number of suppliers, who can provide high quality, meet delivery schedules and remain flexible to changes, is price value alone without considering these other factors. This may be an important lesson for public agencies to consider, since procurement laws and regulations often require compliance with "low bid" provisions.

Also, it would be easier to implement JIT if the relation with the suppliers were more of a partnership. But all these changes require better communications. Requirements and changes need to be communicated quickly and accurately. If this were done, vendors would be able to time deliveries closer to the actual need date with a higher quality, while also reducing the total dollars in inventory. U.S. companies have had impressive results including: lead time reduction of 90 percent; inventory reduction of 35 – to 73 percent; se-up times reduced by 75-to94 percent; cost of purchased materials reduced 6-to-11 percent; and the cost of quality reduced 26-to-63 percent (26).

4.2.1.3 Production

Organizations can experience an increase in productivity as a result of Internet use. Many of these benefits are intangible, but they are very important for firms to consider. The benefits can include:

- Improved morale from sharing work and interests with co-workers
- Accurate, easily accessible and timely information available
- Research, via search engines, customized new feed
- Cross pollination of engineering project information, yield new synergistic engineering projects. For example, Genentech (23) greatly improved their research and development from use of the Internet. They mainly used it for: “(1) acquiring data or computer programs for use at Genentech; (2) collaborating with colleagues at other institutions; (3) participating in electronic forums; and (4) finding and using data, information, or computing resources available outside Genentech.” It has become clear to Genentech’s scientists and management that the Internet is an important link in their research and development effort. The information available on the Internet is necessary part of their ability to be competitive.
- More effective outsourcing of functions, as companies become electronically linked
- Personnel home pages/Frequently Asked Questions
- Remote access of information in support of field sales and telecommuting. At Cyrix, a leading supplier of high-performance processors and PC systems, all 20 U.S. salespeople are currently using the Internet to capitalize on this benefit (27).

4.2.1.4 Development of New Products

Improved communication among product development team members will result in shorter product development cycles. If projects can be completed sooner, the savings can be considerable. For example, Caltrans paid a $14 million bonus to a contractor who completed a construction project 70 days ahead of schedule after the Northridge earthquake.

Communication of customer preferences and marketing information to team members will enhance development. Collecting good data on the customer’s needs is a difficult task for the design team (25). The collection of good data will become easier with the Information Superhighway. To illustrate the importance of this information, on of the tools used by businesses for new product development is Quality Function Deployment (QFD). This tool uses the customer’s needs and “compares the company’s and key competitors’ abilities to satisfy those needs.” One of the key requirements for successful implementation of QFD is good information about customer needs. QFD is one of the tools for companies using concurrent engineering. The concept of concurrent engineering will be discussed in more detail later in this chapter.

4.2.2 Impacts of the Information Superhighway on External Activities

An essential difference exists between internal communication and external communication. A great deal more organizational control exists with internal communication. An organization has control over whether all employees have access to the Internet. In addition, by posting certain internal information only through an intranet, employees are given a very strong incentive to access the system on a very frequent basis. Organizations also may require training and/or only hire those people who have computer expertise. Obviously few of these conditions exist when a transportation agency communicates with the public. The lack of control with the public has significant implications for the use of the Internet with external communications. In general, less control means that different and stronger motivational techniques are needed to encourage the public to access an agency’s website than the techniques needed with employees. In addition, in dealing with the public, other means of communication are needed.

A significant difference also exists between a public agency’s external communications and a business institution's external communications. A business firm can decide to target only certain segments, or niches, with information. A public agency, on the other hand, needs to try to provide information access to the entire public. As with the above difference between internal and external communications, this difference also means that other modes of information, in addition to the Internet, need to be used by a public agency in communicating with the public.

The main types of communication functions between transportation agencies and the public involve a) agencies providing "product/service" information to the public concerning transportation, and b) providing a "customer service" function that allows the public to ask questions, make complaints, and provide input and opinions on transportation issues. Each of these functions are discussed below.

4.2.2.1 Product/Service Distribution

Seattle Metro is an example of using the Information Superhighway to provide relevant, accurate, and timely information to the public through their RiderLink program. This program integrates text and photos, with the potential of video, to create an accessible easy-to-use resource for their customers. RiderLink provides information on fares, schedules, and connections to other systems. Also Seattle Metro is constantly looking for ways to improve products – from computer-optimized rideshare programs that connect commuters with vanpools and carpools, to traffic signal pre-emption systems that aid buses through congested intersections during peak commute times. As another example, Caltrans uses a website to provide information ranging from highway conditions, updates on highway construction, transit information, to the history of transportation in California.

In providing product/service information to the public, the key challenge facing transportation agencies is providing sufficient motivation to those with Internet access to actually access the appropriate websites on an ongoing basis. This is a very daunting task, given the amount of competition on the Web. On the other hand, much of the public is very interested in transportation issues.

In general, motivation can be stimulated both by the type of information provided and the manner in which it is presented. There is a wealth of web-marketing references available, and new publications appear frequently. Some general recommendations appear below:

- The definition of transportation-related information should be a broad-based one. It should be based more on the information of interest to at least some segments of the public than on the specific functions of a transportation agency.
- Given both the wide range of information available to present and the variance in desired information from one segment of the population to other segments, some research would be useful in website design.
- Given that a large amount of information on a variety of topics probably needs to be provided, a site-specific search engine and/or index would be very useful
- Information should be localized, given that the specific information desired often is local in nature
- Links to and from other transportation and government agencies need to be established and maintained
- Information needs to be updated frequently to encourage frequent access.

4.2.2.2 Customer Service

The main purposes of the customer service are to provide accurate and timely information to customers, to solve customer complaints, and to obtain feedback from customers.

Millipore (23) was successful in using the Internet to improve customer service. They have been successful in finding out what customers are saying about their products In one case, a customer was using e-mail to complain that a filter was on back order. The marketing director was able to reach the customer with e-mail and shipped the filter out immediately. The value of solving customer complaints expeditiously is tremendous. Some statistics from a Century 21 training course showed that 50 percent of dissatisfied customers never complain, 45 percent complain to the front-line representative and only five percent complain to management. One upset customer will, on the average, tell at least nine other people and they will each tell five more so that more than 50 people will hear about the problem. Thus it becomes important to find out about upset customers as quickly as possible. Also, customers who have a reason to complain and don't are the least loyal to a company and 90 percent will not return. But 95 percent will do business again if the complaint is resolved on the spot. The value of a loyal customer depends on the business. In the case of an automobile manufacturer, this study stated that the value of a satisfied customer was worth $140,000 over their lifetime.

The importance of customer service should not be underestimated. The 1994 Malcolm Baldrige National Quality Award gives more weight to Customer Focus and Satisfaction than to any other category (300 points out of 1000). The main areas to address in the evaluation are:

- "how the company determines current and near-term requirements and expectations of customers"
- "how the company addresses future requirements and expectations of customers"
- "how the company evaluates and improves its processes for determining customer requirement and expectations"

The Information Superhighway will be an asset to firms obtaining this information, and the importance of this feedback from customers should not be underestimated. At the present time no transportation company has won a Malcolm Baldrige award, but that should not discourage an agency from trying.

Transportation/highway agencies, however, operate as virtual monopolies and do not face market pressures resulting from regular market mechanisms to improve service or to reduce costs (28). They do face periodic pressure from legislative and other oversight bodies to cut costs, as any government agency would. In order for public agencies to move away from cutting costs by simply reducing service, they need regular and competitive forces. Government agencies need to keep searching for new methods which will enable them to lower costs and provide equal or better service to the public.

Since members of the public with complaints often are highly motivated, some of the recommendations cited in the previous section on product/service information are not as relevant here. However, some non-motivational recommendations are presented below:

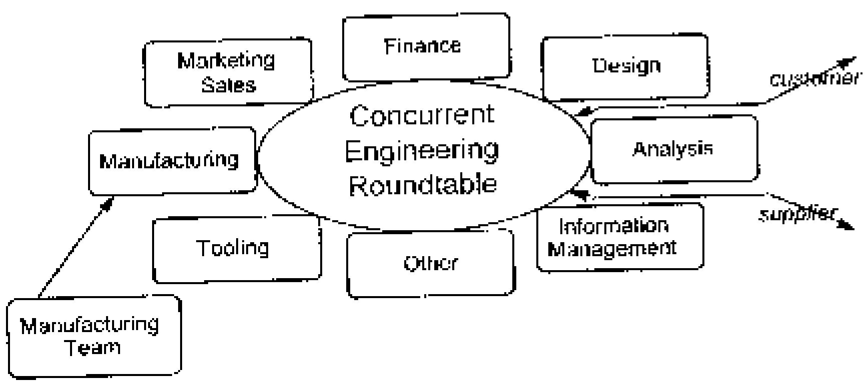
- Particularly for public agencies, which may be perceived as being unresponsive and bureaucratic, it is critical to provide quick responses that, to the extent possible, are constructive and responsive, rather than defensive.
- Public complaints and suggestions, along with agency responses, should be incorporated into a centralized information system. This will help spot more prevalent complaints and perspectives.
- Communication among the public can be encouraged and monitored by helping establish newsgroups and chatrooms.

4.3 Development of New Products with Concurrent Engineering

Historically, some groups with important input to new product planning have not been brought into the planning process until well into the process. In "marketing oriented" organizations, engineering and manufacturing often are not brought into the planning process until after the Research and Development budget has been established and also after product attributes are identifies. Conversely, in a "technically oriented" organization, marketing and sales may not be included until after a prototype of the new product exists. Both of these patterns tend to identify mistakes too late in the process. The solution to this historical process involves incorporating all relevant groups and viewpoints at the very beginning of the new product planning process. This is the basic underlying concurrent engineering.

Concurrent engineering is replacing sequential engineering for new product development and involves all groups (design, manufacturing, marketing/sales, finance, tooling, etc.) in the design and development of products (see Figure 4-1 below). It requires team members from all areas of business to communicate and share information with each other easily. Low-cost computer-aided design and manufacturing software and flexible factories could help companies develop multiple prototypes quickly and competitively without large product development labs. Lockheed-Martin has implemented these concepts in their research and development (R&D) division (23). The R&D scientists are able to use other information sources rather than "reinventing the wheel." In the past, R&D scientists usually relied on their own resources, but now they have achieved significant labor savings by reusing information provided by others.

Figure 4-1: Concurrent Engineering

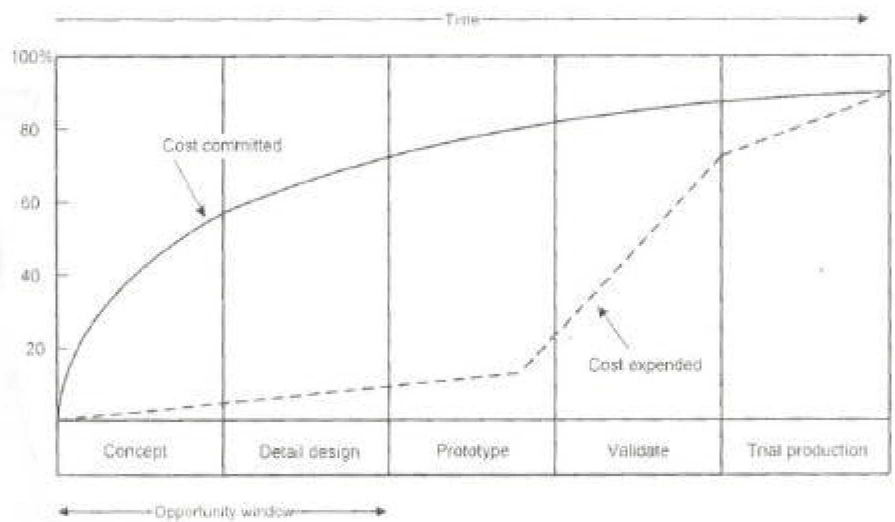


Source: Shunk, Dan L. *Integrated Process Design and Development*. Business One Irwin, Homewood, Il. (1993), p. 45. Used by permission of The McGraw-Hill Companies.

How is the Information Superhighway relevant when implementing concurrent engineering? A roundtable forum, born out of concurrent engineering, can be extremely useful to transportation agencies. (The concept and applicability of a roundtable forum will be referred to several times throughout this report.) This forum often involves people from multiple locations. The coordination and teamwork needed to implement concurrent engineering, particularly in a multiple location environment, is greatly facilitated with the Information Superhighway.

The main benefits of using concurrent planning in new product planning are cost and time savings. The importance of good information early in the design process should not be underestimated. The following graph (Figure 4-2) shows the cost committed and cost expended from product concept to production. During the concept and design stage, about 70 percent of the total costs are committed, but only about five percent of the costs are expended (29). A frequent mistake is spending too little during the early stages of a project and having to make changes later.

Figure 4-2: Committed and Expended Costs



Source: Nicholas J. Aquilano & Richard B. Chase. *Fundamentals of Operations Management*. Richard D. Irwin, Inc. (1995) p. 63. Used by permission of The McGraw-Hill Companies

Other issues to consider are the cost of making a change at various stages in the development process and whether it matters if a change occurs later rather than earlier in the process? In manufacturing, the costs of engineering changes often follow the "law of tens," which assumes that the cost of an engineering change increases by a factor of ten at each succeeding stage in the development process. This law is demonstrated in Table 4-1.

Table 4-1: Costs of Changes

When Change is Made	Cost
Design	$1000
Design Testing	$10,000
Process Planning	$100,000
Test Production	$1,000,000
Final Production	$10,000,000

Source: A Smarter Way to Manufacture. Reprinted from April 30, 1990 issue of *Business* Week by special permission, copyright © 1990 by the McGraw-Hill Companies, Inc.

The general principle of the law of tens can also apply to transportation agencies and transportation projects. A change to a bridge/road/rail project is easier during the design stage than after it has been built and put into use. For example, the Bay Area Rapid Transit (BART) District in the San Francisco area, one of the first modern rapid-rail transit systems, did not design for wheelchair access into their stations. During the construction phase of the project, in response to strong advocacy by a member of the disability community, the BART Board decided to include elevators at each station. Rather than place the elevators where it would be most convenient to users, the elevators had to be inserted into places where they would cause the least amount of disruption to the construction process. Earlier consideration of this issue could have resulted in lower cost and less inconvenience, although BART did become a model for future rapid-rail accessibility design.

The benefits of concurrent engineering are summarized in Table 4-2, below:

Table 4-2: Benefits of Concurrent Engineering

Benefits	Percent Difference
Development Time	30%–70% less
Engineering Changes	65–90 fewer
Time to Market	20–90 less
Overall Quality	200–600 higher
White-Collar Productivity	20–110 higher
Dollar Sales	5–50 higher
Return on Assets	20–120 higher

Source: A Smarter Way to Manufacture. Reprinted from April 30, 1990 issue of *Business Week* by special permission, copyright © 1990 by the McGraw-Hill Companies, Inc.

Given that the highway industry spends a great deal of money on what could be termed now product planning, the use of concurrent engineering should have substantial benefits to transportation agencies. To expand, the highway industry spends about $84 billion a year (28). Almost half of all highway spending falls under the category of construction, reconstruction, and other capital outlays. Large savings in the construction and reconstruction categories can be brought about by promoting concurrent engineering.

A related issue is team-work within improved communication/information exchange. Good team-work with people in other locations will be necessary to make the concept of concurrent engineering work well.

An analysis of Caltrans District 7's expenditures shows (see Table 4-3) that the amounts involved in planning and design are significant by themselves, and improvements in these functions could save large amounts of money.

Table 4-3: Distribution of Expenditures for Caltrans District 7 (1994-1995)

District 7- Los Angeles	Operating Expenditure (in $000)	Percent[1]	Personnel Expenditure (in $000)	Positions
Administration	6,208	7.2	9,980	202
Planning	9,075	10.6	7,220	113
Traffic Operations	6,955	8.1	17,640	315
Maintenance	36,453	42.4	42,590	936
Right of Way	732	0.85	9,730	169
Design/Contract Oversight	20,603	24.0	35,180	562
Construction	85,917	100.0[2]	140,730	2,606

Source: Caltrans District 7,Elaine Hiyashi and Gerson Rapfogel, August 28, 1995
[1] Percent of total operating expenditure
[2] Because of rounding, the figures may not sum to totals

4.4 The Future Workplace

The introduction of new technology has altered the workplace. Through the use of telephones, personal computers, and modems, workers are able to perform a significant amount of work at a location other than the employer site. This work arrangement not only offers benefits to both the employer and employee, but also minimizes work disruption in the aftermath of an emergency situation such as an earthquake. Typical remote workers include anyone who produces information that can be transmitted electronically and/or has a large amount of telephone contact with others, such as customers or suppliers.

4.4.1 Virtual Office

A "virtual office" is the part of a business whose work force includes a large number of remote workers (http://www.globaldialog.com/~morse/arevo.htm). The Internet helped create "virtual companies" in which "no one works in a single location and all workers communicate across the network" (4). Companies can now work on projects continuously and the nine-to-five workday will be less prevalent. Improved information and communication technologies enable companies to efficiently utilize their world-wide staff. For example, a firm with its headquarters in Toronto and most of their world-wide offices in the United Kingdom can start working on the project at 9 a.m. London time (3 a.m. Toronto time). At 7 p.m. London time, the project is handed off to the office in Toronto (1 p.m. Toronto time). The Toronto group continues to work on the project until 7 p.m. (1 a.m. London time). In essence, the firm can keep the project going for sixteen hours a day (http://www.meckler.web.com/mags/iw/v5n5/feat3.4htm).

4.4.2 Benefits of the Remote Employment/Virtual Office

The Remote Employment/Virtual Office (RE/VO) arrangement offers significant advantages to both the employer and the employee, but is often not used due to a lack of information training. Employees do not understand the technology which makes RE/VO possible and the employers are fearful of reduced worker accountability and lower productivity. But these problems can be overcome to make workers accountable, increase productivity, and realize the following benefits for the employer:

- Increased productivity and reduction of turnover due to better morale
- Increased recruiting since geographic limits are eliminated
- Less office space required
- Greater flexibility in choosing the central office, in changing the staff size
- Possible tax incentives.

Benefits to the workers of RE/VO include:

- Greater flexibility in daily schedule
- Flexibility in location for two career couples
- Financial and time savings from reduced commuting
- Financial savings from food costs
- Financial savings in cost of housing
- Increased productivity

4.4.3 Telework

The Loma Prieta earthquake on October 17, 1989 provided an opportunity to telecommute when "highways were structurally impaired, a freeway in Oakland collapsed, and one section of the Bay Bridge collapsed" (30). Even with a breakdown in the transportation system, telecommuting provided the means for uninterrupted work at the California State Public Utilities Commission (PUC) in San Francisco.

The PUC, as part of a 3-year pilot telecommuting project for state employees, had already trained some of their employees to telecommute for one and a half years, starting in mid-1987. Following the earthquake, top managers authorized expansion of their telecommuting program to other workers. Thirty-three post-earthquake telecommuters were added to the program. Table 4-4 shows the distribution of telecommuters within the PUC divisions. Managers were more inclined to allow additional staff to telecommute if they already had people in the program (30). Although all divisions had pilot telecommuters, only division C was active in promoting telecommuting and added the most post-earthquake telecommuters. In some cases, top-management did not allow for either telecommuting or a compressed work week.

Table 4-4: Distribution of Telecommuters within PUC Division

PUC Division	Pilot Telecommuters	Post-Earthquake Telecommuters Added
A	2	0
B	12	1
C	18	32
D	5	0
E	3	0
Total	40	33

Source: Pratt, Joanne H. Travel Behavior Impact of Telecommuting Following the San Francisco Earthquake: A Case Study. In *Transportation Research Record 1305*, TRB, National Research Council, Washington. D.C., 1991, pp. 282-290,

Additional behavioral characteristics of the telecommuters are noteworthy. "Pilot telecommuters increased their telecommuting time only temporarily, if at all, then returned to pre-earthquake schedules when the Bay Bridge reopened" (30). Almost half of the post-earthquake telecommuters continued telecommuting two to six months after the earthquake. Equipment, job-related, and personal circumstances were the primary factors contributing to those who stopped telecommuting.

The 1994 Northridge earthquake is another example which illustrates some of the lifestyle/employment changes that will occur with the Information Superhighway. A surprising consequence of the traffic jams brought on by eight collapsed segments of the freeway system was a headlong rush toward the Information Superhighway. Mayor Richard Riordan announced a grandiose plan to relieve traffic congestion by extensive 'telecommuting.' He also spoke of 'satellite office centers' outside the downtown districts. The Southern California Telecommuting Partnership was organized in the earthquake's aftermath. Its members, a coalition of businessmen and government officials hope to make telecommuting a viable option for the city, bring permanent change to the way its work force is organized. "This will become the country's most advanced telecommuting system ever," said Riordan, a lawyer and former venture capitalist. "People are happier because they don't have to fight the traffic, and they get more work done. When an 800-number line was set up for companies interested in establishing satellite offices, more than 600 firms called in just the first week" (31).

4.5 Making Change Happen

Businesses are faced with the major question of how to organize to facilitate change. A the current time organizations do not appear to have a systematic, integrated approach to change. One of the biggest challenges is to continue running the business while at the same time changing the business.

Organizations do not have a choice as they must figure out how to do both at once. Two key parts to be successful are top management support and employee involvement. KPMG cited a lack of employee involvement as a key problem from their Managing Change survey (http://www.kpmg.ca/change/change.html). Employee involvement in the design phases of the change almost never occurs, and only a modest number are involved during the implementation. But one of the most important elements to any successful change is having employee support and involvement.

Change occurs effectively when top management leads the change while other managers run the business. Top management needs to provide the leadership so that progress is made toward the vision. Management also can ensure that adequate resources and training are provided.

For business to utilize the new technologies, including the Internet, it must be recognized that there is a substantial learning curve involved (23). It quickly becomes apparent that substantial resources for Internet training need to be allocated. The training will run the spectrum from basic awareness training to very technical training. But in organizations where the Internet has become a solution to everyday problems, it is completely integrated into the other systems (23).

It may be concluded that a change towards better utilization of the emerging technologies will require top management to lead the change. At the same time, they must involve employees in planning the change, to allocate sufficient resources for training, and continue to run the current business.

4.5.1 Organizational Changes

Management information systems (MIS) are increasing in importance for all business. Accurate information, obtained in a timely manner, can significantly affect the quality of decisions. Because of the importance of information, private businesses have often placed the chief MIS executive at the highest level of the organization (32) while this is often not the case with public organizations. There are currently significant changes taking place within public organizations due to the Information Superhighway. Having the proper amount of management support is an important part of making any change successful. This support is an important part of making any change successful. This support is easier to obtain if the chief MIS executive or CIO (Chief Information Officer) is at the highest level. Also CEOs (Chief Executive Officers) must understand the importance of information technology (33) and the strategic value of this information for the leadership of the information systems department to be truly effective. But Jeff Moad (34) states that many CEOs still need training in the importance of IS (Information Systems). According to Thomas Lodahl, chairman of CogniTech Services, only about 30 percent of top IT (Information Technology) managers are included in high-level strategic planning (34). Without a close working relationship between the CEO and the CIO, it will be difficult for an organization to maximize their return on this new technology (35).

Boyle (36) provided a list of some of the implications for CEOs, CIOs, and senior line managers of promoting the use of these new information systems. These suggestions are summarized below:

Implications for CEOs:

- Understand the strategic value of information technology
- Include the CIO in the strategic planning process.

Implications for CIOs:

- Speak the language of the organization
- Report to an executive who understands and supports the Information Systems function (ideally the CEO, but this depends on the CEO)
- Focus on conferring competitive advantage
- Create a technology platform and standards that will provide long-term flexibility and competitive advantage
- Actively participate in strategic planning.

Implications for Senior Line Managers:

- Consider the function's technology needs
- Be proactive in seeking out technology solutions
- Coordinate the centralized support of decentralized IS and the establishment of standards.

4.5.2 Interoperability

One other important consideration for management is the issue of interoperability. Interoperability is the ability of two or more systems (computers, communications devices, data bases, networks or other information technologies) to interact with one another and exchange data according to a prescribed method in order to achieve predictable results" (http://nii.nist.gov/optimum/html).

Interoperability allows different vendors' systems to communicate with each without user involvement. Everyone will agree that interoperability is an important goal for any business and is increasing in importance with the development of the Information Superhighway. But, there is no consensus at the present time on how to achieve interoperability and even in full interoperability is desirable. Some people are concerned about "reducing consumer choice or removing incentives for innovation and competition" (http://nii.nist.gov/optimum html*)*. Others argue that full interoperability is the only way to proceed.

Economically, one has to decide how to minimize chaos and inefficiency when having multiple vendor systems and still encourage innovation. Neither zero nor 100 percent interoperability seems to be the optimal solution, but it is not clear what is the best strategy. It is generally accepted that the benefits of interoperability increase until an optimal level is reached and after that optimal level the benefits decrease. But no one yet has figured out what that optimal level is and how to obtain it. It is also not clear what the management structure should be to support interoperability, but it is clear that is an issue that needs to be addressed. Transportation agencies need to strive for a high degree of interoperability and have the management structure in place to support that level.

4.6 Summary of Conclusions

A summary of the major conclusions reached in this chapter follows.

1. Transportation agencies are very similar to all business organizations. Thus the advantages of the Information Superhighway for businesses will also apply to transportation agencies.

2. The traditional marketing function was not readily apparent for most of the transportation agencies analyzed. Most public agencies do have an identified function of public information, but this is very often based primarily on disseminating information on the agency's own activities. It should be noted that the emergence of the Information Superhighway will provide the opportunity but also a need to increase activity in this area and especially in overall public relations and marketing.

3. The concept of a roundtable forum, born out of concurrent engineering, can be extremely useful as transportation agencies learn to take advantage of the Information Superhighway.

4. Improved communication/information technologies have great potential to transform the future workplace. Workers can conduct their work outside the normal workplace and at hours outside traditional working hours.

5. A difficult process for any firm is how to manage and facilitate change and the Information Superhighway will be a major change in the organization. Top management commitment is essential to lead, but employees also need to be actively involved throughout the planning process.

6. The CIO needs to be places at the highest level in the organization and needs to be included in the strategic planning for the agency.

7. Interoperability is an important issue that needs to be addressed by transportation agencies, but there is not a clear solution at the present time.

4.7 Recommendations

The following major actions are recommended for transportation agencies:

1. Training regarding the benefits and use of the Information Superhighway and should be conducted for upper management are down to worker level.

2. Conduct training throughout the organization on implementing change. It is recommended that Caltrans set up a review committee designated to study the implementation of these recommendations. The committee should have representatives from all levels of the organization, all functions, and also draw from other organizations which are stakeholders.

3. Have the CIO (or equivalent) report to the CEO or top person in the organization.

4. Conduct training throughout the organization to work in teams, which could include people in locations outside the office.

5. Promote the use of concurrent engineering concepts throughout the organization.

6. Develop a stronger customer marketing focus for the limited public information functions that are currently found in public transportation agencies. The Information Superhighway can be a very useful tool to implement these activities.

7. Study interoperability and recommend the appropriate actions to be taken for the organization.

5. TRANSPORATION/ COMMUNICATIONS RELATED SOCIETAL CHANGES

Having discussed the technological aspects of the emerging Information Superhighway in chapter 3 and business organizational structure and opportunities in Chapter 4, this report now moves to address the lifestyle changes resulting from emerging technologies and the subsequent impacts they will have on tripmaking. Lifestyle is a pattern that is related to the individual's attitude, values, and behavior. It is defined by how individuals and households allocate time to activities such as work, in home time, and reaction (37). During the past decade, the use of a computer network to communicate and to retrieve information has grown immensely. "The new technology holds the potential to change human settlement patterns, change the way people interact with each other, change our ideas of what it means to be human" (38). Rapid technological development has allowed many business transactions to take place over communication lines and thus making distance irrelevant. While companies will no longer need to be based in city centers, employees will no longer need to commute to these urban city offices. As a result, work and lifestyle patterns will change.

The overall goal of this chapter is to explore the various societal changes which have resulted from improved information and communication technologies, and have an impact on transportation, the impact that these changes will have on transportation and the opportunities offered by these technologies. The following topics will specifically be addressed:

- Increase in working at home
- Increase of entertainment, information, and services provided to the home
- Formation of communities and isolation from society
- Impacts of telecommuting on transportation
- Additional impacts of telecommuting
- Possible additional transportation impacts
- Some possible future societal changes and transportation related impacts
- Ethical issues resulting from emerging technologies.

A summary of major conclusions and recommendations for the chapter then follows.

5.1 Increase in at Home

The 1990 Census reported that 3.25 percent of California workers age 16 years and older work at home. In the Bay Area, 3.4 percent of the workers work from their homes, a 79 percent increase from 1980. This number is expected to continue to increase as emerging technologies make working at home more possible and convenient. In 1992, approximately 2 million workers practiced telecommuting; this number is likely to reach 7.5 to 15 million by 2002 (39). The phenomenon of telecommuting as a form working at home and thus substituting for the commute trip to and from work has been gaining popularity in the corporate world recently.

The term "telecommuting" was coined by Jack Nilles in the 1970s to characterize the use of telecommunications to access information resources and interact with co-workers and others, thus substituting trips to and from work (40). Today's advanced telecommunication technologies make telecommuting a "natural substitute for transportation." For example, telephone calls and teleconferencing can replace travel to meetings while file transfer protocol (FTP) and electronic transmission of files substitute for postal delivery. Employees equipped with a supportive supervisor, computer, modem, and phone line can work virtually anywhere by remote access. Telecommuting is one method in which employers can reduce the number of employees commuting. By telecommuting, the employee avoids daily traffic, costs, and stress of traveling to a central work site, and is able to get more work done. Also, it was noted in Chapter 4 that disruptions after emergency situations may be minimized with telecommuting.

Telecommuting can be classified into two basic types of remote work: home-based and center-based (41). In the “classical” form of home-based telecommuting, a salaried employee works at home instead of at a central office. Center-based telecommuters travel to a facility (single employer or multiple employers) where they share equipment at the site with other users. These telecenters can be set up in residential areas such that workers only travel short distances to a remote work center. In 1960, only nine million workers in the U.S. has jobs which were located outside their county of residence, but in 1990, that number grew to 27.5 million, a 206 percent increase over the thirty-year period (42).

The goal of telecommuting is to reduce or eliminate trips made to and from work, thus resulting in a more efficient, clean, and safe commute for the remaining vehicles on the road. In a heavily congested area such as Los Angeles during the 1984 Olympic Games, small reduction of seven percent in traffic made a significant difference; congestions decreased by 60 percent (40).

According to a telephone survey by LINK resources (43), as of early 1993, telecommuting accounted for 7.6 million U.S. workers, up 15 percent from 6.6 million in 1992. This includes people with company or government jobs who work full or part-time at home during the day. The increasing number of people telecommuting is likely to “accelerate with the arrival of newer, more user-friendly technology designed specifically for mobile employees” (44). Overall, telecommuters probably make up less than five percent of the U.S. workforce, leaving an enormous population untapped (40).

Travel by workers on days they telecommute, however, is not entirely eliminated but is reduced by 75 percent, indicating that the time saved is not used to make additional trips (40). A 100 percent reduction cannot be expected since commuting accounts for only 22.7 percent of total travel (45). Telecommuters tend to avoid making trips in the morning and late afternoon during rush hours, but rather make trips which are close to home. As a result, people will devote less time and cost to transportation.

It is, however, difficult to accurately predict the reduction of travel resulting from telecommuting since trips not made are not directly observable. According to Gary Ritter and Stan Thompson (40), the typical practice of telecommuting is just one or two days a week, which affects only 20-to-40 percent of the weekly worktrips. Thus, telecommuting will displace only as much as two percent of the total vehicle miles of travel over the next decade. The U.S. Department of Transportation recently calculated that over the next ten years, a reduction in commuting travel of 2.3 to 4.5 percent is expected, and a reduction in vehicle miles traveled of 0.7 to 1.4 percent is projected (43). One reason for such low figures is that the space a telecommuter leaves could be filled by someone else who usually car pools or uses transit, after observing that traffic is less congested.

The practice of telecommuting has grown steadily in the past couple of years. Some experts estimate that currently 4.5 percent or 300.000 Bay Area workers and 8.1 million people nationwide telecommute up to three days a week (46). Susan Handy and Patricia L. Mohktarian reported in “Technical Memo 1: Current Levels of Telecommuting in California” that in 1993, 1.4 percent of California workers were likely to telecommute on a given weekday. Results from telecommuting pilot programs indicate that the average telecommuting frequency is 1.2 days per week (or 24 percent). This is a significant number, given that by comparison, 5.8 percent of workers in the State telecommute at some time (47). Statistics from the 1990census showed that only 4.1 percent of California workers use public transportation.

The Association for Commuter transportation, AT&T, the U.S. Department of Commerce, the U.S.

Environmental Protection Agency, and the U.S. general Services Administration sponsored a week-long telecommuting program during the week of October 22-27, 1995. This was part of a nationwide effort to promote the benefits of telecommuting and nontraditional work environments to corporations, small businesses, and individuals.

The major force opposing the shift toward telecommuting is society's "basic resistance to change" and the casting-off of traditional command and control management methods from the industrial age (40). Some resist spending too much time away from the office, fearing the old staying "out of sight, out of mind." Other people are hesitant to telecommute because of a lack of information on the latest technologies. In a national poll conducted by CDB Research & Consulting, Inc. (48), 38 percent were afraid they would not "have access to the information and records" needed. Workers generally appear to not be aware of the capabilities of Integrated Services Digital Network (ISDN) which can give telecommuters equal access to corporate documents and data.

Telecommuting, moreover, is not for everyone. Although some people have experienced an increase in work satisfaction and productivity, some are also feeling more stressed. Telecommuters sometimes have a difficult time balancing their time between work and their personal life. Also, people who thrive on the social contact of the office or whose social life revolves primarily around their co-workers should continue working at the office. In a one-year study in Washington's Puget Sound region (49), one-third of the 280 participants stopped working at home; eight percent said that they simply didn't like it. They can no longer turn to their co-workers to exchange ideas or talk over problems. "Telecommuters may feel left out of the loop on official company business – or office gossip" (50).

One issue which is often overlooked by people who work at home is that their homeowner's insurance policy does not usually cover a home office (51). Most homeowner policies do not cover business losses in the home or liability for accidents happening to business customers visiting the home. It is advised, however, that people who work from their homes full-time should buy separate policies for their businesses. A business policy will "cover inventory, accounts receivable, professional liability of loss of income because of a business disruption, and it is generally less restrictive about the types of claims covered" (51). It should also be noted that working at home may involve additional issues such as monitoring safety issues in the home office or accounting for overtime hours of a normal work schedule.

Before embarking on a telecommuting program, it is necessary to conduct training workshops to educate both the supervisor and prospective telecommuters of the possible forms of telecommuting and of the potential impacts resulting from telecommuting. The supervisor may decide whether the employee's work is suitable for telecommuting or if the arrangement is a feasible one, especially if equipment such as computers and printers need to be purchased. The workshop will also give employees a chance to decide whether telecommuting can work for them.

5.2 More Entertainment, Information and Services at Home

5.2.1 How Much?

It should be noted, however, that people's use of time is not always determined on a rational basis. On average, Americans have about five hours more free time per week today than they did 30 years ago (52). People are busy because they want to be and make themselves feel more important when they fill up their schedules. According to a 1990-92 survey by Leisure Trends (53), Americans have about 41 hours of leisure time a week. But one-third of free time during the week and one-fourth on weekends is spent in front of the television. Table 5-1 shows the results from the Americans' Use of Time Project conducted in 1985, which seem to verify this (52). According to this study, Americans spend more than fifteen hours of their leisure time watching television. More recent data (1994-95 survey) will not be available until some time in 1997.

Table 5-1: Time Use Data [a] (Americans' Use of Time Project)

[a] **Hours per week men and women aged 18 to 64 spent on various leisure time activities, as recorded in time diaries**

Activity	1975	1985	Percent change
Television	15.2	15.1	-.7%
Visiting	5.5	4.9	-10.9
Reading	3.1	2.8	-9.7
Traveling	2.6	3.1	+19.2
Talking	2.2	4.3	+95.5
Hobbies	2.3	2.2	-4.3
Adult Education	1.6	1.9	+18.8
Cultural Events	.5	.8	+60.0
Clubs/Organizations	1.2	.7	-41.7
Activity	**1975**	**1985**	**Percent change**
Religion	1.0	.8	-20.0
Sports/outdoors	1.5	2.2	+46.7
Radio/recording	.5	.3	-40.0
Thinking/relaxing and Listening	1.1	1.0	-9.7
Total	**38.3**	**40.1**	**+4.7**

Source: Trends: Trends in Media Usage by William G. Mayer in *Public Opinion Quarterly* (Vol. 57, no. 4. 1993. Used by permission of he University of Chicago Press and by the American Association for Public Opinion Research.

5.2.2 Internet Access and Usage

Both the amount of time spent on leisure activities and the specific leisure activities are likely to change as the possibility of having many television channels, video-on-demand, interactive television, and other forms of electronics-based entertainment become available. According to a survey by Nielsen Media, Americans and Canadians spend the same amount of time on the Internet as they do watching rented videos. Users are on the Internet for an average of 5 hours and 28 minutes per week. The percentage of persons age 16 years and older in the U.S. and Canada using the Internet for various applications are summarized in Table 5-2. Although most people primarily think of the Internet as a means to send e-mail, the frequency of accessing the WWW exceeded e-mail use in this survey. The survey sampled 3,000 randomly selected individuals which represented the populations of the United States and Canada.

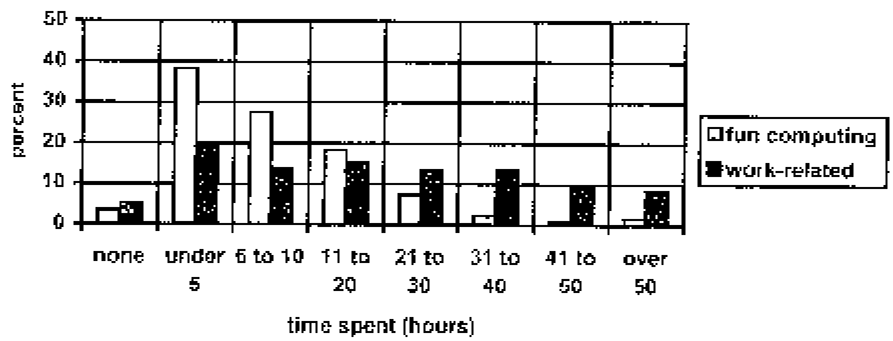
Table 5-2: Applications Used on the Internet in the Past 24 Hours

Application	Percentage of persons
Access the WWW	72%
Send e-mail	65%
Download software	31%
Participate in an interactive discussion	21%
Partake in a non-interactive discussion	36%
Use another computer	31%
Utilize real-time audio or video	19%

Source: CommerceNet and Nielsen Media Research
http://www.nielsen.com/media/press/connect.html

In another survey conducted on the Internet, it was reported that 18.5 percent of the respondents spent over 41 work-related hours per week on the computer, while only 2.6 percent spent over 41 hours per week doing fun computing. Figure 5-1, shows that nearly 85 percent of the users spend 20 hours or less a week on the computer doing fun computing; twenty hours per week is approximately half of their leisure time. According to a recent study by Coopers & Lybrand Consulting, more than half (58 percent) of the Internet users are spending time on-line they normally would have spent watching television.

Figure 5-1: Time Spent on the Computer



Source: GVU's Fifth WWW User Survey
<URL: http://www.cc.gatech.edu/gvu/user_surveys>

5.3 Formation of Communities and Isolation from Society

5.1.1 Virtual Communities

"As a general rule, people tend to form groups, clustering themselves around common concerns, interests, or purposes" (9). The computer has become a medium for making new friends and enlarging one's social circle. With the potential for anonymity and the irrelevance of distance, the anxiety of social contact is lessened when people are on-line. "An estimated 80 percent of all users are looking for contact, and commonality, companionship and community" (54). Mailing lists, Usenet, localized conferencing systems, and bulletin boards have provided a place for the growth of groups around every imaginable topic (9). Thus "virtual communities" are formed. People who belong to these virtual communities may or may not meet one another face-to-face, but do exchange words and ideas through the mediation of computer bulletin boards and networks (55).

Since users cannot see the person on the other end, they are unable to form prejudices before they read their message (55). An individual's characteristics, such as race, gender, age, national origin, and physical appearance, are not apparent in cyberspace. People with physical disabilities, who may find it difficult to form new friendships, discover that in virtual communities, they are treated as "they always wanted to treated – as thinkers and transmitters of ideas and feeling beings" (55).

5.3.2 Educational Use

The Dalton School, a private academy in New York City, is taking advantage of the latest technology (56). For example, sixth-grade social studies students use a computer simulation of an archeological dig – shoveling sounds and all – based on an actual site. In this course, the "kids learn by doing – absorbing science and ancient history through acts of discovery." Students are also taking part in the school's own e-mail and bulletin-board system, chatting with friends or joining on-line discussions. One of the most popular offshoots is a senior-class seminar in civil rights. Interested students who are not in the class can also participate in the discussion groups. "The exchange, moderated by the teacher, is both analytical and heated, especially on divisive topics like affirmative action." This new technology is changing the traditional roles of the teacher as a lecturer to more as a resource and guide to the students (56).

5.3.3 Seniors On-Line

Millions of older and retired people are connecting onto the Internet. Because they have more leisure time and discretionary income than many youths, they are using their new computing power to perform tasks such as monitoring their investment, tracking genealogy and producing their memoirs (57). By learning how to use computers and connecting on-line, some seniors feel more connected with the rest of the society and do not feel left behind by technological improvements. “I feel like I’m with it. I’m connecting with the present and the future,” says a 68-year-old social worker from Newton, Massachusetts. Besides communicating with one another and sharing memories, seniors are also connecting with school children. On SeniorNet, several programs link schoolchildren with seniors (57).

5.3.4 Isolation from Society

The Internet offers people the choice of anonymity. In cyberspace, people can disguise or distort their true identity and personality. “Most users are more likely to project aspects of the person they wish they could be” (54). With a sense of distance, people are able to become more trusting and vulnerable. But over time, the distance can become an obstacle to “deepening the bonds of friendship, romance, and community.” There is a fear that the networks we build today will destroy intimacy, “both making solitude impossible and by making physical presence immaterial to communication” (38).

5.4 Impacts of Telecommuting on Transportation

5.4.1 Movement to the Suburbs and Further

As more business is conducted electronically, geography becomes irrelevant for many industries (58). Improved information and communication technologies will allow us “to telecommute, live anywhere, and work more productively at home” (58).

One life-style change likely to occur with new communication technologies is the shift of housing away from the city. “The American dream is to live in a suburban single-family house on a half-acre lot with a three-car garage” (37). In a 1992 land use and travel behavior survey of five Bay Area neighborhoods (59),“housing cost,” “quiet neighborhood,” and “safety and security” were marked most frequently as the most important reasons why the sampled households chose their current homes. The primary deciding factor for residential location was whether it was affordable (“housing cost”), followed by its living quality (“quiet neighborhood” and “safety and security”), and how accessible it was (“close to transit,” “close to work,” and “close to shops and services”).

For some, however, movement to the suburbs is not far enough. Today, telecommuters move to remote towns such as Telluride, Colorado; Bend, Oregon; Coeur d’Alene, Idaho; and Jackson Hole, Wyoming, where they hop on an airplane to get to their meetings (60). A Telluride telecommuter has the opportunity of going snowboarding when she feels the urge, while maintaining her position as an environmental engineer for a consulting firm in Virginia. She is not alone. Other residents of Telluride include a software consultant for a Silicon Valley company; an analyst for Manhattan-based J.S. Childs; and a money manager for bicoastal clients (60). More individuals are likely to join these telecommuters in the near future as this may be representative of the trend taking place. According to the Census Bureau, the population of telluride was 1309, as of April 1, 1990. In 1995, the population of the town grew to 1500 (60), almost a 15 percent increase. And of the 1500 residents, about one-third have Internet access (60) compared to only 4.1 percent of the households nationwide with access.

When people start telecommuting a few days during the work week and work in their homes instead of traveling to a central work station, they will be more inclined to travel further to the office on the few days they commute and live in a larger house. A small portion of the telecommuters in San Diego considered moving “two and three times farther away from the workplace than were their current residential locations” (61). Six percent of the telecommuters in California’s two-year pilot program, since beginning to telecommute, said they had either moved or were considering moving 45 miles or more farther work (61).

According to an analysis, conducted by Nilles (62), of data collected for the California State Employee Telecommuting Pilot Project, the residential relocation patterns of telecommuters were not significantly different from the control group. The analysis was conducted for a period of only two years. Further scrutiny of the data revealed that the availability of telecommuting does play a role in their decision to relocate and could allow them to actually move beyond the suburbs to a different town. It should be noted, however, that without the impetus of telecommuting, people have been moving out of urban core areas.

Data, presented in Table 5-4, shows that there has been a steady decline in the proportion of workers living in central counties while the percentage of workers living in the suburban counties shows a gradual increase. “Suburban counties continue to make rapid gains as both a work location and a residence location” (42).

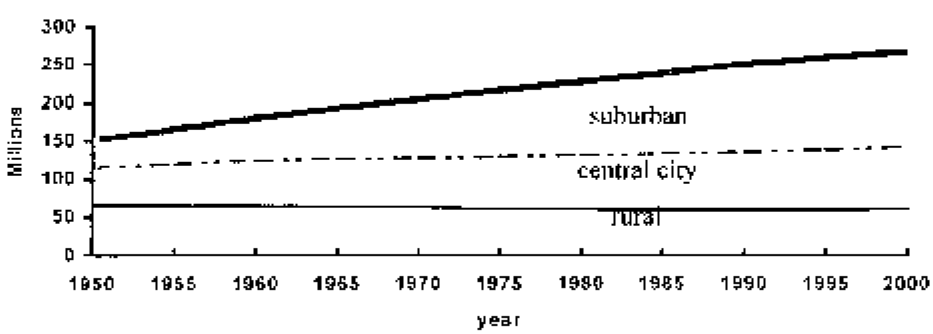
Table 5-3: Workers by County of Residence, Large Metropolitan Areas, 1960 – 1990

Year	Areawide Population	Central County	Percent	Suburban County	Percent
1960	29,033,438	15,444,704	53.2	13,588,734	46.8
1970	37,416,482	18,310,716	48.9	19,105,766	51.1
1980	46,444,001	21,016,490	45.3	24,760,108	54.7
1990	56,456,047	24,180,355	42.8	32,275,692	57.2

source: Rossetti, Michael A. and Barbara S. Eversole.. *Journey-To-Work Trends in the United States and its Major Metropolitan Areas, 1960-1990.* Publication No. FHWA-PL-94-012. FHWA, U.S. Department of Transportation, November 1993.

In 1950, forty-four percent of the total national population of 151 million lived in a rural or non-metropolitan area while the remaining 56 percent lived in a metropolitan area (63). The metropolitan population reached 77 percent of the total national population by 1987 as the non-metropolitan population decreased to only 23 percent of the population. Some of the “decline” in rural population shown in Figure 5-2 can be attributed to the expansion of suburban developments into previously rural areas. As a result, some of the rural population is often shifted to the metropolitan category (63).

Figure 5-2: Trends in Rural, Central City, and Suburban Population, 1950-2000

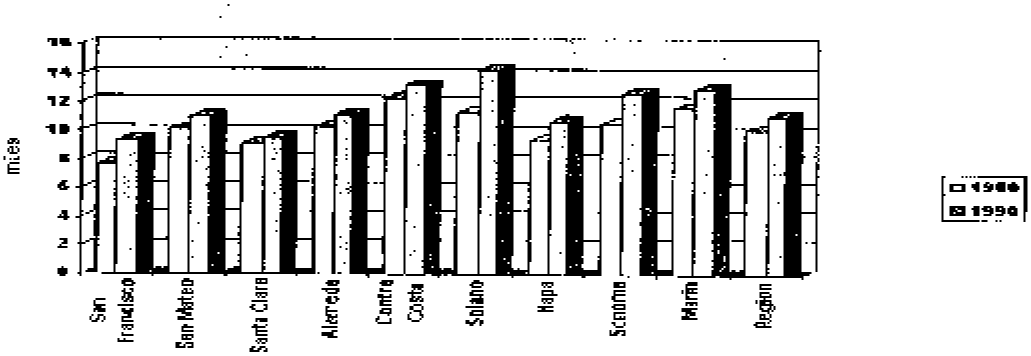


Source: Institute of Transportation Engineers. *Transportation Planning Handbook*. Prentice-Hall. New Jersey, p.75. Used by permission of Simon & Schuster Company.

5.4.2 How Far?

A perspective on the difference between the commuting distances of telecommuters and other commuters can be gained by examining data collected in the San Francisco Bay Area. As shown in Figure 5-3, the average commute length increased for all nine counties during the period from 1980 through 1990. The average commute distances exclude workers working-at-home. Generally, workers who live in the suburbs of the Bay Area have the longest commute distances (64). Residents of eastern Contra Costa County (Antioch/Pittsburg) averaged the longest commute distance in 1990 (19.1 miles) while resident workers of greater downtown San Francisco averaged the shortest commute distance (4.5 miles) in the same period. The Metropolitan Transportation Commission (MTC) calculated an eight percent increase in the average commute trip length from 10.2 miles in 1980 to 11.0 miles in 1990 for the Bay Area region (64). The fastest growing portion of commuters was those whose jobs were located outside their county of residence.

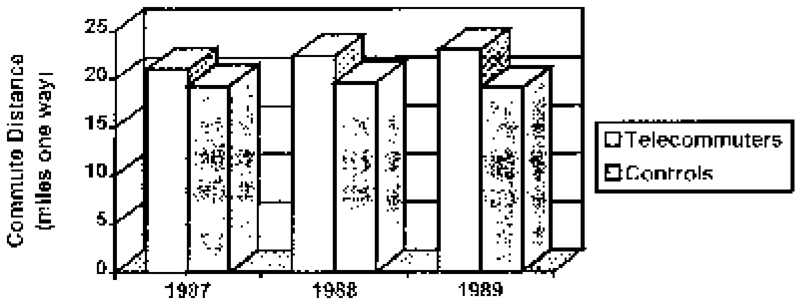
Figure 5-3: Mean Commute Distance for Drive-Alone Commuting, 1980-1990



Source: Purvis, Charles L. *Detailed Commute Characteristics in the San Francisco Bay Area,* Working Paper #7. Metropolitan Transportation Commission. Oakland, California, March 1994.

The change in mean commute distance traveled by the telecommuters and the control group during California's State Employee Telecommute Pilot Project is shown in Figure 5-4. It can be seen that the telecommuting group, although already living farther than the control group, moved even farther from the work place in the years subsequent to the start of telecommuting.

Figure 5-4: Commute Distance Traveled for California's Telecommuting Project



Source: Nilles, Jack M. Telecommuting and Urban Sprawl: Mitigator or Inciter? *Transportation*. Vol. 18, No. 4, 1991, pp. 416. Used with kind permission from Kluwer Academic Publishers (The Netherlands) and Jack M. Nilles.

5.4.3 Change of Travel Characteristics

The telecenter offers an alternative to sitting in peak hour traffic and has the potential of reducing peak hour traffic congestion. One telework employee in Mililani, Hawaii, works at a telecenter five days a week (65). However, one day out of the week, she begins her day by driving to the telework center 7:30 a.m., then drives to the downtown office around 9 a.m., when the traffic has diminished. At 2 p.m., she leaves the downtown office for the telework center, ending her day there. By adhering to this schedule, she avoids peak hour traffic and shortens her travel and work day by over two and a half hours. Peak period travel by telecommuters is not eliminated altogether. However, an analysis of the travel characteristics of the telecommuters in California's pilot project showed that peak period trips were reduced by 60 percent (66).

This flexible schedule could be expected to induce non-work travel, thereby increasing vehicle-miles traveled (VMT). Experimental evidence has not shown an increase in non-work travel but rather a decrease in vehicle distance traveled and peak-period trips as well as fuel consumption and emissions (61). Not only did the total distance traveled decrease by 75 percent on telecommuting days in California's pilot project, but freeway miles were reduced by 90 percent (66). Approximately ten percent of the average 6.8 miles telecommuting-day trip is spent on the freeway (0.68 miles) while 50 percent of the average 14 mile commuting-day trip is spent on the freeway (7 miles). Although it can be seen that there was no increase in surface-street travel (6.12 miles on telecommuting days vs. 7 miles on commute days), the number of shorter trips originating from the home increased on telecommuting days. This may imply that there is a higher concentration of surface-street travel around residential locations (66).

5.4.4 Mileage Saved

By having an office set up in their own homes, workers can perform tasks without leaving their homes each morning and traveling back home each evening. Impacts of telecommuting presented in "Technical Memo 2: Estimates of Current Levels of Telecommuting in California" by Patricia L. Mokhtarian estimated total travel savings of 26.3 vehicle miles per telecommuting occasion or 4,858,000 vehicle miles per day state-wide (47). Under the assumption that the number of work days per year is 250, this represents 0.51 percent of the state-wide total of 239 billion vehicle-miles traveled per year. In March 1990, President George Bush stated, "if only five percent of the commuters in Los Angeles telecommuted one day each week, they'd save 205 million miles of travel each year" (65). Studies done in California and Washington State showed that telecommuting households reduced commuting and had fewer household trips overall than those from non-telecommuting households (67).

Commute savings calculated from telecommuting studies may not be a true representation of future savings since the participants in the programs, on average, had a commute length that was 1.87 times longer compared to their region's average (45).

It is difficult to predict the impacts of telecommuting on transportation because there are many factors involved. For example, how telecommuting is perceived by the public and whether the employer considers the implementation of a telecommuting program feasible will affect the number of telecommuters. However, reduction in highway congestion, time lost, accidents, and fuel consumption are possible. Some predictions of the effects of telecommuting are shown in Table 5-4 (39).

5.5 Additional Impacts of Telecommuting

Table 5-4: Transportation Impacts from Telecommuting

Transportation Impacts	1992	1997	2002
VMT Saved (billions)	3.7	10.0-12.9	17.6-35.1
% of total Passenger VMT	0.23%	0.49-0.63%	0.7-1.4%
% of commuting VMT	0.7%	1.6-2.0%	2.3-4.5%
Annual Hours Saved for Average Telecommuter	77	93	110.3
Total Annual Hours Saved (millions)	156	444-577	826-1,652

Source: *Transportation Implications of Telecommuting*, Report PB93-201119. U.S. Department of Transportation, April 1993.

5.5.1 Environmental Impacts

Transportation's use of energy generates most of the air pollution in urban areas and accounts for approximately one quarter of all energy used today (68). The desire for mobility has resulted in a dependence on imported petroleum; 11 million barrels of petroleum products burn each day for transportation activities in the United States. The production, handling, and combustion of such enormous quantities of fuel create serious unintended and undesirable consequences (68). These energy problems include air pollution from fuel combustion, greenhouse gas emissions, and energy sustainability. This appetite for oil created the challenge of finding energy sources to meet future demands, while also protecting the global environment.

Public transportation has long been seen as a solution to the oil dependence, environmental, and congestion problems. Advocates believe that diverting commuters from autos to transit will reduce auto emissions and the number of people on the highways and thus improve air quality and mitigate congestion. Telecommuting, viewed by some as a travel demand management tool, can possibly aid in pursuit of a solution to the energy problems.

It was estimated that an average of 1.3 gallons of gasoline and 581.2 grams of CO (carbon monoxide), 62.0 grams of NOx (nitrogen oxides), and 70.2 grams of TOG (Total Organic Gas) emissions are saved per telecommuting occasion. A minimum of 118,800 gallons of gasoline with a maximum of 580,00 gallons are saved each day; the savings per day equals 0.48 percent of state-wide total of 12.5 billion gallons (47). However, since telecommuters represent only a small portion of the total workers, the effect it has on the total VMT, amount of energy saved, and air pollutants emitted is limited, but helpful.

5.5.2 Increased productivity and cost savings

Studies have shown that employees increased their productivity by 15 to 25 percent due to telecommuting (46). The increase can be attributed to enhanced job satisfaction and a reduction of commute travel time. The Association of Bay Area Governments (ABAG) documented the productivity increase experienced by several corporations, which is summarized in Table 5-5.

Table 5-5: Productivity Increase due to Telecommuting

Organization	Percentage of Productivity Increase[1]
Amex Life Assurance	20%
State of California	10 to 30%
Blue Cross/Blue Shield	20%
Traveler's Insurance	20%
Smart Valley Inc.	18 to 23%
3 Com	
Cisco Systems	
Deloitte & Touche	
Gray Cary Ware Freidenrich	
Hewlett Packard	
Pacific Bell	
Regis McKenna	
Silicon Graphics	
IBM	15%
Information Access	20 to 25%
Mountain Bell	30%

[1] Percentages are rough estimates of productivity increases.
Source: "Productivity Documentation." Association of Bay Area Governments.
http://www.abag.ca.gov/telecomm/producti.html

Companies with a telecommuting program are also able to reduce their costs in buying office equipment and renting real estate. FindSVP Inc., a market research company based in New York, estimates an investment of $5,500 for a start-up home-office while the traditional work station can cost between $12,000 to $15,000 (46). Last year, IBM converted most of its U.S. marketing and services workers to "mobile" status and reported a cost savings of $35 million of 40-60 percent reduction in real estate costs (55). Ernst & Young experienced similar savings after practicing the concept of "hoteling," whereby employees reserve office space when they need it. Hoteling has cut the firm's need for office space by 30 percent and saved them $30 million a year in real estate costs (69).

5.5.3 Opportunities for Activities

The results from a U.S. News/*CNN* poll (70) of 820 adults, show that of the nine percent of Americans who have telecommuted (defined as working from home by computer), more than four-fifths said that being available to their family was an important advantage of telecommuting, while more than three-quarters said having a flexible schedule was an advantage. Six of the telecommuting advantages most commonly considered by Americans are shown in Table 5-6.

Table 5-6: Telecommuting Advantages Americans Consider

Advantage	Percent

Available to family	82%
More flexible hours	76%
No commute	59%
Don't have to dress up	42%
Fewer distractions from co-workers	43%
Available for service people and deliveries	39%

Source: Computer Homework, *U.S. News & World Report*, November 27, 1995, p. 25. Used by permission of *U.S. News and World Report* and CNN.

Many people are able to take advantage of the flexible schedule which telecommuting offers. The time normally taken up by commuting and other activities, which is saved by using the Internet, can be used to accomplish other activities such as grocery shopping, laundry, housework, or yard work. People who work odd hours are better able to juggle their schedule to manage daily work and family commitments (40). This flexibility also gives "housebound workers or those who are transportation-disadvantaged due to physical disabilities" the opportunity to work (40). Employees who are on maternity leave, ill, or injured can continue to work at home as well.

Telecommuting can become an alternative to using transit for people living in rural areas. Rather than planning their time around the usually-very-limited bus schedule, they can avoid the transit system altogether by telecommuting from their own homes. Telecenters present workers with another solution to traffic congestion.

5.6 Possible Additional Transportation Impacts

Improved communication technologies may have two different results upon life-styles as it affects transportation. Some people are more likely to remain at home given the opportunity to watch a television program or a program presented through another medium at any time or interact with others electronically. On the other hand, others may increase their trip-making as they become aware of events taking place in their area.

5.6.1 Trip Stimulation

People will want to physically participate in events publicized through the various improved communication channels, thereby generating additional trips Transportation systems are expected to work more efficiently as a result of improved communication and information technologies, making traveling on the roads a more attractive option.

Also, the space that telecommuters "free up" on the road may be taken up by someone who normally used transit or carpooled to and from work. This concept is known as "latent demand" (67). After noticing that the traffic is less congested, others will choose to drive themselves.

In addition, recent advances in transportation and communication technologies and globalization of the economy may bring a resurgence of jobs to the major cities and metropolitan areas. "The acceleration of commerce tends to generate customized, single-purpose trips that leave immediately and go by the fastest means" (67). The single-occupancy vehicles and small trucks which are usually used will generate trips. Services such as home-delivery of fast food and overnight package delivery will also produce traffic on the roads as they are meeting people's needs. New relationships will be developed which will result in an increased number of transactions and interactions. "Even if 90 percent of the new interactions are done electronically, the remaining ten percent involving personal visits or movement of physical matter via package shipment represents a net increase in travel" (67).

Although people will reduce the total number of trips made as a result of home shopping via cable TV and/or the Internet, the overall trips reduced may be minimal. This is primarily due to the increase in trips needed to deliver the products and services ordered. Carriers such as Federal Express, DHL, and United Parcel Service will play a large role in the success of home shopping as consumers will expect delivery within hours of purchasing the goods (71). This added characteristic will make living in the rural areas more attractive and convenient for residents as they will not need to make a long drive into town to purchase goods that can now be delivered to their homes.

5.6.2 Trip Substitution

With an Internet connection, one will be able to remotely access information and services; one can chat with electronic friends across the country, browse through on-line reference materials, and play games.

Trips may be eliminated by electronically sending messages and data instead of physically transporting them by holding teleconferences. Also, teleneting, or remotely accessing a computer, will allow one to access another computer's database such that information may be exchanged between the two terminals.

5.7 Future Societal Changes and Transportation-Related Impacts

It is impossible to predict exactly what future societal changes, which will have transportation-related impacts, will take place. Some idea of future developments can be formed by assessing trip purposes to see where additional savings may be attained as a result of improved information and communication technologies. These issues will be discussed in this section, together with some of the trends in work trips and mobility increases.

The 1990 Nationwide Personal Transportation Study (NPTS/72) reported that the daily work commute accounted for 26 percent of the average household's annual trips by vehicle (see Table 5-7). Shopping accounted for 20 percent, other family and personal business accounted for 24 percent, social or recreational trips accounted for 21 percent, while the remaining nine percent went to trips for other reasons such as trips to schools, doctors, dentists, and business appointments. Since 1969, the number of trips that increased the greatest was in the areas of shopping and family and personal business, up 88 percent and 137 percent, respectively.

While the average private vehicle miles traveled on home-to-work trips increased 16 percent in 1990, the commute time shave increased by just 42 seconds since 1980 to 22 minutes and 24 seconds, according to the 1990 census.

Table 5-7: Distribution of Vehicle Trips, and Average Trip Length by Trip Purpose

	Percent of All Trips[a]		Average Trip Length[b]	
Trip purpose	1983	1990	1983	1990
Earning a Living				
To or from work	27.8	26.1	8.6	10.9
Work-related business	2.9	1.8	11.3	14.0
Subtotal	30.7	27.8		
Family and personal business				
Shopping	20.0	20.2	5.3	5.1
Doctor/dentist	1.2	1.1	9.8	10.5
Other/family/personal	18.3	24.1	6.5	7.2
Subtotal	5.9	5.3		
Civic, educational and religious	5.9	5.3	5.5	7.4

Social and recreational				
Vacation	0.2	0.1	113.0	80
Visit friends/relatives	9.9	8.8	10.7	11.3
Pleasure driving	0.4	0.3	19.7	20.9
Other recreation	12.1	11.2	8.7	10.1
Subtotal	22.6	20.4		
Other	2.3		7.2	10.7
ALL PURPOSES[c]	**100**	**100**	**7.9**	**9.0**

Source: Liss, Susan. Nationwide Personal Transportation Study: Early Results, FHWA, U.S. Dept.of Transportation.

[a] Vehicle trips by purpose (Table 9)

[b] Average vehicle trip length in miles (Table 12)

[c] Because of rounding, the figured may not sum to totals

From the data in Table 5-7, it can be seen that the percentage of trips made for earning a living, family and personal business, and social and recreational remained about the same from 1983 to 1990. There was an overall increase in average vehicle trip length from 7.9 miles in 1983 to 9.0 in 1990. The trip lengths for work, work-related business, civic, educational, and religious, other family and personal business, and other social and recreational trips increased during the same period of time. Each type of travel offers an opportunity for trip reduction, although commuters are usually targeted for trip reduction programs because their trip times and destinations are often seen as relatively predictable events and therefore they could easily travel together (72). But commuting trips are as "individualistic" as the person makes them. Oftentimes, coordination of carpools and vanpools is made difficult by commuters who have flexible hours, work at odd hours, or have to make multiple stops to the grocery store, dry-cleaners or day-care centers and schools to pick up their children.

From Table 5-7 it can be seen that the magnitudes of the percentages of trips undertaken in the category of "family and personal business", as well as in the "social and recreational" category, are comparable to or higher than those in the "earning a living" category. Even if only a small portion of these trips could be eliminated as a result of the improvement of communication information technologies, the effect on total trip-making could be substantial.

The first stage of traditional shopping involves the gathering of information, which "requires travel to a shopping place in the absence of in-home shopping alternatives" (73). Often, the consumers enter the market when they recognize a need. They evaluate the information obtained about a certain item and may take several cycles until enough information is gathered to make a decision. However, today's technology allows for gathering the necessary information at home, thus potentially saving several trips to the store. The consumer is able to compare the various choices available before making a purchase.

A study by commerceNet-Nielson Media Research reported that only 2.5 million users in the United States have purchased any products or services via the World Wide Web (10). That number is likely to grow as companies are designing "tamper-proof electronic payment systems" which will make it safe and secure to do business on the network (74). According to IntelliQuest's survey of 415 people who own a computer or intend to buy one this holiday season, 72 percent of the respondents said that they would not trust sending their credit card number over the Internet. The same survey also reported that eight percent were likely to give someone a gift purchased this season on-line, while 13 percent said they were likely to within the next 12 months; that portion of people more than doubled to 30 percent for making a purchase within the next 5 years (75). On-line shopping may actually offer more in-depth information about products or services than a store clerk would be able to during the holiday season

(75).

In 1994, QVC's sales in goods and services ($1.4 billion) via cable TV increased 16 percent from the previous year (71). Ideally, individuals would shop through their TV and therefore eliminate the need to leave the home to shop for goods. Corporations such as CBS, QVC, Viacom, and AT&T have been competing against each other for a piece of the action as shopping at home, on-line promises to "alter not only how we buy and sell as well as distribute our goods, but also the physical landscape of America" (71).

On the other hand, it may be years from now before consumers will be able to purchase goods using interactive TV. U.S. West, Inc., a Denver-based telephone company providing regional service, together with retailers such as Nordstrom Inc., the J.C. Penney Company, and the Ford Motor Company, began in 1993 the development of a service that would have allowed customers to place orders for merchandise using their televisions. However, due to high costs and premature technology, U.S. West. Announced in August 1995, the ending of their interactive television shopping experiment (76).

Another area which leads itself to changes in tripmaking is education. Telecourses have been offered at a number of college campuses and other sites that would otherwise have been inaccessible to local residents. These courses are becoming more and more common. Students in these courses watch their lectures on a local cable or broadcast channel at home. The Chabot-Las Positas Community College District averages 1,200 students a year in its telecourses (77). Solano Community College began offering classes via teleconferencing in the fall of 1995 (77). Professors taught the courses in a room in Suisun City equipped with technology that allowed the students and teachers to see and hear each other, and interact in real time.

A similar approach was begun in October, 1996, for IISTPS' first Masters-level transportation course presented via distance learning, which is offered through the San José State University College of Business Graduate Programs Office. This course originated from Caltrans offices in Oakland, California, and was received by students at additional sites in San Jose, Santa Ana, Sacramento, and San Diego. Student reaction to the program has been positive, and there have been requests for additional reception points for courses.

During spring of 1995, Foothill College in Los Altos Hills offered a class on the "C++" computer language via the Internet (77). The professor wrote up the week's lecture and e-mailed it to the students. After reading the notes, the students e-mailed questions to their professor or to other students. The questions and answers were posted to each participant, so that there was an ongoing discussion. Students from all over California, as well as out-of-state and one student from Sweden took the class.The University of Phoenix has further developed this idea and is currently offering students the opportunity to obtain an MBA on-line (78). Instead of the traditional live discussions held in classrooms, students are expected to participate in on-line class discussions and keep up with the reading assignments and project deadlines.

Table 5-8: Summary Statistics on Workers from the 1990 U.S. Census and 1990 NPTS

	1980	1990	Percent Change	1990 NPTS
Bay Area Population	5 million	6 million	+16%	
Number of Workers	2.5 million	3 million	+25%	118,343

How workers get

to their jobs

Drive alone	62.8%	68.2%	+9%	70.7%
Carpool	16.3%	13.0%	-20%	12.0%
	1980	1990	Percent Change	1990 NPTS
Ride Transit	11.4%	9.5%	-17%	5.0%
Walk	4.4%	3.6%	-18%	3.7%
Work at Home	1.9%	2.3%	+79%	unknown
Other	3.1%	2.3%	-26%	2.5%
Total	**100%**	**100%**		
Average Travel time To work (minutes)	24.3	25.6	+5%	20.0
Average Commute Vehicle Occupancy Rate	1.132	1.097	-3%	

Source: U.S. Census and National Personal Transportation Study

From Table 5-8, it can be seen that the percentage of people driving to work alone has increased, while the proportion of the people carpooling and using public transit has declined in the San Francisco Bay Area between 1980 and 1990. This is also true for the working population in the United States. The percentage of people who drove to work alone increased from 64 percent in 1980 to 73 percent in 1990 (42). Furthermore, the portion of transit riders decreased from 6.2 percent to 5.1 percent as the percentage of people carpooling fell 32 percent between 1980 and 1990.

Table 5-9: Changes Over Time

Year	**Daily Vehicle Miles per Household**	**Persons per Household**	**Daily Vehicle Miles per Capita**	**Vehicles per Household**
1969	34.0	3.2	10.8	1.2
1977	33.0	2.8	11.7	1.6
1983	32.1	2.7	12.0	1.7
1990	41.4	2.6	15.9	1.8

Source: Liss, Susan. Nationwide Personal Transportation Study: Early Results. FHWA, U.S. Department of Transportation.

The mobility of the U.S. population continues to increase with time, which is shown in Table 5-9. Between 1969 and 1990, the number of persons per household decreased by 18.7 percent while the number of vehicles per household increased by 50 percent, compared to only a 20.9 percent increase of VMT.This increase in the number of vehicles per household and decrease in the average household size contributed to the declining vehicle occupancy for trip purposes, as seen in Table 5-10. These trends do not bode well for finding a solution to transportation problems through promotion of public transportation Elimination of trips may be helpful through better use of improved communiaiton/information technologies, as discussed previously.

Table 5-10: Average Vehicle Occupancy[1] for Selected Trip Purposes, 1977-1990

	Percent

Trip Purpose	1977	1983	1990	Change 77-90
Home to Work	1.3	1.3	1.1	-15
Shopping	2.1	1.8	1.7	-19
Other family or personal business	2.0	1.8	1.8	-10
Social and recreation	2.4	2.1	2.1	-13
All Purposes[2]	1.9	1.7	1.6	-16

Source: 1990 Nationwide Personal Transportation Survey: summary of Travel Trends, Table 8.

1 Persons miles per vehicle mile

2 Includes other purposes not shown above: eg., trips to school, church, doctor, sentist, and work-related business trips.

Table 5-11: Consumer Expenditures, 1992-1993[a]

Item	1992	Consumer Price Index, 1992	1993	Consumer Price Index, 1993	Change in Consumer Price Index
Average annual expenditure	$29,846	140.3	$30,692	144.5	4.2
Food	4,273	137.9	4,399	140.9	3.0
Food at home	2,643	136.8	2,735	140.1	3.3
Food away from home	1,613	137.5	1,664	143.2	2.5
Housing	9,477	137.5	9,636	141.2	3.7
Apparel and service	1,710	131.9	1,676	133.7	2.7
Transportation	5,228	126.5	5,453	130.4	3.9
Health care	1,643	190.1	1,776	201.4	11.3
Entertainment	1,500	142.3	1,626	145.8	3.5
Personal Insurance and pensions	2,750		2,908		
Other expenditures	3,274	183.3	3,218	192.9	9.6

Source: Department of Labor, Bureau of Labor Statistics

[a] For all urban consumers; CPI based on 1982-84=100

Consumer Expenditure Survey data from 1993 shows that 17.8 percent of the average annual expenditures was spent on transportation. The only other expenditure greater than that was for housing (31.4 percent). These data indicate that, since expenditure on transportation are comparatively large, small changes will be comparatively significant.

5.8 Ethics

As new technologies change lifestyles, individuals' attitudes, values, and behavior will also be affected. Ethical issues which have emerged from the use of the Internet include the distribution of undesirable material, the misuse of Internet facilities such as electronic mail, and other related aspects of Internet use (19) as well as failing tog ive credit to the author(s) of the work. The electronic age and the emerging communication and information technologies are raising new ethical questions for our legal system to answer.

The electronic age has also made it less difficult to copy another person's work. Copyright and patent laws are intended to protect intellectual property in the written format, but they inadequately protect intellectual property that is digitally formatted. At the time of publication, no written law exists which protects the intellectual property rights digitally transmitted over the Internet. Because the electronic community is not regulated by a central entity, making sure one receives the appropriate credit and compensation for his/her work becomes nearly impossible (20).

If barriers are not placed to prevent the electronic copying of information and people do not receive the proper credit for their work, people will soon decide not to put their work on the network, where it is easily accessed by others. This may have a negative impact on society because the exchange of, and access to, information can help in avoiding duplication of work as well as increasing "the rate of knowledge production by others" (20). The value of information often goes unrecognized because it is difficult to evaluate. However, the lack of easy access to information results in inefficient and costly efforts.

Since the Internet is a global network, it is not constrained by national boundaries. While each nation has its own definition of intellectual property and laws, enforcement of these laws across the borders is not practical or possible (20). Determining the source of information is difficult to do without electronic signatures, but even with them, the information can be easily modified.

Organizations, including transportation agencies, will have to decide how these issues will affect them and how they should be dealt with.

5.8.1 Brown Act/Sunshine Laws

Many states have "sunshine" or "open government" laws, which seek to ensure that public agencies conduct their decision-making in a forum that is generally open to the public. In California, this body of law is known as the Ralph M. Brown Act (Government Code Sections 54950-54962).

Among the actions prohibited by the Act is "any use of direct communication, personal intermediaries, or technological devices that is employed by a majority of the members (of the policy board of a local public agency) to develop a collective concurrence." In the past, this prohibition has generally been applied to "serial meetings" such as telephone calls or direct interactions. Now, however, the use of fax, e-mail and similar electronic media means that messages and communications can be readily transmitted to additional parties, even beyond those for whom the information was originally intended, and often without the original sender's knowledge. Great care must be taken by public employees and officials to ensure that even inadvertent violations of the law (or its intent) are avoided.

5.9 Summary of Major Conclusions

Regarding the societal changes, related to transportation, which may take place in response to the development of the new technologies, the following major conclusions were reached:

1. The implementation of improved communication/information technology has had the effect, and will continue to have the effect, of making it easier for people to live and function wherever they choose. This could impact transportation facilities in rural and suburban areas significantly which could then require additional funding and transportation management in those areas.

2. Telecommuting may not significantly reduce VMT. Although telecommuters will not be making the longer commute trip, they will be making an increased number of shorter trips. As a result, the alleviation of traffic congestion on commuter highways may only be modest, but the additional traffic in rural areas may be notable.

3. It is difficult to predict the growth rate of telecommuting and its transportation implications. The actual impact of telecommuting on transportation, air quality, and energy savings will depend on factors such as the degree to which telecommuting is feasible and is adopted, the portion of peak-hour trips eliminated, the re-allocation of time, and future travel demand management-related policies. It should be noted, however, that the number of people who telecommute is of a similar order of magnitude as the number of people using public transportation. This would indicate that telecommuting could be significant in future growth and environmental impact policies.

4. Trips in the category of family and personal business (as well as in the category of social and recreational) constitute portions of total tripmaking comparable to that of earning a living (including work trips). These trips could potentially be significantly affected by the new communication/information technologies should trip substitution occur in a way similar to telework substituting for work trips.

5. The electronic age and the emerging communication and information technologies are raising new ethical questions about the use of information.

5.10 Recommendations

The following actions are recommended:

1. Investigate the desirability of establishing a central telecommuting organization which will distribute information and make training available to organizations and individuals who are interested in telecommuting. Such an organization could help set up satellite centers at various locations in the state.

2. In order to further understand the impact of emerging technologies, a case study could be conducted on a suburban or rural area which has shown a population increase in recent years and has a significant number of telecommuters. The area can be selected from surveys of current telecommuting programs. The study should document the changes in lifestyle and travel behavior as a result of telecommuting, include a time use survey, and determine the potential markets for telecommuting and trip substitution in the categories of family/personal business as well as social/recreational.

3. “Integrity” guidelines should be developed for the use of information on Web pages and for using information available on the Internet.

6. SOME OPPORTUNITIES AND CHALLENGES

Improved information and telecommunication systems offer many opportunities to a transportation agency. As an organization, it can reap all of the benefits outlined in Chapter 4. The product that the agency delivers, i.e., the provision and management of transportation facilities, can also be enhanced by the incorporation of improved communication and information technologies as discussed in Chapter 5. The primary objective of this chapter is to discuss some of the applications of the principles, established in Chapter 3 and 4, to the functions of a transportation agency. The emphasis will be on these issues as they relate to Caltrans, but other transportation agencies could also consider some of the issues discussed here.

New technology, and in particular the collection of new technology and systems, generally known as Intelligent Transportation Systems (ITS), has been presented by some as having the potential to make major contributions to solving today’s transportation problems. While few would argue that new technology will favorably impact transportation, there are some issues, regarding the implementation of these systems, which warrant discussion. While not all of these systems automatically fall within the category of information and communication technologies are intertwined with almost all of these systems.

Significant attempts are in progress to implement ITS systems. The ITS Early Deployment Program (79) is an example of such an effort. Organizations such as ITS America are making a significant effort in promoting the implementation of ITS systems. To the extent that these programs and efforts are doing much to bring about the implementation of these technologies and systems, it may be worthwhile to view these efforts from a long term perspective.

While there are some advantages to promoting these technologies and systems by using names such as “intelligent” and promoting their novelty, there are in fact few really new systems. For instance, traffic management and toll collection systems have been in existence for a long time. However, the new technologies integrated into these systems make them less expensive and/or more convenient to implement. If the systems remain the same, then the issues surrounding these systems should remain the same. For example, improved traffic management systems will effectively add capacity to the system. The old issues of whether the environment is negatively impacted will still remain. If ITS were implemented as new or different projects, then the fact that the issues are the same as those discussed previously for similar systems may be obscured. Partly because of the novelty of the project, debate about the real issues may be delayed if it is not made clear early on that the project or system is not new, but only more efficient or less costly.

However, there are issues related to the employment of new technology, and not the basic systems, that could significantly influence the policy and operation of the organization. With the rapid development of technology, there will be a greater need for training. The training will be required for personnel involved in the application and decision-making processes regarding systems and projects utilizing new technology.

A discussion of all the opportunities provided, by improved communication and information technologies, to the organization, is outside the scope of this project. Instead, a discussion of some of the major opportunities/problems will be presented and some conclusions and recommendations made regarding broad policy issues.

It should be noted that the headings used for the following sections were based upon commonly used section or division titles used by Caltrans. These headings are:

- Administration
- Transportation Planning
- Right of Way
- Project Development
- Construction
- Maintenance
- Operations

Following the discussion, a summary of major conclusions and recommendations will be provided.

6.1 Administration

6.1.1 Correspondence, Communication and Information

As improved communication technologies allow for more extensive and efficient correspondence at lower costs, the issue of compatible hardware, software, and protocols emerges. In this respect, Caltrans headquarters and several of their districts use common software, i.e., Novell Groupwise for e-mail, and consult with Caltrans' Information Systems and Service Center before purchasing hardware and software to ensure that compatibility is maintained as far as possible. It was recommended in Chapter 3 that Caltrans should consider leadership role in developing and maintaining standards for communication with other transportation agencies and/or organizations with which Caltrans often interacts.

However, Caltrans is probably not in a position to dictate to other agencies what standards to accept. Caltrans could influence the process by establishing its own standards in such a way that it would be relatively easy for other participants to conform. To encourage cooperation, communication standards should not be exotic nor have significant cost implications. These are, however, issues which transcend correspondence and will impact the ability to implement the "roundtable concept" discussed in Chapter 4. It should be noted that federal transportation agencies are nationally in many of the roles Caltrans occupies within the State of California, and that some standards should be established in cooperation with federal agencies as in the case of standards for Intelligent Transportation Systems.

Caltrans and other transportation agencies should experience direct cost savings and other advantages from better communication. In turn, the public should also benefit from having better communication among all agencies. In a discussion with Caltrans personnel, it was noted that common communication standards, for the purpose of traffic management, were established among Caltrans personnel, it was noted that common communication standards, for the purpose of traffic management, were established among Caltrans and other transportation agencies in District 12 (Orange County). Here, Caltrans took the lead in setting standards without making it mandatory for the other agencies to follow.

It should also be noted that availing the public of often-requested information on the Internet and its successors will obviate the need for some correspondence. The Internet now provides a medium for people to easily exchange and access information. Further development of the Information Superhighway will enhance this opportunity. Government agencies and research laboratories are beginning to post standards, project results, and reports or summaries on the Internet.

Other information such as engineering drawings, large manuals, business plans, and statistics can all be sent or received electronically. This saves time while also reducing the costs of producing and distributing these documents. The exchange of this type of information for specific purposes, such as planning, will be discussed in subsequent sections, but some of this information may also be useful to the public and for better public communication in general. It can be expected that as the public becomes more accustomed to readily obtaining information by electronic means, their expectations of having such information available will likely increase.

An example of easily accessible information can be found on the experimental on-line SMART Library (http://www.bts.gov/smart/smartlinks.html), which has organized some transportation research and planning information on the Web. SMART Library is administered by the Bureau of Transportation Statistics (BTS), an operating administration unit of the U.S. Department of Transportation (DOT), created to supplement intermodal transportation data required by Title V of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 (80). Available information includes results from case studies and research projects, Caltrans' Environmental Handbook, pavement management manuals, and software to assess the air quality. Information on lnd use, safety, transportation history, and travel demand forecasting are also obtainable via the Web.

Currently, there are a number of California government transportation-related agencies on-line, with ore being transferred frequently. They include: Association of Bay Area Governments (ABAG), Caltrans, California Department of Transportation – Transportation Programming, California Partners for Advanced Transit and Highways (PATH), San Francisco/Oakland Bay Area Transit Information, Ventura County Transportation Commission, and Southern California Traffic Reports. Each site has different resources and services. For example, the Transit Information Project, which was originally developed by two UC Berkeley students, provides on-line access to transit information for the San Francisco/Oakland Bay Area. On the other hand, the California PATH's site announces meetings, offers forums, news groups, and conference and journal publications, and contains PATH abstracts, reports, papers, and memoranda. Caltrans' Transportation Programming site maintains on-line state highway project programming documents as well as downloadable software.

Caltrans already has several information sites on-line. A centralized, coordinated effort may be required to make an increasing amount of information available in a cost-efficient manner. This will create the public image that the agency as a while desires: to decrease unnecessary duplication, and to reduce conflicting information. Caltrans may be too large to coordinate all of this information exchange at a central location, but it could be advantageous to authorize a central unit responsible for setting standards (as recommended in Chapter 3) and for monitoring other public information exchange sites.

6.1.2 Breaking Down Barriers

Improved communication and implementation of the "roundtable concept" will aid in producing better work by closing the communication gap. Working with projects that transcend district and jurisdictional boundaries should become easier.

6.1.3 Training

Currently, personnel at Caltrans and other transportation agencies are either sent to courses conducted by outside resources or are trained in-house. According to Caltrans personnel, limited computer-based training is available in-house. In the future, employee training will increasingly occur via computer, distance learning, and other electronic media. Courses can then be taken by employees at the appropriate time without traveling. Ultimately, these courses could be listed in Caltran's homepage and could be available on demand.

At the moment, most of the training at Caltrans is executed or procured at the department or program level. In recent years, Caltrans has subsidized a training program for personnel of local transportation agencies, i.e. the Local Technical Assistance Program (LTAP) administered by the Institute of Transportation Studies Extension at the University of California, Berkeley. Caltrans has the opportunity to further take the initiative for developing and administering a training program using new media. One or more universities could also be involved. However, issues of cost sharing will need to be resolved. Consideration could also be given to educate the public and decision-makers about the advantages of these new technologies. Caltrans personnel may find themselves more often in leadership roles when projects cross jurisdictional boundaries or when technical assistance is needed.

6.1.4 Telecommuting

Like any other organization, Caltrans should be able to benefit from appropriate telecommuting. At the moment, permission for telecommuting (of Caltrans employees) is administered at the program level. Caltrans could use its own efforts as a demonstration and promotion of telecommuting. Furthermore, more ongoing research on appropriate telecommuting programs could be carried out on Caltrans' own telecommuting initiatives.

6.1.5 Toll Card Sales

At present, electronic toll collection is in use for the SR-91 Express Lanes and Transportation Corridor Agencies (TCA) Foothill Corridor, as well as being tested at the Carquinez Bridge Toll Plaza. The cards are prepaid by the user and have "read only" communication. Utlimately, two-way communication will permit the traveler to be debited until the funds on the card have been exhausted or merely debit each transaction and periodically bill the user. Such transactions and other electronic sales, e.g. sale of toll cards over the Information Superhighway, will require Caltrans to obtain the capability to conduct business over the Information Superhighway. Caltrans will need to decide whether such a system is worth investing in, since they may be forced to adopt the prevalent system. Moreover, in the case of toll collection, it would be cost-effective to have common standards for the various vendors. Again, Caltrans may have to facilitate the establishment of standards.

6.1.6 Other Issues

Improved communication and information technologies will facilitate other organizational functions such as financial management, accounting, purchasing, etc. Detailed discussions of these issues are considered to be outside the scope of this report.

6.2 Transportation Planning

The arrival of improved technologies presents great opportunities for Caltrans to improve transportation planning, ranging from improved planning of projects to planning for the substitution of travel through telecommunications.

It was noted in Chapter 4 that greater information integration and planning at the beginning of projects will lead to savings and added efficiencies. Increased access to information will allow transportation agencies to implement these concepts to a larger degree. The concept of the roundtable discussion was introduced in Chapter 4 From the viewpoint of planning, this roundtable could not only mean having different departments communicate better by using the improved communications technology, but it will also allow communication with other organizations and across district boundaries.

The issue of cost shifts is very important and warrants further consideration. As discussed in Chapter 4, it is advantageous to invest more funds at the beginning stages of projects so that more information is available. This will mean that funds will have to be shifted from areas such as construction to earlier stages, e.g. planning. Hopefully, savings from efficiency gains in correspondence will clearly justify the funding change, although it may be difficult to show that the benefits of investing more in planning will outweigh those of spending more in construction. Since construction is more tangible than planning, the public and decision-makers could become suspicious of spending relatively more money on less tangible products. It could therefore be worthwhile to monitor costs of projects to determine the existence and magnitude of cost savings resulting from these cost shifts.

The improved technologies also provide Caltrans with the opportunity to present information on projects during the project formulation stage. Descriptions of projects, status, and public meeting notices related to the projects could be provided to the community on the Internet to help build consensus. Substantial effort may be needed to place information and data on-line since many local authorities are not yet on the Internet. Restricted use of other people's data and on-line use of transportation models by other organizations are areas that Caltrans needs to review. Opportunities exist here to create project advisory groups at very low cost by having member participate through electronic media. These issues will be discussed in more detail in the following sections.

There is also an opportunity for travel substitution through telework, teleshopping, etc. Caltrans will need to consider its role, if any, regarding the promotion of travel substitution. The role that transportation agencies could plain in the promotion of travel substitution is not clear. On the one hand, promoting telework and teleshopping could reduce travel demand. On the other hand, there is a commercial impact to these activities, and the extent to which government agencies should participate requires careful consideration.

6.2.1 The Planning Roundtable

Both Caltrans and other project participants will benefit from the use of a roundtable during the planning process. Projects can be run more efficiently if project partners "got together" at a roundtable periodically (e.g., the first Monday of every month) for discussion. The individuals involved do not necessarily physically meet, per se, but can set a convenient time for a conference, i.e. either a teleconference, videoconference, or an electronic conference. By being on-line at the same time, they can simultaneously review plans or reports sent to each member and be able to see the exact document the other people have before them. The agenda for the meeting may also be posted ahead of time so that the attendees will have a chance to prepare for the topics to be discussed.

In order for this to take place, some sort of "meeting place" will have to be set up on the Internet so that information related to the project may be viewed by any of the project members and perhaps also by the public. This meeting place should be organized in a way that would allow individuals involved with the project to download the latest documents, arrange meetings (e.g., face to face, video conference, or teleconference) and see progress reports. However, a site of this kind requires the various participants to openly shre their information as each person will have access to the site at any time, e.g. In-between meetings. Also, the hardware and software used by the project members will need to be compatible with one another.

A demonstration project for the planning of a project could be developed to illustrate the advantages of the roundtable concept. A Web site dedicated to a particular project, which will need enable the various project members to exchange information, will need to be established. Global Construction Network (GCN) (*http://www.gcn.net)*, builds such specialized sites, called ProjectSpecific Web Site™ (PSWS), on the Web. A PSWS utilizes the Internet to link prime participants in a project together in a secure closed-communication environment (81). General information about the project and project partners will be accessible by the public. However, access to files, email, message boards, and forums will require passing a security checkpoint. Unauthorized users cannot come in, but project partners will be able to venture out elsewhere onto the Internet. Such a demonstration project will aid in solving problems with communication and can show benefits for future implementation.

6.2.2 Public Communication

The Internet has made communication and access to information simpler. The public, with greater access to e-mail and the Internet, will find it easier to get information on transportation agencies and their projects. This may also lead the public to expect more and to become more involved with the planning stages of a project. They will be able to see how their tax dollars are being spent and perhaps also participate in the planning process more effectively. Transportation agencies may use this to their advantage and as a means to improve their public image. More information may be distributed at a lower cost by posting messages on electronic mail/listservs and Usenet groups, two of the most frequently used Internet-based communication applications.

The Usenet is a collection of more than 10,000 discussion groups (also called newsgroups) in which thousands of people exchange ideas, information, and opinions. The newsgroups are organized into hierarchies, i.e. science (sci), recreation (rec), society (soc) and a miscellaneous category called alternate (alt). Here, people post messages, announcements, or questions pertaining to the subject of that particular newsgroup and other users will post their responses, offering their advice or support. Regular users view this as an opportunity "for gathering and disseminating raw, uncensored news" (6).

Transportation professionals can also use the Internet and its successors to their advantage. Currently, at least 11 states and several countries have a "listserv" system which will allow for nearly real-time discussions between transportation professionals on a national or international level via the Internet (82). In a 199 survey of transportatio professionals conducted by a project team at the Norman Y. Mineta International Institute for Surface Transportation Policy Studies (IISTPS), less than ten percent of the respondents currently acquire information through electronic means (83). The small percentage of Internet users do so primarily for electronic mail. However, this activity is bound to grow in a manner similar to general use of the Internet.

The Upper Great Plains Transportation Institute and North Dakota DOT cosponsor the U.S. DOT discussion group. Participation in the discussion groups is free, although new members need to send an e-mail message to listserv@vm1.nodak.edu to begin subscription. A confirmation letter which includes rules of the discussion group and a document describing the commands such as download services is later sent to the participant. A list of other transportation usenet newsgroups as well as additional Websites and examples of information available via the Internet is included in Appendix B of this report.

Another valuable source of information accessible to the public is stored on FTP (file-transfer protocol) servers, which are linked together through the Internet. These host sites have file libraries or archives of applications and data, such as free or low-cost shareware programs or statistical files, that are available for downloading. For example, the FTP site for BTS will allow users to download the name and telephone numbers of federal transportation specialists or the current copy of the National Transportation Statistics.

A possible future activity may be the posting of regional planning models on the Internet. These models could then be accessed by other agencies and individuals to test some scenarios which they may wish to explore.

6.2.3 Substitution of Travel

As discussed in Chapter 5, telework (telecommuting is a subset of telework) may be one answer to some congestion problems.

It could be advantageous if Caltrans were to promote the concept of telecommuting and to help promote the building of remote work centers on a state-wide basis. Both Caltrans and the San Bernardino Association of Governments (SanBAG) have supported programs which promote telecommuting and policies intended to mitigate pollution and traffic congestion (84). Since Caltrans already has a telecommuting program in operation and District 8 participated in the WorkSmart Project, this experience can be used to help and encourage firms to start alternative work strategies. (The WorkSmart Project was a collaborative effort between five Southern California organizations that explored new workplace strategies.) Here Caltrans can provide the state leadership in the development of telecommunications.

Caltrans has taken a proactive role in considering the movement of information as a form of transportation and as a substitute for physical transportation. Several information highway and telecommunications-as-a-travel-mode projects are in progress. A list of these projects as of January 1995 is provided in Appendix C. Information on telecommuting can be obtained from the Smart Traveler system. This system has been in operation in the Sacramento area (i.e., Lake Tahoe to Solano County to Chico) since September 1995 and is expected to be available on the Internet in Southern California and in San Diego within a few months of the date of this report. Smart Traveler provides travelers with a "one-stop" shop for transit, rail, airport, ferry, highway, rideshare, and telecommuting information. The system can be accessed by telephone, personal computer, and cellular phones. Eventually, the system will also be accessed by kiosks, interactive TV, and in-vehicle devices.

6.2.4 Household Travel Surveys

Since one of the most challenging tasks facing a transportation planner today "is to develop a cost-effective way of collecting and managing travel data," the collection and analysis of travel surveys will benefit from the application of new technologies (85). These new technologies will not only improve the accuracy of the data collected, but will reduce the cost of the surveys. Examples of the new technologies include: computer-assisted telephone interviewing (CATI), computer-assisted personal interviewing (CAPI), geographic information systems (GIS), and the global positioning system (GPS) (85). The CATI system allows telephone interviewers to do away with the paper and pencil and to mark logically inconsistent responses for clarification. CAPI is similar to CATI, but permits the interviewer to perform interviews in the field using notebooks and/or palm computers (85).

The use of GIS offers a means of displaying the spatial data collected from GPS. This can be a powerful tool because the maps, which are color-coded by various attributes, are more easily understood by decision makers. The user an also retrieve, manipulate, analyze, store, query, and display maps of the data after the GPS information is downloaded into a GIS (85). One advantage of using GPS technology in travel surveys is that it can accurately monitor the vehicle's movement, including the route taken and all short trips or stops made. Self-reporting travel diary surveys often include rough estimates of the travel time as people tend to round travel times to the nearest five or ten minute intervals (85).

6.3 **Right of Way**

According to Caltrans personnel, fiber optic cable has been placed along approximately 175 miles of urban freeway (out of the 2000 miles of urban freeway in California) in state-owned right-of-way (ROW). Caltrans is currently exploring the possible opportunity of having a private company install fiber optic cable at no cost to Caltrans. In return, Caltrans will allow the company to place cables for their own use. There is also a possibility of Caltrans' raising revenue from this source. Local authorities could use Caltrans' cable or utilize their own ROW for cable placement. If cable companies are allowed to operate in the ROW, a hazardous situation may result. It may, however, be argued that the improved traffic management and better safety resulting from improved communication will offset these concerns.

San Francisco's Bay Area Rapid Transit (BART) District is currently working with MFS Network Technologies to build and maintain a communications conduit system (86). The system will support the telecommunication needs of BART, local police, and telecommunication companies, i.e., paging, cable television, and cellular providers. "This is an exciting opportunity to maximize the return on our taxpayers' investment and generate new sources of revenue to help fund critically needed improvements to our transportation operations," said Richard A. White, recent General Manager for the BART District (86).

There is a potential for generating revenue from selling information, for instance, providing an opportunity for advertising and leasing space in the right-of-way. The desirability and legality of these issues should continue to be studied.

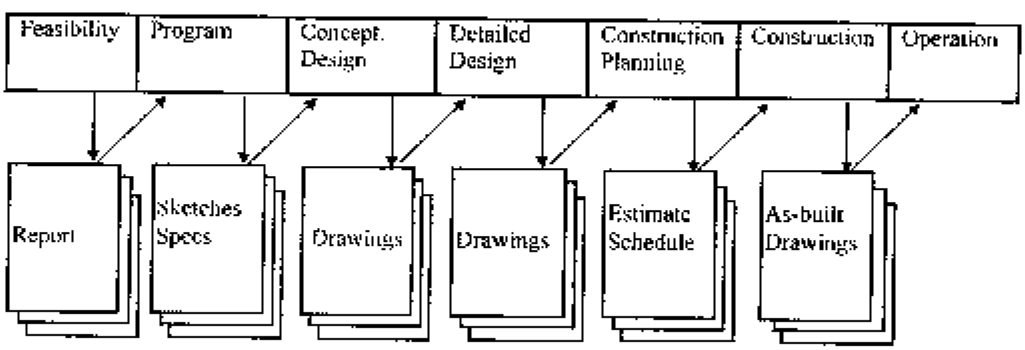
6.4 Project Development

The opportunities offered by improved information and communication systems to the area of project development are similar to those discussed in the transportation planning area. As noted in Chapter 4, the developmental stages of a project is critical as it commits a large percentage of the total project cost while expending only a small portion of the total cost (see Figure 4-2). The availability of information at this stage will aid project managers to make more informed decisions and minimize errors. Thus, the need for and costs of changes at later phases of the project are reduced. It was also noted in Chapter 4 that the cost of making changes in the final stages increase by magnitudes of 10.

Ensuring that uniform standard and design policies are used will also yield benefits. Currently, Caltrans' Office of Project Planning and Design (OPPD) is publishing most of their standards on the Internet where the public is able to download it free of charge. Manuals and publications such as the Metric Program, the Cooperative Agreement Manual and Project Development Procedures Manual are already on OPPD's homepage (http://www.dot.ca.gov/hq/oppd). The Highway Design Manual and Project Development Workflow Tasks Manual are still under construction. OPPD's principal objective is to "promote Statewide consistency in the design and project development process in support of Caltrans' mission of developing high-quality transportation projects." By continuously updating design standards, policies, procedures, and practices, project development will be a more consistent process, and changes will be minimized. It should be noted that Caltrans has projects other than civil works, e.g. electronic projects.

Figure 6-1, below, shows the various stages of a traditional project. Typically, drawings and reports are transferred from one phase to the next. Project participants filter out only the information they need to produce new drawings and reports. Thus this process is more inclined to errors as "data is extracted, transferred, interpreted, and repackaged very frequently" (87).

Figure 6-1: Traditional Fragmented and Sequential Project-Delivery Process



Source: Teicholz, Paul and Martin Fischer, Strategy for Computer Integrated Construction Techoology. *Journal of Construction Engineering and Management*, ASCE, Vol 120, No. 1, March 1994, p.123. Used by permission of the American Society of Civil Engineers.

Another issue facing the development phase of a project is the conflict between the various types of software utilized (88). Typically, database, word processing, and spreadsheet applications are not compatible with each other. Consequently, information is manually entered for each application, which in turn creates opportunities for errors to be made. It is critical that information can be easily accessed and accurately transferred. Therefore, it would be beneficial to link the information from the different programs together and use the same software, hardware, and protocols. There isn't a "price tag" which can be placed on the ability to link information. However as an example, Joe Peters, Vice President of Quadrants Inc., a general contractor based in Michigan, says that the company has been able tot rack more information with the same number of people while reducing the error rate and turnaround time, as a result of linking information (88).

6.4.1 Smart Permitting

Smart Permitting consists of electronically submitting applications for building permits and being able to track the status of the permit on-line. The goal is to streamline the permit process through "the implementation of network-based electronic permitting systems" (89). With Smart Permitting, the contractor submits electronic copies of the permit application and the plans. This will eliminate the need to make several copies of the plans (one for each division, i.e. building, electrical, plumbing, fire, etc.) and save the cost and time of printing blueprints.

Electronic submission of plans and permits will speed up the turnaround time for a permit to be approved. If an inspector should run across problems or have questions regarding the plans, the project manager could immediately be informed via e-mail of the problem. The plans may then be changed accordingly. At *The Electronic Government: Opportunities in Conducting the People's Business on the Internet* Conference in San Jose on April 19, 1996, Smart Valley made a presentation on the redevelopment of software for plan checking. As part of the Smart Valley's Smart Permitting Project, they hope to develop software, much like the spell-checker in word processing programs, that will check whether the submitted plans meet the minimum requirements of the Uniform Building Code.

A demonstration project has been developed by Smart Valley, Inc., in collaboration with Andersen Consulting, and the City of Palo Alto, to demonstrate the benefits of on-line permitting. The project uses building applications from the City of Palo Alto and has a searchable archive of the building codes as well as other relevant information to help complete the forms (89). The use of permitting through electronic means should be further pursued.

6.5 **Construction**

The construction industry has been known to have long lead times for technology transfer while also lagging "behind other industries in developing, identifying, and adopting innovative technology." (90). According to Paul Teicholz and Martin Fischer (87), the construction industry in the U.S. does not place a high priority on research and development (R&D) to improve "the basic methods, equipment, and materials used for design and construction." Thus, their productivity growth rate from 1948 to 1981 was only 15 percent, while manufacturing experienced a productivity growth rate of 132 percent during the same period (90). With the arrival of improved communication technologies, the construction industry will be able to benefit from increased information available on-line, easy access to outside resources, the integration of information, and the automation of processes. Some examples of applications of these technologies will be discussed in the following sections.

6.5.1 Presence on the Internet

At the June 1995 American Society of Civil Engineers Computing Conference held in conjunction with (Architecture/Engineering/Construction) A/E/C Systems '95, John Lynch, the Vice President of Autodesk's Advanced Product Group, emphasized the importance of engineers making a presence on the Information Superhighway (91). He predicted that information regarding bidding, specifications, and management will be obtained via the Internet in the future. In addition, with the possibility that design standards, guidelines, local regulations and ordinances will be available on-line, design changes may be carried out in real-time.

Since a construction project involves multiple phases and professionals from different organizations need to work together, it is essential that information be easily and accurately transferred from one place to the next. “Fragmentation is the predominant problem facing the construction industry, period,” says Jeffrey Russel of the University of Wisconsin (92). Currently, two organizations, Mercury Productions Inc. in Tampa, FL., and FMI Corp. in Raleigh, N.C., are helping to create the Global Construction Network (GC) (93). Customized sites will be set up for construction projects such that participants from all around the world will be able to have partnering sessions on-line (94). Not only will participants be able to see progress photos taken a few minutes before with a digital camera, but their personal schedules will be simultaneously updated when a meeting is set. “The site will also provide a dozen simultaneous forums, such as those for revisions to drawings, requests for information, safety, progress photos and reports, change orders, payment requests and partnering” (94). GCN’s purpose is to become a network on the Internet devoted to the exchange of information on any aspect of the construction industry, where users will be able to search for information on companies, codes, regulations, and product information, download information on selected topics, and post messages on bulletin boards to other professionals in the industry (93).

Today, there are many WWW sites which provide contractors, builders, and suppliers and manufacturers a presence on the Internet. For instance, BuildNet provides “a comprehensive network of links, resources, and opportunities for the entire construction industry from architects to the men and women on the job” (14). At this and other similar sites, users are able to download software, participate in discussion groups regarding various aspects of the construction industry, and research companies in the field.

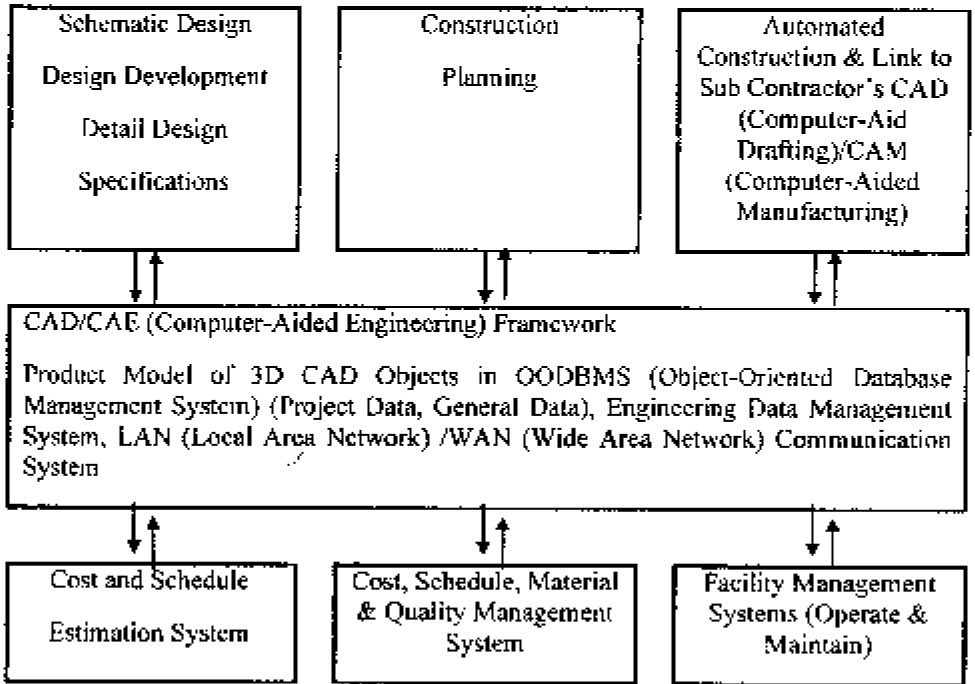
During a discussion with Caltrans personnel, it was concluded that having a roundtable-type of coordination among agencies would be especially beneficial in conducting road closures. By having all the surrounding cities, counties, and local authorities “get together,” they would be able to coordinate their road closures in such a way as to optimize the network usage and then publicize the affected areas.

6.5.2 Computer-Integrated Construction

As discussed above, the construction industry faces the problem of fragmentation. The resistance to change and to share information has many companies still using an ineffective communication medium of paper documents rather than electronic technology (92). In recent years, research and development has been conducted in the automation of the industry. The concept known as computer-integrated construction (CIC) is a process that creates a database of information such that participants in a construction project will be able to exchange information through “an intelligent database” (92). CIC’s primary goal is to reduce design and construction time, but not having to sacrifice quality nor increasing the project cost (87).

Figure 6-2, below, provides an overview of the CIC framework proposed by P. Teicholz and M. Fischer (87). In principle, this is similar to the system discussed under “Project Development.” The diagram shows the relationship between the various engineering processes and CIC.

Figure 6-2: CIC Technology Framework



Source: Teicholz, Paul and Martin Fischer. Strategy for Computer Integrated Construction Technology. *Journal of Construction Engineering and Management*, ASCE, Vol. 120, No. 1, March 1994, p.123. Used by permission of the American Society of Civil Engineers.

An engineering data-management system integrates all of the processes shown in the figure with an object-oriented project database and general engineering databases. These databases might be organized as one central database, i.e. they would all reside on the same system in the same location or they could be distributed geographically and use a variety of computer platforms. A wide area or local area network could electronically link the project participants. This would ensure that all participants have access to the same general engineering and project specific data.

All stages of the construction process can benefit from CIC as it uses technology to assist the sharing of data and knowledge. Engineers today can design in three or even four dimensions using CIC software, producing a more accurate representation of the drawing and/or model. Three-dimensional computer models aid in the communication process between the architect and engineer as well as the construction management and the working environment (95). One software package being used, Construction Management Display System (COMANDS), enables constructors to develop three-dimensional computer models into the finished product over the fourth dimension, i.e. time. Thus, they can plan the order of construction steps and identify the conflicts that may arise (96). Since computer models are electronically transmittable, construction plans may be better communicated to materials suppliers and subcontractor personnel in other locations. COMANDS also calculates from the graphic model the true area and volume of every component and determines the quantities of material needed. Managers can then produce more efficient construction schedules which can help track daily progress. CIC provides a linkage between the various project participants such that data is consistent and compatible with one another.

The implementation of CIC in the design of an environmental retrofit for a powerplant in Stevenson, AL, led to significant benefits (96). The use of three-dimensional models helped to minimize field welds, cut all welding time by approximately 15-20 percent, eliminate fit-up problems, optimize the superstructure framing arrangement for the flue-gas ductwork, and reduce field costs (96). Not only was the project completed on time, but it was completed under the budget; it was estimated that more than $3 million was saved on the $60 million project.

The construction industry has the opportunity to experience substantial benefits from implementing CIC and other similar networking technologies. It should be kept in mind that the goal is to improve communication and data exchange between project participants. Thus, the information infrastructure should be relatively easy to connect onto, and common protocols should be established.

6.5.3 *Automatic Identification*

Radio-frequency identification (RFID), a branch of automatic identification (auto ID) technologies, utilizes radio frequencies to capture and transmit data (97). RFID is comprised of tags or transponders that collect and store data which is transmitted to a reader and then sent to a host computer. Currently, RFID tags are being used for toll collection, material identification, tool handling, equipment maintenance, and asset location and tracking (97). RFID also has the potential to track the activities of workers and equipment; as the object passes a fixed scanner, the movement of the object is recorded. The use of RFID can save the construction industry time, money, and effort. It is however, limited by the lack of standardization and common protocols; one supplier" tags cannot be read by another supplier’s reader.

6.5.4 Advanced Positioning Technologies

Locating and positioning components in the field, a basic construction operation, traditionally requires surveyors using optical instruments, levels, total stations, and chains or tapes (98). This can be a time-consuming, expensive, and error-prone method. In the construction industry today, there are several positioning technologies available which provide three-dimensional (3D) coordinate data, e.g. total stations, differential global positioning systems (DGPS), and Real-Time Position Measurement (RtPM) (98). Total stations typically use an electronic distance measuring (EDM) device to measure distance, a theodolite to measure vertical and horizontal distances, and an on-board processor to automatically measure each of the resulting measurements (98). The satellites orbiting the earth transmit Global Positioning Systems (GPS) data to receivers which then process the information to determine the receiver’s position. DGPS is the positioning of one point relative to another. RtPM is a state-of-the-art laser-based system which consists of a minimum of two transmitters and one receiver. The transmitter sits on a tripod with the face plate aiming the infrared “light” towards the site. Several known points on the site are required to back-calculate the position of the transmitters. A user with a receiver is able to determine the operator’s position as long as the operator can see two transmitters.

Each of the three positioning systems described above can be integrated with computer-aided design (CAD) “to form a real-time construction layout and as-built development system” (98). Such a system offers many advantages as it allows for real-time modeling, real-time data distribution, and real-time control of the equipment and can save substantial time in rebuilding and inspections. Many people are, however, skeptical about the reliability and accuracy of data generated from such methods. It is hard to have “faith in a tool in which you cannot see or feel any part of the element being measured” (99). For this and other reasons, training in basic systems is necessary to keep the workers up-to-date with the latest technologies.

6.6 Maintenance

Transportation systems must be consistently maintained to ensure success. Manual inspections of the sites, condition reporting, scheduling a crew to fix the problem, and submittal of field reports to the office for processing require significant amounts of time and effort. Improved telecommunication technologies offer new and better ways of recording data, tracking resources and inventory, evaluating performance, and planning activities (100). Most of the state transportation agencies today are using electronic equipment and automated electronic procedures for collecting and transmitting data (101). Automation of existing procedures can help transportation agencies "reduce costs and improve the overalll efficiency of maintenance data collection" as well as the maintenance unit (101).

Innovative technologies being considered include: barcode scanners, voice recognition systems, globacl positioning system (GPS) receivers, mobile phones, and digitized maps. These technologies may also be applied to sign inventory and sign maintenance management. The application of the technologies addresses the following maintenance data collection activities: work scheduling, work reporting, roadway feature inventory updating, and maintenance quality evaluation (101). In the following sections, the various application of technologies will be discussed.

6.6.1 Quality Evaluation

A maintenance quality evaluation (MQE) program inspects sections of highway sites to determine whether the conditions of the road meet the state's standards (101). The use of advanced field data collection equipment for recording and uploading site assessment data can eliminate paperwork and reduce the amount of time entering the data (101).

6.6.2 Scheduling

Maryland, Connecticut, and Arizona have all tested computer-aided scheduling on a full-function electronic clipboard with a glass screen. The procedure permits activities to be planned in weekly or bi-weekly schedules from the following potential work categories: annual work program, service requests, patrol reports, leftover work, emergency needs, and recommendations of a Pavement Management System (PMS) (100). New files may be transferred into the electronic clipboard so that the scheduler can build a schedule from a more complete list of projects. The scheduling system automatically generates work orders in the form of crew cards when the scheduler picks a task from the list. These crew cards are prefilled with information such as the location, crew size, and equipment, and thus save time in writing.

6.6.3 Work Reporting

Daily work reports provide feedback to the office regarding the productivity of maintenance units to determine whether adjustments are necessary. Current systems used for daily work reporting include: electronic clipboards, hand-held terminals with bar-code scanner, voice recognition, GPS, and remote data transfer (100). Crew leaders fill out reports on electronic clipboards which displays a digitized image of a crew card. This allows a report to be partially filled and saved to be completed later. Because crews are sometimes working at distant places for days at a time and cannot return to headquarters to turn in their work reports on a daily basis, the electronic clipboards are equipped with a modem and phone jack. This allows for data transfer via telephone lines. The bar-code system requires a set of preprinted bar-code labels for each data field. The crew leader can either scan a label or use the keypad to enter the data. Voice recognition systems work in a similar manner in that the user creates voice templates with vocabulary such as employee names, equipment names, and numbers from 0 to 0. The user, connected to a headset with microphone and earphone, is able to do reporting in the field.

6.6.4 Inventory Updating

Inventory updating is necessary for accounting and maintenance purposes. Annual work programs and budgets often rely on the quantity of maintenance elements and may influence the allocation of maintenance resources available (100). District officials and superintendents use the inventory list to assess needs and review work schedules (100). The process of updating the inventory is, however, often ineffective since crew leaders and supervisors lack the means to accurately locate roadway features. The electronic clipboards described above are capable of updating inventory, but use of GPS with its digitized maps and coordinate-referencing provide a more effective and precise way of locating inventory assets (100).

Three states have already implemented a route-milepost system to identify highway locations and are now looking into integrating their GPS data with a geographic information system (GIS) because they feel that GPS is able to provide a more accurate location description than can their current procedures (101). Workers will then input daily work reports and update roadway feature inventory into the system and be able to recall the information on a computer in the form of a map. It will be necessary for GPS to be compatible with other electronic devices such that automatic transfer of coordinates is possible. The accuracy of GPS ranges from 300 feet to as little as less than one foot, depending on the system used.

6.7 Operations

Caltrans and other transportation agencies have, in recent year, made a considerable effort to apply new technologies to traffic operations. Information and communication technologies play an integral role in the deployment of new technologies. While it is difficult to determine what proportion of the total expenditure on transportation is on new technology, some idea of the importance placed on new technology can be gleaned from the expenditures on major research and development programs.

A summary of recent research expenditures for the Federal Highway Administration (FHWA), the National Cooperative Highway Research Program (NCHRP), and a sample of state R&D programs is shown in Table 6-1.

Table 6-1: Summary of Expenditure Assignments

	Expenditure (5)		
Category	FHWA	NCHRP	States
Incremental Improvements	59	56	54
Breakthrough Research	5	13	0
U.S. Transportation Systems Issues	<1	4	<1
Policy Analysis and Regulatory Compliance	9	0	<1
Intermodal Transportation	<1	10	<1
Technology Transfer/Field Applications	11	15	6
Education and Training	10	<1	15
Technical Support and Testing	6	0	25

Source: Research and Technology Coordinating Committee. Highway Research: Current Programs and Future Directions. In Special Report 244, TRB, National Research Council, Washington, D.C., 1994, pp. 84-85

A breakdown of the incremental research categories is shown in Table 6-2 below. The table indicates that a substantial proportion, i.e. 42 percent of the total amount, was spent on traffic operations and Intelligent Vehicle Highway systems (IVHS), now Intelligent Transportation Systems (ITS).

Table 6-2: Expenditures in Incremental Research Categories by Technical Topic, 1993

	Expenditure (%)			
Technical Topic	FHWA	NCHRP	States	Total
Highway safety, including highway design	11	10	8	10
Traffic Operations; IVHS	47	17	18	42
Pavements: design, construction, performance	10	13	33	17

Bridges and other structures	14	33	21	16
Materials and maintenance	5	3	12	5
Environment	4	24	2	4
Planning	10	0	6	9

Source: Research and Technology Coordinating Committee. Highway Research: current Programs and future directions. In Special Report 244, TRB, National Research Council, Washington, D.C., 1994, p.86

It should be noted that Caltrans already has a significant research program in the area of advanced technologies. Major initiatives related to new technologies have taken place in California and nationally. An example of such an endeavor is the Metropolitan Transportation System (MTS) Management Strategy program undertaken by the Bay Area Partnership. Thirty-one agencies form this Partnership, which is actively concerned about moving people and goods and protecting the environmental quality in the Bay Area (102). It is beyond the scope of this project to review all of the initiatives and to attempt to improve on these efforts. It may be useful, however, to present a brief review of some of the major development efforts, to review the essential goals of the developments, to make some conclusions regarding some major policy issues and to suggest some possible future actions and initiatives.

6.7.1 Overview of Traffic Operations

While the field of traffic operations is complex and multi-faceted, it could be argued that regarding highways and streets, most people understand traffic operations to consist of the improvement of traffic flow (reducing delay) and safety. In addition, vehicle operating costs, environmental impacts and comfort and convenience are also considered. Transit agencies also deal with the management of transit vehicles. In recent years, commercial vehicle management has received increased attention.

The limitations and/or capabilities of drivers and vehicles have always been considered in design standards and traffic management procedures. With the advent of new technologies, it has become possible to exert greater control over vehicles from the roadway environment. It may be argued that vehicle control should not be part of this discussion, but the control issues are closely related to the information issues in transportation. Moreover, it is highly probable that information and control data will use some of the same conduits. Because of these reasons, this topic will be included in this discussion.

6.7.2 Highway and Street Traffic Management and Control

The process of traffic flow improvement through traffic management and control has essentially consisted of obtaining data and information on traffic, roadway and control conditions; optimizing the traffic flow through roadway and control improvements and subsequently providing travelers with information which will aid in their regarding trip-making. Safety improvements have primarily consisted of making improvements in the vehicle and roadway environment and by regulating drivers.

Better traffic management can be attained through additional and more accurate data collection and traffic surveillance. Improved traffic modeling techniques and use of the modeling outcomes should lead to better traffic control. Improved information on traffic and roadway conditions can be made available to drivers to make better route choices.

6.7.2.1 Traffic Data Collection and Traffic Surveillance

New data collection and surveillance systems utilize video, laser, sonic, optic and electromagnetic technologies. Some systems are designed to collect traffic flow, speed and occupancy data for use in traffic management systems, while others are designed to classify vehicles for the purposes of toll collection, pavement design, and traffic management. Some video systems are designed for real-time surveillance of traffic to allow for traffic control and incident management. By combining these developments with better communication and data processing capabilities, the ability to collect, process, and distribute traffic data has been significantly improved.

One issue which requires consideration here is the specification of objectives and standards for these systems. For instance, according to Caltrans personnel, the primary function of the current Caltrans loop detection systems is incident detection. This requires a certain amount of accuracy. If, however, these systems were to be used for other functions, the specifications for both hardware and software may have to change or perhaps a different system should be used. Also, the districts currently operate their systems in different ways and with different standards. There may be benefits, from the viewpoint of cost-efficiency, to standardizing objectives and/or assuring compatibility for the development and operation of the systems. This will also be important in view of the benefit of accessing and sharing of information by different districts or among different organizations.

There is an on-going effort to develop a national architecture for ITS (103). However, it will probably be impossible to foresee all the possible problems that may arise from integrating the hardware, software, and protocols into the systems and projects at all levels of transportation agencies. Continued participation in the development of the national architecture will be necessary to influence the process of meeting Caltrans’ goals. In addition, it will be helpful to conduct an internal review of long-term goals and objectives for these systems in determining the required standards. Moreover, these systems should be reviewed in view of the integration with the systems employed by local authorities.

It should be noted that since the change associated with the development of new technologies is rapid, the development of standards should be on-going. In the past, a great deal of the implementation had been coordinated by the Metropolitan Planning Organizations (MPOs) (102). Today there is a need for including local authorities outside the MPOs, especially in view of the impacts on these communities. Telecommuting and other factors have caused growth in these surroundings urban and rural communities. Regional Transportation Planning Agencies (RTPAs) provide similar functions as the MPOs in the rural areas of California, but the individual agencies may not have the necessary expertise to deal with the application of the systems which employ the new technologies. Caltrans personnel have indicated that some of these communities do not have a large tax base available for making improvements. Implementation of new technologies may decrease some of the cost associated with implementing solutions to congestion and safety problems. Also, research has shown that some small communities falling under an MPO do not have the expertise to deal with some of these systems (104). For these communities and some rural areas, Caltrans appears to be the logical organization to aid in the implementation of these systems.

6.7.2.2 Data Processing and Traffic Modeling

The data obtained from the traffic surveillance is mainly used to provide information for travelers to choose the best route based on travel conditions, and for managing and controlling traffic. In order to provide travelers with this type of information and to choose the best management plan, the data needs to be processed and different alternatives evaluated. This requires computer models which can process large amounts of data and simulate traffic on large networks. Such simulation models, e.g. NETSIM and INTEGRATION, have been in development for a long time. The INTEGRATION model has been applied to demonstrate the simulation of advanced traveler information systems. The appropriate use of these models require substantial expertise and ubiquitous use of the models will necessitate education and training. Again, Caltrans appears to be the logical agency to aid in this process.

Computer models can be employed for planning purposes, using projected data, and for analyzing problem situations. In addition, computer models are valuable tools for evaluating the performance of systems after implementation. It is difficult and expensive to evaluate the performance of a traffic management system by collecting data on such performance measures as total delay, fuel consumption, etc. Using historical data in a judicious manner with these models, evaluation can probably be accomplished less expensively. This is an important issue, since proper evaluation will provide evidence of the advantages that sophisticated systems can offer. Funds for post-evaluation of a project are often hard to justify. Decision makers and their constituents often do not see the value of expenditure for evaluation when the funds could be spent on the implementation of improvements to roads, etc. Being able to carry out evaluation at low cost makes evaluation more feasible.

It is proposed that an evaluation of the Santa Monica Freeway Smart Corridor project and the Highway 17/880 Smart Corridor project be undertaken, as planned, once these projects are fully implemented, and specific recommendations be made regarding the coordination of the implementation effort, as well as the integration of the traffic management and other functions across jurisdictional boundaries. In the case of the Highway 17/880 Smart Corridor, the post-implementation situation should be compared to the pre-project situation as much as possible.

Further, it is recommended that a pilot project be undertaken where Caltrans and other transportation agencies coordinate their construction and maintenance activities, perhaps on a weekly basis. This could be accomplished by establishing a video-conference at regular times to resolve issues. Between meetings, proposed changes in schedules and other relevant information can be posted on message boards on the project's intranet, which can be accessed only be project members. An evaluation of this project should also be undertaken with the view of implementing long-term integration of traffic management.

6.7.2.3 Traffic Management and Control

Transportation management and control systems can be improved by implementing less expensive and more effective control systems. New technology applications can be used to improve or to decrease the cost of every aspect of these processes. Use of modern inventions in materials, such as fiber optic cable to communicate with signal systems, make traffic management and control more cost-effective and efficient.

New communication technologies have made the integration of systems possible or feasible which in the past would have been very costly to implement. This integration can occur in several ways. By integrating traffic surveillance, processing, and disbursement of the data to travelers or using the data for traffic management and control, real-time traffic management becomes possible. This can be characterized as vertical integration of the system. Horizontal integration, i.e. integration across geographic and jurisdictional boundaries, also becomes more feasible because of lowered cost.

There are several other ways in which vertical integration is utilized. A typical automatic incident detection system includes a central computer or distributed microprocessor system that monitors signals from vehicle detectors spaced along the highway. The computers are programmed to detect incidents by identifying particular disturbances in traffic flow patterns. The surveillance and control points within a specific service area can be joined at a roadside cabinet, then connected to a surveillance center. Video cameras at strategic points can also be used to view the cause of the incident before appropriate action is taken to solve the problem, e.g. dispatching a tow truck.

Ramp metering is another example where advanced communication technologies can be advantageous. The ramp metering rate can be established based on automatic detection of the mainline flow.

Automatic Vehicle Identification (AVI) systems consist of information contained in an electronic tag placed on the vehicle; read by an antenna; transmitted to a central computer where road tolls can be deducted from a pre-paid account or charged to an account. AVI systems can also be used for road pricing and have made toll collection more efficient. Currently, the Route 91 Express Lanes in Southern

California charge different toll rates at different times of the day: 25 cents for a trip in the middle of the night and $2.50 for a trip during the middle of rush hour. The existing electronic toll system will soon use an AVI subsystem which will identify vehicles by toll classifications and collect the appropriate toll (105). Similar projects are now being considered in other parts of the State.

Table 6-3: Summary of Electronic Toll Collection System Benefits

Operating expenses	Decrease up to 90%
Capacity	Increase 250%
Fuel Consumption	Decrease 6%-12%
Emissions	Decrease CO emissions 72% per affected mile
	Decrease HC emissions 83% per affected mile
	Decrease NO_x emissions 45% per affected mile

Source: Intelligent Transportation Infrastructure Belefits: Expected and Experienced. The MITRE Corporation, Federal Highway Administration, Washington. D.C., January 1996.

From the "Working Paper: Overcoming Non-Technical Barriers: Lessons Learned from ITS Operational Test," it became evident that difficulty in deploying these systems may not only lie with technical staff or lack of technical staff, but also with decision makers not fully understanding these systems and the benefits they offer. Since these decision makers are responsible to the public and the public is ultimately the users of the transportation systems, education of decision makers and the public is necessary to successfully implement these systems.

A concept of interactive traffic control systems is being formulated (106). Ideally, such a system would link real-time traffic monitoring and short-term forecasting together with electronic route guidance. The system would then be able to use the data on actual vehicle destinations to optimize signal coordination and vehicle route choice within the highway network.

6.7.3 Driver/Traveler Information

If travelers were provided with accurate current information on travel time by mode and by route, they will be better able to make appropriate choices and therefore make better use of the transportation system and avoid undue delay.

Trip information can be provided at different times of the trip: before starting and/or during the trip. Before starting the trip, the correct choice of mode and the initial appropriate route can be chosen. When en route, drivers can choose the appropriate route for the remainder of the trip, when such choices are available.

Route distances, and in some cases travel time, have long been available on maps, while traffic reports on television and the radio enabled motorists to avoid routes where inordinate delay was experienced. Transit information, showing routes and schedules, have also long been available. New developments have made it possible to obtain this information on demand in various forms.

Some of the major new developments in driver/traveler information systems include the creation of road maps on the Internet, providing real-time information on traffic speeds and electronic route planning in various forms. In this regard, Maxwell Laboratories, Inc. and Caltrans are currently providing real-time traffic information for freeways in Southern California over the Internet at http://www.scubed.com/caltrans/transnet.html. The Southern California Real-time Traffic Report provides freeway speeds for the areas of San Diego, Los Angeles, and Orange Counties.

The speeds and flow rates for all lanes and on and off ramps are monitored from the detectors embedded in the roads: 1050 detectors in Los Angeles County, 400 detectors in Orange County, and 185 detectors in San Diego (http://www.scubed.com/catlrans/la/how.html). These maps show the freeways and detector locations and contain clickable links to each of the detector locations. By clicking on a detector dot, specific flow and speed information for that location will be displayed. Speeds for L.A. freeways in tabular format are also available at the same Web site. The real-time data are updated approximately each minute and the user must "reload" the screen for the most current data.

Incident reports, Caltrans construction closures, and flow rates are available for the county of San Diego at http://www.scubed.com/caltrans/sd/sd_transnet.html, while general road conditions for the entire state of California (i.e., Interstate Highways, U.S. Highways, State Routes, and a few mountain passes) are available to the public at http://www.dot.ca.gov/hq/roadinfo/.

Changeable message signs provide real-time information to drivers regarding incidents, traffic and weather conditions on the road and also on appropriate routes to deviate onto. The issue of deviating traffic to local streets is a sensitive issue, since local authorities may not wish to cope with the problems caused by the increased traffic. Improved and continuous communication among authorities, when the deviations are contemplated, will help alleviate this problem. Improved data collection devices can aid in monitoring traffic conditions and the impacts.

Rental car firms in the U.S. are using an electronic route planning system to provide drivers with directions to their destinations and aid the pretrip planning process. Users can access (either directly or through a telephone line) the electronic route planning system which is linked to highway network databases. A destination is first selected from a structured database. The system then finds the optimum route for the drivers by using minimum-path computer algorithms (106).

Etak Inc., a provider of automotive navigation technology and software, has developed digital road maps, geographic databases, and navigation software for use in various ITS projects, i.e. Los Angeles' Pathfinder, Orlando's TravTek, Chicago's ADVANCE, and the San Francisco Bay Area's TravInfo.

TravInfo is an Advanced Traveler Information Systems (ATIS) sponsored by the Federal Highway Administration (FHWA). The TravInfo Field Operational Test (FOT) is being implemented through a public/private partnership and administered by the Metropolitan Transportation Commission (MTC). In early 1996, the system went on-line providing travelers in the nine-county San Francisco Bay Area with "up-to-date" multimodal information. Data from TravInfo is to be disseminated throughout the Bay Area and to longer distances, either by way of the Traveler Advisory Telephone System, Landline Data Server (LDS), or the Wireless Data Broadcast System (DBS). Travelers call the Traveler Advisory Telephone System for data, while registered TravInfo participants have on-demand access to the database through leased-line and dial-up line modem connections. In the fall of 1996, DBS was planned to transmit the same data as the LDS over a high-speed FM subcarrier.

The TravInfo system will be housed at the Traveler Information Center (TIC), which has been established by the public sector and operated by a private contractor. Data will be either manually collected or automatically transmitted from various public and private sources and integrated in a comprehensive database. The geo-locations and speeds transmitted by the Freeway Service Patrol's roaming tow trucks to the TIC will be combined with the speed and congestion data collected from Caltrans' Traffic Operation System (each of the tow trucks is equipped with an automatic vehicle locator and communication system). Data such as video feed, raw five-minute volume, occupancy, and stop and delay rates will be available from San Jose's Traffic Signal Control Center. MTC is also sponsoring a regional transit database which is to include each operator's routes, schedules, and stop locations. Traffic and mobility information gathered by the privately owned Metro Networks will be transmitted via computer links and two-way radio the TIC operators. TIC will receive a real-time list of incidents and accidents on the entire Bay Area freeway system and selected major arterials from the CHP's Computer Aided Dispatch (CAD) system. Just as Caltrans will be able to provide real-time information on construction and maintenance sites (many of their vehicles have are equipped with mobile communication devices), Bay Area Commuters' vanpool drivers also have cellular phones from which they can call to report incidents on their routes to the TIC. The California State Automobile Association will relay incident and congestion reports it receives from their fleet of vehicles equipped with Specialized Mobile Radio to the TIC via telephone or the Internet. Other information such as the weather and bikeways will be collected from various sources.

Information from TravInfo which will be broadcast include: roadway incidents, announcement and status of planned interruptions or events, and status of planned events, transit incidents, real-time transit schedule, availability of parking, speed for roadway segments for HOV and non-HOV lanes, roadway congestion for HOV and non-HOV lanes, identification of point-of-interest locations, transit fare information, transit routes, regional bikeway information, and weather status.

For all these systems to be successful, it will be necessary for the public to be aware of the availability of the systems and the benefits. In addition, the systems should be easy to use and not intimidate the public. In cases where private vendors are providing the systems, the profit incentive should lead them to market the systems in an adequate fashion. In cases where a public agency is marketing the system, it will be necessary to create public awareness and also market the system.

EtakGuide, a digital travel guide for car navigation system, combines both the travel guide information with the road information, showing a vehicle's progress as it navigates toward a destination. When both a vehicle navigation system and the EtakGuide are installed, EtakGuide is able to pinpoint the vehicle's location on a map using signals the Global Positioning System (GPS) receives from satellites orbiting around the earth. The system allows the user to zoom in a map to see the major regions as well as the individual streets (107).

Real-time traffic information is an important part of ITS. Studies in this area are being conducted in the U.S. and in Japan. One on-going projects is the ADVANCE (Advanced Driver and Vehicle Advisory Navigation ConcEpt) in the northwest suburbs of Chicago. This is a project between private, commercial and public agencies which will evaluate the performance of an in-vehicle navigation and dynamic route guidance system. Test vehicles serve as probes, providing real-time traffic information to a Traffic Information Center. The traffic center processes this information and the embedded loop detector data it receives is used to develop preferred route instructions and estimate travel times. This data is then transmitted to vehicles, other than the probe vehicles, equipped with the navigation and route guidance systems in the form of dynamic routing instructions.

Highway advisory radio (HAR) broadcasts traffic information in the U.S. and Japan. The location, extent of coverage, and message content is regulated by certain rules since HAR is operated by local and federal government agencies (106).

Many transit agencies around the world have successfully implemented a database system which allows travelers remote access by telephone to transit information such as travel route, schedules, and fares (106). This method of telephone inquiry and remote access are potentially applicable to any mode of transit including ridesharing and dial-a-ride facilities.

The Transit Information Project provides instant on-line transit information for the San Francisco Bay Area on the Internet. The Bay Area Transit Information Project began on May 25, 1994 as a project by two UC Berkely students (108). Information available includes schedules for AC Transit, CalTrain, Golden Gate Transit, Greyhound Lines, Sam Trans (San Mateo County), San Francisco MUNI, and

Santa Clara Valley Transit. Regional information such as service to the airports, service to special events (e.g., sporting events and concerts), commuters' guide for bicyclists, and the East Bay – Peninsula Commuter Club, are all on-line. An announcement section was added in September 1994 to inform people of the latest Bay Area transit news. Other announcements such as service changes and additions to the Transit Information Page are also made available via the Internet. Maps for various regions are downloadable or printable.

It is now possible to make trip reservations and payments by calling a facility and leaving a credit card number (106). It is anticipated that usage of voice pattern recognition technology will minimize the risks of making and confirming a reservation over the phone by being able to verify the identity of the person making the booking. In the future, the "smart card" will eliminate current "multijourney card punch or magnetic strip based pretrip purchase schemes" (106). The "smart card", which is roughly the size of a credit card, will contain a microprocessor that can hold information about the cardholder, i.e. name, address, and social security number, and may also be used as a personal identification device.

Real-time information such as timeliness of transit vehicles and connecting services is valuable to travelers in determining the amount of time spent at the interchange. Ideally, this could be connected to an interactive system, such that a terminal is installed at each bus or rail seat. The system can acts as an information provider for passengers, e.g. locating stops, as well as a guide for tourists, referring to places of interest by using information already stored on a compact disc.

In Chapter 4, the conclusion was made that transportation agencies have essentially the same structure as businesses and could potentially operate in the same way. In cases where these new systems require marketing, the same principles of marketing used by businesses could be employed.

The issue of business transactions also arise in another context. Discussions with Caltrans personnel revealed that revenue could be generated by selling information and advertising space. Traffic information could be sold to vendors providing dynamic route guidance. Caltrans could allow logos to be placed on Web pages displaying information. The legality of generating revenue in this fashion still needs to be resolved.

6.7.4 Transit Management

The concepts of Advanced Traffic Management Systems (ATMS) are also applied to transit vehicles. These concepts include the preferential treatment of certain vehicles and to the enforcement of to undergo the time-consuming process of violations on the roads. ATMS technologies are applied primarily in the following six areas: traffic signal priority, reserved highway lanes, ramp metering bypass lanes, toll highways, parking areas, and enforcement (106). By using inductive loops or piezoelectric axle sensors, transit vehicles may be identified on the approach to an intersection. The intent is that traffic signal timings are then adjusted in favor of the transit vehicle. Violations of bus-reserved lanes may also be detected using the same technologies. Electronic still cameras, installed by the side of the road, record images on a magnetic disk that can be transmitted over a telephone line. The image is displayed on an ordinary television monitor without having developing photographic film.

There are a variety of computer software being used today by many transit agencies for planning their network and operations, scheduling vehicles and crew, marketing, and management and administration. Some other available software may even analyze performance and control production and spare parts (106).

Electronic ticketing systems (ETS) can potentially collect detailed information when passengers board the vehicle and pay their fare. (Collected data is limited to passengers who pay by cash and do not use prepurchased travel cards.) The revenue data gathered may then be classified by route, ticket type, or passenger type; information regarding the passenger may also be sorted by ticket class, route, or time of day. Transit agencies may use the data collected to monitor the demand or input the data into a transit software package.

Onboard computers (OBCs) consist of a computer connected to several electronic sensors that are attached to different components of the vehicle. These sensors collect data on vehicle performance and driver behavior. The data is then stored, downloaded to a control center, and later used to put together historical records which may include vehicle speed and length of idling periods. Some OBCs allow the operator to input various parameters.

AVI technologies, as applied to fleet management, can be implemented to monitor vehicle information at a control center. Readers installed at selected locations will scan the transponder mounted on the transit vehicle as it passes by and transmit the data. Management can then track down and identify the location of the vehicle and route number. AVL technologies may also be used to monitor the location of vehicles in the fleet as AVI does.

6.7.5 Commercial Vehicle Operations

The application of ITS technologies will benefit commercial vehicle operations (CVO), i.e. trucks, transit, and emergency response, by making them more safe, productive, and efficient. Being able to locate the position and to communicate with a commercial vehicle or a fleet of commercial vehicles is very desirable, since it provides the fleet manager with the ability to better utilize the fleet and to better predict and schedule arrival times at pick-up and delivery points. In the past, radio has been used for this purpose. New automatic vehicle location (AVL) systems offer the advantage of being better able to locate vehicles without having to communicate with the drivers. A fleet manager is able to schedule complex trips with multiple destinations in real-time, as orders are received or circumstances change. AVL systems consist of dead reckoning (DR), beacon proximity, or radio-determination, which compute the location of the vehicle. This information is then available to the manager at the control center either on a map or as a coordinate listing.

Advanced technologies will also allow for automated roadside safety inspections and on-board safety monitoring which targets unsafe carriers, vehicles, and drivers (79). The processes of regulating commercial vehicle operations, administering taxes, and acquiring credentials can also be automated such that the paperwork is minimized and labor costs reduced (79). Vehicles can be precleared when crossing national and international borders. Development of a commercial vehicle information systems network (CVISN) will improve the exchange of information between commercial carriers and fleet managers.

6.7.6 Vehicle Control

Steering, braking, and speed control constitute the major vehicle control functions. When on a road, the driver has to maintain a safe following distance from the vehicle ahead and maintain the appropriate lateral position relative to other vehicles, lane markings, and obstacles. The driver also has to detect and avoid collisions with other vehicles performing expected and unexpected maneuvers and also stationary objects in expected and unexpected locations. Advances in new technology have enabled systems which aid the drivers in the driving tasks. Some of the advances envisioned will take some of the tasks away from the driver and have the vehicle or other systems perform the task.

The antilock braking system is one of the early developments in the area of Advanced Vehicle Control Systems (AVCS). The system uses sensors and a computer to detect excessive braking and pumps the brakes such that there is rapid, nonskid braking. Intelligent Cruise Control aims to interpret sensor information on road and traffic conditions, speed of other vehicles, obstacle detection and forward visibility to adjust the speed accordingly (106). Automatic Steering Control (ASC) systems have: “(1) a roadway reference system that can be sensed by a vehicle in order to ascertain its lateral position relative to the highway; (2) onboard sensors that measure the lateral displacement and determine any necessary remedial action; and (3) a steering control system that acts automatically on command signals to maintain or adjust the lateral position as required” (106).

When all of the driving functions are automated, the system is called an Automated Highway System (AHS). Such a system has the potential for increased capacity and safety. The capacity and safety gains are still being studied, but capacities of multiples of the existing capacity are expected. The AHS concepts currently being studied include systems which require dedicated lanes and some that do not.

The implementation of an AHS will require significant changes to road planning, design and operating standards and procedures. Policies related to these changes will have to be developed, but these issues are outside the scope of this report. The communication and information systems required for an AHS will probably be partly shared with the ITS systems. It is therefore essential that Caltrans be continuously involved in the development of the national architecture as well as the AHS system. At the moment, Caltrans is heavily involved in the development of the AHS as a member of the National AHS Consotium and through the PATH program.

6.8 Conclusions

It was found that there are many applications, spread over a wide spectrum, for the new communication/information technologies. Development is rapid and will affect all agencies. The following major conclusions were made:

1. There is an opportunity to make more information available on-line, and the image of transportation agencies will be enhanced if a central unit, such as recommended in Chapter 3, could coordinate the information.

2. In view of the rapid development and implementation of new technology, increased attention and funding should be given to education and training. Education and training in the understanding of the underlying systems is also essential. The training will be necessary for technical personnel as well as for decision-makers to allow them to evaluate and use new proposed systems correctly. Because projects cross jurisdictional boundaries more often, Caltrans personnel may find themselves more often in leadership and/or coordinating roles. This will necessitate training in skills other than the technical aspects of the projects. New technology, through distance learning and computer and other electronic media, makes learning on demand possible and/or less expensive and there is probably room for improvement in this area in Caltrans as well as other transportation agencies.

3. Financial transactions, such as selling toll cards, could be accomplished over the Internet.

4. New technologies will make the implementation of the roundtable concept possible through electronic media, without having to meet physically. It will be easier to work with projects that transcend district or jurisdictional boundaries.

5. Caltrans could promote telecommuting within and outside the organization, thereby lessen congestion on commuter routes and could also research the telecommuting patterns of its own program for future decision-making.

6. There are several opportunities for Caltrans and other transportation agencies to utilize the new technologies in planning activities. These could include making information on planning projects available to the public and other agencies, collecting and processing data. Also, as the public becomes more accustomed to being able to access information by electronic means, their expectations of having such information readily available will likely increase.

7. New technologies could make the collection and processing of data more efficient. Having better information available will allow for better planning and design. As discussed before, this could lead to cost savings by eliminating more potential problems at the beginning of the project. Also, linking of information from initiation of the project through operation, by using compatible hardware, software and protocols, will lead to efficiency and cost savings.

8. The rapid application of new technologies to the planning, design, management, construction, maintenance and operation of transportation systems offers the opportunity of implementing more sophisticated systems because of the cost advantage provided y these new technologies. Most of these systems or the function that they fulfill are not new, but the decrease in cost makes the implementation of more extensive, complex and more effective systems feasible. Decisions on implementing road closures may be one area where an on-line roundtable can especially facilitate discussion among Caltrans and local governments.

9. There are potentially great benefits to be obtained through better communication, organization, and planning. Improved information and communication technologies make these activities less expensive and the advantage should be taken of these opportunities. It is, however, often difficult to convince decision-makers to spend more on these activities, which have seemingly intangible outcomes, to save money later on in the product life, rather than on tangible projects. Evaluation of projects with these components will be necessary to serve as input to future decision-making.

10. There is a potential for generating revenue from, for instance, selling access to information, providing an opportunity for advertising and leasing space in the ROW for fiber optic cable or similar equipment. The desirability and legality of these issues should continue to be studied. The Alameda County Congestion Management Agency (CMA) is currently investigating the feasibility of such projects, including advertising rights on changeable traffic message signs, along the I-680 corridor.

6.9 Recommendations

The following actions are recommended:

From a policy point of view, Caltrans should take advantage of all technologies, which could improve the efficiency and effectiveness of traffic operations. The question is, what should Caltrans do differently? Because a large portion of what are presented as new systems are probably not new (only the technologies that support the systems are new), significant changes in the organizational structure or the operating procedures are probably not necessary or desirable. It will be advantageous, however, to give attention to the areas where significant changes are necessary or desirable. The following recommendations are made:

1. The training program proposed earlier should address all functions, from administration through operations. The program should educate and train personnel to implement and use the systems necessary and desirable for the operation of the agency as well as the transportation systems, with special emphasis on the implementation of new technology.

   The objectives for the program should be developed in consultation with the individual agency departments and could be administered by Caltrans or by one or more of the state’s public universities. The program could be similar to the LTAP program administered by the Institute of Transportation Studies Extension Program at U.C. Berkeley. The program should encompass all of the transportation agency functions, and the courses must be useful to all levels of agencies. The specially-designed and other relevant available training courses should be listed in the Caltrans headquarters homepage.

Consideration should be given to educating decision makers and the public of the advantages and use of systems which use new technology and which may be foreign to them.

2. The unit, proposed earlier to oversee interagency communications, should also investigate the opportunity for savings provided by linking the information, used in the different phases of a project, through compatible hardware, software and protocols.

3. The following studies should be undertaken:

- Once projects such as the Santa Monica Freeway Smart Corridor project and the Highway 17/880 Smart Corridor project are implemented, the planned evaluations should be undertaken and specific recommendations be made regarding the coordination of the implementation as well as the integration of the traffic management and other functions across jurisdictional boundaries. In the case of the Highway 17/880 Smart Corridor, the past-project situation should be compared to the prior situation as much as possible.
- Issues relating to the desirability and legality of selling information and leasing space in the Right of Way should be further investigated.
- The feasibility of selling toll cards over the Internet should be evaluated.

4. A pilot project should be undertaken where Caltrans and other transportation agencies in a specific region, coordinate, perhaps on a weekly basis, their construction and maintenance activities. This could be accomplished by establishing a regular video-conference at regular times to resolve issues. Between meetings, proposed changes in schedule and other relevant information can be posted on message boards on the project’s intranet, which can be accessed only by project members. An evaluation of this project should also be undertaken with the view of implementing long-term integration of overall traffic management.

7. OVERALL SUMMARY AND RECOMMENDATIONS

Hardly a day goes by without mention of the "Information Superhighway" or the Internet. The federal government refers to the emerging Information Superhighway as the "National Information Infrastructure" (NII). In "The National Information Infrastructure: Agenda for Action," (1) the government envisions the NII to be "a seamless web of communications networks, computers, databases, and consumer electronics that will put vast amounts of information at users' fingertips."

The future Information Superhighway will include the Internet and more. Cable and television companies are fighting for control of who will build the information highway and hope to be able to connect each home and business. The concepts of video-on-demand and interactive television are also a part of what the Information Superhighway comprise.

The Information Superhighway and the associated information and communication technologies are emerging topics of significant importance to California's economy and infrastructure. They involve important, and as-yet-ill-defined, issues of technological development and societal behavior. For example, it has been predicted that implementation of improved communication will reduce congestion and improve productivity. However, there has been no comprehensive policy-oriented review of the individual and societal impacts of these developments. The California Department of Transportation (Caltrans) funded a project, described in this report, that had the overall goal of developing an action plan for state and local transportation agencies, related to the opportunities offered and challenges posed by the "Information Superhighway."

The specific objectives of this project are:

- To identify information and emerging technologies, related to the Information Superhighway, that have potential application for public sector transportation agencies.
- To document potential transportation-related impacts of these emerging technological changes on societal and behavioral aspects of California life.
- On a long-term basis, to develop recommendations and propose an action plan for state and local decision-makers regarding further consideration of these issues.

To meet these objectives, the following issues were discussed:

- The various views of what comprises the "Information Superhighway" and the issues that are important for future use
- Some opportunities for information- and communication-related changes as related to businesses and to the general operations of a transportation agency
- Some documented potential transportation-related societal responses to, as well as emerging demands for, the development of improved information and communication. Relevant conclusions and recommendations were made.
- Some specific opportunities for the application of the new technologies. It should be noted that it is outside the scope of this project to make recommendations regarding all the tasks that transportation agencies undertake. The recommendations are restricted to broad issue areas of application of the principles as established in the discussions, mentioned above.

The Information Superhighway

It was found that there has been rapid growth in the development of communication and information technologies and this development will probably accelerate. The existing Internet is only the beginning of the development of the future Information Superhighway, which will provide significant opportunities for information sharing, communication, and computing. Opportunities will not only arise for dealing more efficiently and effectively with existing tasks, but may offer opportunities to undertake new or substitute activities which will further the attainment of the overall mission of transportation agencies. Along with the opportunities there will be challenges for transportation agencies in dealing with these changes, which will probably occur very rapidly. The major specific conclusions reached in this regard are:

1. It will be advantageous to be pro-active in dealing with the emerging issues. The most important issues are:

    - Identification of which functions will be affected by the Information Superhighway as well as determining which additional functions could be advantageously dealt with through the Information Superhighway
    - Standards for computing hardware and software
    - Possible security problems.

2. The improved information sharing and distributed computing offered by the Information Superhighway will create the opportunity to deal with Caltrans units, other transportation agencies and other organizations located in remote sites in an efficient manner. Caltrans could provide leadership to establish priorities for the areas of information transfer and distributed computing which will benefit most from the opportunities offered by the Information Superhighway. This can be done within the context of Caltrans' and other transportation agencies' on-going evaluation of their functional organization and operation.

3. The way in which transportation agencies deal with the public will probably also need to change over time. With the establishment of a World Wide Web presence, Caltrans has introduced potential benefits and liabilities

4. The benefits or liabilities and the costs or savings associated with these developments, will depend on the ability of Caltrans to have a policy established for hardware and software standards by which organizations, which Caltrans deals with, could communicate.

It is recommended that Caltrans and other transportation agencies should develop a policy/strategic plan for dealing with the public, other transportation agencies, vendors and other commercial enterprises. In the short term, this policy should focus on issues related to the Internet. The specific issues for Caltrans to deal with are as follows:

- Establishment of a unit that will oversee and/or establish leadership for interagency communication and, most importantly, distributed computing
- Establishment of a unit that will oversee and/or establish leadership for communication with the public and contractors using the World Wide Web.
- Establishment of protocols, of hardware and software standards.
- Establishment of a training program for Caltrans and other transportation agencies for the purpose of electronic communication
- Establishment of a cost sharing formula for Caltrans and other transportation agencies for hardware, software, and training costs.

It is further recommended that Caltrans establish a task force to initiate a policy/strategic plan for dealing with the above-mentioned issues. This task force should preferably include representatives from other transportation agencies and possibly also representatives from other organizations, such as consultants, which Caltrans and the other agencies routinely deal with. An initial policy will probably have to be proposed by Caltrans. This should be a very worthwhile action since it will establish a cost-efficient and cost-effective direction for dealing with the opportunities and challenges presented by the emerging technologies.

Basic Business Organization and Communication
Regarding business practice and communication, it was found that:

1. Transportation agencies are generally similar to all business organizations. Thus the advantages of the Information Superhighway for businesses will also apply to transportation agencies.

2. The traditional marketing function was not readily apparent in the transportation agencies. Most public agencies do have an identified function of public information, but this is very often based primarily on disseminating information on the agency's own activities. It should be noted that the emergence of the Information Superhighway will provide the opportunity but also a need to increase activity in this area and especially in overall public relations and marketing.

3. The concept of a roundtable forum, born out of concurrent engineering, can be extremely useful as transportation agencies learn to take advantage of the Information Superhighway.

4. Improved communication/information technologies have great potential to transform the future workplace. Workers can conduct their work outside the normal workplace and at hours outside traditional working hours.

5. A difficult process for any firm is how to manage and facilitate change and the Information Superhighway will be a major change in the organization. Top management commitment is essential to lead, but employees also need to be actively involved throughout the planning process.

6. The CIO needs to be placed at the highest level in the organization and needs to be included in the strategic planning for the agency.

7. Interoperability is an important issue that needs to be addressed by transportation agencies, but there is not a clear solution at the present time.

The following major recommendations are proposed for state and local transportation agencies:

1. Training regarding the benefits and use of the Information Superhighway should be conducted for upper management area down to worker level.

2. Conduct training throughout the organization on implementing change. It is recommended that Caltrans set up a review committee designated to study the implementation of these recommendations. The committee should have representatives from all levels of the organization, all functions, and also draw from other organizations which are stakeholders.

3. Have the CIO (or equivalent) report to the CEO or equivalent position in the organization.

4. Conduct training throughout the organization to work in teams, which could include people in locations outside the office

5. Promote the use of concurrent engineering concepts throughout the organization.

6. Develop a stronger customer focus for the limited public information/marketing functions that are currently found in public transportation agencies. The Information Superhighway can be a very useful tool to implement these activities.

7. Assign someone the responsibility of studying interoperability and recommending the appropriate actions to be taken for their organization.

Transportation/Communication Related Societal Changes

Regarding the societal changes related to transportation, which may take place in response to the development of the new technologies, the following major conclusions were reached:

1. The implementation of improved communication/information technology has had the effect, and will continue to have the effect, of making it easier for people to move and work in more remote locations. This could impact transportation facilities in rural and suburban areas significantly which will require additional funding and transportation management in those areas.

2. Telecommuting may significantly reduce VMT. Although telecommuters will not be making the longer commute trip, they will be making an increased number of shorter trips. As a result, the alleviation of traffic congestion on commuter highways may only be modest, but the additional traffic in rural areas may be notable.

3. It is difficult to predict the growth rate of telecommuting and the resulting transportation implications. The actual impact of telecommuting on transportation, air quality, and energy saving will depend on factors such as the degree to which telecommuting is feasible and adopted, the portion of peak hour trips eliminated, the re-allocation of time, and future travel demand management related policies. It should be noted, however, that the number of people who telecommute is of a similar order of magnitude as the number of people using public transportation. This would indicate that telecommuting could be significant in future growth and environmental impact policies.

4. Trips in the category of family and personal business (as well as in the category of social and recreational) constitute portions of total tripmaking comparable to that of earning a living (including work trips). These trips could potentially be significantly affected by the new communication/information technologies should trip substitution occur in a way similar to telework substituting for work trips.

5. The electronic age and the emerging communication and information technologies are raising new ethical questions about the use of information.

The following actions are recommended:

1. Investigate the desirability of establishing a central telecommuting organization which will distribute information and make training available to organizations and individuals who are interested in telecommuting. Such an organization could help set up satellite centers at various locations in the state.

2. To further understand the impact of emerging technologies, a case study could be conducted on a suburban or rural area which has shown a population increase in recent years and has a significant

number of telecommuters. The area can be selected from surveys of current telecommuting programs. The study should document the changes in lifestyle and travel behavior as a result of telecommuting, include a time use survey, and determine the potential markets for telecommuting and the potential for trip substitution in the categories of family/personal business as well as social/recreational. <u>This may be a particularly appropriate follow-up to the current report.</u>

3. "Integrity" guidelines should be developed for the use of information on Web pages and for using information available on the Internet.

Opportunities and Challenges

It was found that there are many applications, spread over a wide spectrum, for the new communication/information technologies. Development is rapid and will affect all agencies. The following major conclusions were identified:

1. There is an opportunity to make more information available on-line, and the image of transportation agencies will be enhanced if a central unit, such as recommended in Chapter 3, could coordinate the information.

2. In view of the rapid development and implementation of new technology, increased attention and funding should be given to education and training. Education and training in the understanding of the underlying systems is also essential. The training will be necessary for technical personnel as well as for decision-makers to allow them to evaluate and use new proposed systems correctly. Because projects cross jurisdictional boundaries more often, Caltrans personnel may find themselves more often in leadership and/or coordinating roles. This will necessitate training in skills other than the technical aspects of the projects. New technology, through distance learning and computer and other electronic media, makes learning on demand possible and/or less expensive and there is probably room for improvement in this area in Caltrans as well as other transportation agencies.

3. Financial transactions, such as selling toll cards, could be accomplished over the Internet.

4. New technologies will make the implementation of the roundtable concept possible through electronic media, without having to meet physically. It will be easier to work with projects that transcend district or jurisdictional boundaries.

5. Caltrans could promote telecommuting within and outside the organization, thereby lessen congestion on commuter routes and could also research the telecommuting patterns of its own program for future decision-making.

6. There are several opportunities for Caltrans and other transportation agencies to utilize the new technologies in planning activities. These could include making information on planning projects available to the public and other agencies, collecting and processing data. Also, as the public becomes more accustomed to being able to access information by electronic means, their expectations of having such information readily available will likely increase.

7. New technologies could make the collection and processing of data more efficient. Having better information available will allow for better planning and design. As discussed before, this could lead to cost savings by eliminating more potential problems at the beginning of the project. Also, linking of information from initiation of the project through operation, by using compatible hardware, software and protocols, will lead to efficiency and cost savings.

8. The rapid application of new technologies to the planning, design, management, construction,

maintenance and operation of transportation systems offers the opportunity of implementing more sophisticated systems because of the cost advantage provided by these new technologies. Most of these systems or the function that they fulfill are not new, but the decrease in cost makes the implementation of more extensive, complex and more effective systems feasible. Decisions on implementing road closures may be one area where an on-line roundtable can especially facilitate discussion among Caltrans and local governments.

9. There are potentially great benefits to be obtained through better communication, organization, and planning. Improved information and communication technologies make these activities less expensive and the advantage should be taken of these opportunities. It is, however, often difficult to convince decision-makers to spend more on these activities, which have seemingly intangible outcomes, to save money later on in the product life, rather than on tangible projects. Evaluation of projects with these components will be necessary to serve as input to future decision-making.

10. There is a potential for generating revenue from, for instance, selling access to information, providing an opportunity for advertising and leasing space in the ROW for fiber optic cable or similar equipment. The desirability and legality of these issues should continue to be studied. The Alameda County Congestion Management Agency (CMA) is currently investigating the feasibility of such projects, including advertising rights on changeable traffic message signs, along the I-680 corridor.

The following actions are recommended:

From a policy point of view, Caltrans should take advantage of all technologies, which could improve the efficiency and effectiveness of traffic operations. The question is, what should Caltrans do differently? Because a large portion of what are presented as new systems are probably not new (only the technologies that support the systems are new), significant changes in the organization structure or the operating procedures are probably not necessary or desirable. The following recommendations are made:

1. The training program proposed earlier should address all functions, from administration through operations. The program should educate and train personnel to implement and use the systems necessary and desirable for the operation of the agency as well as the transportation systems, with special emphasis on the implementation of new technology.

   The objectives for the program should be developed in consultation with the individual agency departments and could be administered by Caltrans or by one or more of the state's public universities. The program could be similar to the LTAP program administered by the Institute of Transportation Studies Extension Program at U.C. Berkeley. The program should encompass all of the transportation agency functions, and the courses must be useful to all levels of agencies. The specially-designed and other relevant available training courses should be listed in the Caltrans headquarters homepage.

   Consideration should be given to educating decision makers and the public of the advantages and use of systems which use new technology and which may be foreign to them.

2. The unit, proposed earlier to oversee interagency communications, should also investigate the opportunity for savings provided by linking the information, used in the different phases of a project, through compatible hardware, software and protocols.

3. The following studies should be undertaken:

- An evaluation of the Santa Monica Freeway Smart Corridor project and the Highway 17/880 Smart Corridor project be undertaken, as planned, when implementation is complete, and specific recommendations be made regarding the coordination of the implementation as well as the integration of the traffic management and other functions across jurisdictional boundaries. In the case of the Highway 17/880 Smart Corridor, the "post-project" situation should be compared to the prior situation as much as possible.
- Issues relating to the desirability and legality of selling information and leasing space in the Right of Way should be investigated.
- The feasibility of selling toll cards over the Internet should be evaluated.

4. A pilot project should be undertaken where Caltrans and other transportation agencies in a specific region, coordinate, perhaps on a weekly basis, their construction and maintenance activities. This could be accomplished by establishing a regular video-conference at regular times to resolve issues. Between meetings, proposed changes in schedule and other relevant information can be posted on message boards on the project's intranet, which can be accessed only by project members. An evaluation of this project should also be undertaken with the view of implementing long-term integration of overall traffic management.

APPENDIX A

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APPENDIX B

KEY TERMS AND ACRONYMS

ABAG Association of Bay Area Governments (Northern California)
AHS Advanced Highway System(s)
ARPA Advanced Research Projects Agency (federal)
ASC Automatic Steering Control
ASCE American Society of Civil Engineers
ATIS Advanced Traveler Information System
ATM (Asynchronous Transfer Mode) International high-speed, high volume, packet switching transmission protocol standard. Competitor with Ethernet for high-speed digital communications.
ATMS Advanced Traffic Management Systems
AVCS Advanced Vehicle Control System
AVI Automatic Vehicle Identification
AVL Automatic Vehicle Locator

Backbone High-speed data paths that connect to the major networks, carrying "aggregated traffic" over relatively long distances
Bandwidth Capacity for telecommunication facilities and is a function of the number of bits that can be transmitted per second
Browser A program which is used with the World Wide Web; it establishes contact with a server, reads the file, and displays the file on a personal computer. A browser makes it much easier to point-and-click to information, versus entering computer commands to use the World Wide Web.[2]
BTS Bureau of Transportation Statistic (USDOT)

CAD Computer-Aided Design
CAD Computer-Aided Dispatch
Caltrans California Department of Transportation
CAPI Computer-Aided Personal Interviewing
CATI Computer-Aided Telephone Interviewing
CIC Computer-Integrated construction
CIO Chief Information Officer
CMA Congestion Management Agency
Commercial Providers Communication services (such as America Online, CompuServe, Netcom, the Microsoft Network, and Prodigy) wich offer users the easiest way to get onto the World Wide Web; also referred to as ISP's (Internet Service Providers)
Cyberspace Term coined by William Gibson in the novel Neuromancer to describe the sum total of computer-accessible information in the world[2]
CVO Commercial Vehicle Operations

DBS Data Broadcast System
DGPS Differential GPS
DOT Department of Transportation
DR Dead-reckoning

EDP Early Deployment Program (of ITS)

E-mail (Electronic mail) A message sent to another person anywhere in the world via computers and modems[1]

Ethernet High-speed serial digital communication hardware and protocol – speed is typically 10-megabytes, but can be greater than 100-megabytes

ETS Electronic Ticketing System

FAQ (Frequently Asked Questions) A document that lists and answers the most common questions on a particular subject

FHWA Federal Highways Administration

FOT Field Operation Test

FTA Federal Transit Administration

FTP (File Transfer Protocol) Method by which user transfers files between two computers

GCN Global Construction Network

GIS Geographic Information System(s)

Gopher A client-server system menu that facilitates finding information on the Internet and arranges the information in a hierarchy rather than with dynamic links used by the World Wide Web[2]

GPS Global Positioning System

GVU Graphic, Visualization, & Usability (Center)

HAR Highway Advisory Radio

HDTV High-Density Television

Home Page A hypertext document that acts as a starting point with links to other points on the World Wide Web

HOV High-Occupancy Vehicle

HTML (Hyper Text Markup Language) The coding Web documents or “pages” use to tell a Web browser how to display a text file

HTTP (Hyper Text Transport Protocol) Protocol for moving hypertext files across the Internet

Hyperlink A highlighted word or image on a Web page that, when clicked on by a mouse, can connect the user to a new location[1]

Hypermedia Sometimes called multimeda, this describes the Web’s integration of audio, video, graphics and text[1]

HDTV High-Density Television

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Hypermedia Sometimes called multimedia, this describes the Webis integration of audio, video, graphics and text[1]

IISTPS Norman Y. Mineta International Institute for Surface Transportation Policy Studies

Internet A global network of computers linked by high-speed data lines and wireless systems;

established in 1969 as a military communications system, it now allows individuals to link with corporations, educational institutions, and other groups[1]

Intranet A digital communication network set up within an organization.
IP Address A unique Internet protocol number, consisting of four parts separated by periods, assigned to every machine on the Internet, e.g. 130.65.181.222
ISDN (Integrated Services Digital Network)
ISN Information Systems Network
ISP Internet Service Provider (See also Commercial Provider)
ISTEA (federal) Intermodal Surface Transportation Efficiency Act, of 1991
ITS Intelligent Transportation Systems

Java ä A computer-scripting language that can be executed by a browser on the World Wide Web.

LANs (Local Area Networks) A computer network limited to the immediate area, usually the same building or floor of a building
LDS Landline Data Service
Links Low-speed connections which local networks tie into the Internet
Listserv Mailing list processor; allows people to organize themselves into the Internet-wide discussion groups
LTAP Local Technical Assistance Program

Mosaic ä A Word Wide Web graphical browser, forerunner of Netscape Navigator™
MPO Metropolitan Planning Organization
MQE Maintenance Quality Evaluation
MTC Metropolitan Transportation Commission (SF Bay Area)
MTS Metropolitan Transportation Strategy

NAP Network Access Points
NCHRP National Cooperative Highway Research Program
Network A system of computers, terminals, and data bases connected by communications lines[5]
NII (National Information Infrastructure) The federal government has proposed that when built, it will be a seamless web of communication networks, computers, databases, and consumer electronics that will put vast amounts of information at user's fingertips
NPTS National Personal Transportation Study
NSF National Science Foundation

OBC On-Board Computer
OPPD Office of Project Planning & Design (Caltrans)

PATH Partners for Advanced Transit & Highways (Calif.)
PC Personal Computer
PMS Pavement Management System
PSWS ä Project-Specific Web Site
PUC Public Utilities Commission (Calif.)

R&D Research & Development
RF Radio Frequency
RFID Radio-Frequency Identification
ROW Right of Way

RTPA Regional Transportation Planning Agency (Calif.)
RtPM Real-time Position Management
Search Engine Keyword searching algorithm or complete software package including search algorithms[3]
Server The computer that handles the primary data management tasks on behalf of its clients
SILDS Security Infrastructure for Large Distributed System
SJSU San Jose State University (Calif.)
SLIP Serial Line Interface Protocol
SMART State and Metropolitan Analysis for Regional Transportation (from BTS)

TCP/IP This is really two protocols: Transmission Control Protocol (TCP) converts messages into streams of packets at the source and then reassembles them back into messages at the destination, and Internet Protocol (IP) deals with routing the packets across multiple nodes within a single network and across multiple networks[2]
Telnet Method of remote login
TCRP Transit Cooperative Research Program
TIC Traveler Information Center
TRB Transportation Research Board

UC University of California
URL (Uniform Resource Locator) Address in a recognizable format, which enables computers all over the world to locate it
USENET A worldwide network exchanging news bulletins grouped under subject categories called "newsgroups"

VMT Vehicle-Miles Traveled

WAIS (Wide Area Information Servers) A distributed information retrieval system which returns a list of documents
WANS (Wide Area Networks) A computer network that covers an area larger than a single building or campus
Webmaster Person at a Web server site who is qualified to administer all Web resources at that site[3]
World Wide Web WWW (The Web) is a hypermedia information storage system linking resources around the world[1]

Yahoo ä A popular gopher on the Internet; it also functions on the World Wide Web as a search server, as such it will seek out keywords or other criteria in tens of thousands of documents over the Net[2]

References:

1. Sussman, Vic and Kenan Pollack. Gold Rush in Cyberspace. *U.S. News & World Report*. November 13, 1995, p. 72 (7).

2. Callon, Jack. *Competitive Advantage Through Information Technology: Business Strategy and Information Systems*. Business 114A Course Reader, Fall 1995, San Jose State University.

3. Harris, Stuart and Gayle Kidder. *Netscape Quick Tour for Windows: Accessing and Navigating the Internetis World*

Wide Web. Ventana Press, Inc., North Carolina, 1995.

4. LDDS WorldCom Network Services. *Telecom Glossary*. Available URL: http://www.wiltel.com/

5. *Websteris Ninth New Collegiate Dictionary*. Merriam -Webster Inc., Springfield, Massachusetts, 1990.

APPENDIX C

GOVERNMENT- AND TRANSPORTATION-RELATED WEBSITES

	Site Name/Sponsor	Information	Address
Government	Census Bureau	Social and economic indicators.	http://www.census.gov
	Library of Congress	A premier research library.	http://lcweb.loc.gov/homepage/lchp.html
	National Technology Information Services		http://www.fedworld..gov/ntis/ntishome.htm
	Bureau of Labor Statistics		http://stats.bls.gov
	U.S. Department of Transportation		http://www.dot.gov
	Caltrans	California DOT	http://www.dot.ca.gov
	ABAG	Association of Bay Area Governments	http://www.abag.ca.gov
	EPA	Environmental Protection Agency	http://www.epa.gov
Transportation-related	Directory of Transportation Resources	A comprehensive listing of transportation Web sites.	http://dragon.princeton.edu/~dhb/
	Institute of Transportation Engineers	Job listings, conferences, transportation news, reports.	http://www.io.com/~itehq/htm
	Transportation Research Board	The nature of and performance of transportation systems	http://www.nas.edu/trb/
	Bureau of Transportation Statistics	Lists of available local, state, and federal transportation publications and transportation data.	http://www.bts.gov
	Intelligent Transportation Systems	ITS America, ITS news, resources and reports on development efforts.	http://www.itsonline.com/
	National Highway Transportation Safety		http://www.nhtsa.dot.gov

	Administration		
	ADVANCE	Advanced Driver & Vehicle Advisory Navigation Concept project in Chicago	http://beijing.dis.anl.gov/ greg/ADVANCE/HTML
	Real-time Southern California Traffic	Real-time freeway traffic information.	http://www.scubed.com/ caltrans/transet.html
	S.F. Bay Area Transit Information	Transit information for the S.F. Bay Area.	http://server.berkeley.edu/ Transit/index.html
	Ventura County Transportation Commission	Transit information for Ventura County	http://sunbox.goventura.org/ transit.html
	Caltrans Highway Information	Road conditions, closures, repairs for interstate & U.S. highways.	http://www.oes.ca.gov:8001/ html/roads/html
	California Path	Research groups with Partners for Advanced Transit and Highways.	http://www-path.eecs. berkeley.edu
	Transweb	International Institute for Surface Transportation Policy Studies	http://www.transweb.sjsu.edu
	Smart Library	Transportation research and planning information.	http://www.bts.gov/smart/ smartlinks.html
Telecommuting-related	Telecommunications and Travel Research		http://nachos.engr.ucdavis. edu/~its/telecom/
	Smart Valley Telecommuting		http://www.svi.org/ PROJECTS/COMMUTE/ index.html
	Gil Gordon Associates	Telecommuting, teleworking, and alternative officing.	http://www.gilgordon.com
	Telecommuting Advisory Council		http://www.telecommute. org/index.html
	Bay Area Telecommuting Assistance Project		http://www.abag.ca.gov/ bayarea/telecom/telecomm.htm
	Telecommute America!	AT$T's telecommuting project.	http://www.att.com/ Telecommute_America/
Miscellaneous	Glossary of Internet Terms	Internet terms defined.	http://matisse.net/files/ glossary.html

GVU's WW User Surveys	Results from World Wide Web user survey	http://www.cc.gatech.edu/ gvu/user_surveys/
Government Technology	Government Technology, the magazine	http://www.GOVTECH.net
Better Business Bureau	Directory, national information.	http://www.bbb.org./bbb
Statistics on the Web	Various statistical resources.	http://maddog.fammed. wisc.edu/~helberg/ statistics.html

	List name	List topic(s)	Address to send Message to send
Transportation-related mailing list servers	TRANSIT	Transit issues discussion list	listserv@gitvm1.gatech.edu Subscribe transit
	DOT	Public transportation organizations	listserv@vm1.nodak.edu Subscribe DOT <your name>
	IVHS-L	Intelligent transportation systems	majordomo@mailhub.ornl. gov Subscribe ivhs-1 <your email address>
	UTSG	Promotes the exchange of information between individuals in the field of transport	utsg-request@mailbase.ac.uk Join utsg <your name>
	TRANS-AQ	Transportation and air quality	majordomo@ce.gatech.edu Subscribe trans-aq < your email address>
	GIS-T	GIS and transportation	gis-t-request@esri.com Put "subscribe to gis-t-request @esri.com" in the subject line
	TRANSP-L	Transportation planning (George Mason University Institute of Public Policy)	listproc@gmu.edu Subscribe transp-1

APPENDIX D

CALTRANS TELECOMMUNICATIONS MOBILITY PROJECTS

Implementation of telecommunications as a mode of transportation for the state's transportation system per California Transportation Plan (Caltrans, March 1994) as of January 26, 1995

Project	***Completion***	***Comments***
Planning		
Strategic plan ($117, 515)*	Winter 96	Statewide action plan for entire program
Telecommunications Cluster ($223,559)*	Summer 96	Regional strategy for Southern California, includes CEO outreach (Los Angeles County MTA subcontract)
Cluster formation		Creating entity within regional Economic Partnership and business plan for mobility and economic growth
CEO Outreach		Communicating "WorkSmart" findings to businesses
Telework/Telecommuting		
Neighborhood Telecenters ($3,492,000)	Winter 97	UC Davis research on mobility data from multi-purpose telecenters in residential areas (http://nachos.engr. *ucdavis.edu/~its/telecom/)*
Telecenter Demos (through 6/96)		Centers are located in Nevada, Solano, Stanislaus, Ventura, Orange and San Diego counties
Report of Findings		Analysis of data from telecommuters and control groups
Distributed work study ($418,950)*	Winter 96	"WorkSmart" project: workplace/workforce trends in Southern California
Telecenter use studes ($125,000)	Summer 96	Mobility data from 2 Inland Empire telebusiness centers as evaluation sites for neighborhood telecenters project
Highland Telecenter		City-run telecenter plus City general plan considerations
Ontario Telecenter		Telebusiness center includes video link to Ontario library
Telecenter marketing ($60,000)	Summer 96	Multi-purpose quake response site at Antelope Valley fairgrounds (also a neighborhood telecenters project evaluation site)
Feasibility studies ($240,000)	1994-1996	Proposed telecenters in Santa Cruz, Encinitas, Paso Robles and Mission Viejo,

Santa Cruz*		Completed. Seeking funding to consider new factors.
Encinitas		Completed. Deemed not feasible as of 1994/95.
Paso Robles		Completed. Next step is study of televillage concept
Mission Viejo		In progress. Conceptually linked with new library.
Distance Learning		
Community Colleges ($450,000)*	On hold	System-wide feasibility analysis for multi-purpose telecenters at community colleges
"Smart" Communities		
Community Network ($477,361)	Summer 96	Davis Community Network (DCN) and "virtual city hall" *(*http://www.dcn.*davis.ca.us/DCN/Research/)*
DCN		Non-profit information utility, travel behavior sutdy
City of Davis		Value-added electronic distribution of city services
Televillage ($88,620)*	Winter 96	Distributed services and technology at transit hub serving low income community (Compton)
Technology Center ($1,200,000)	TBA	Thousand Oaks City Hall enhancement (project being refocused by Caltrans district office in Los Angeles)
"How-to" guidebook ($450,000)*	1996-97	Using lessons learned from "WorkSmart" and DCN/City of Davis, show how communities can achieve economic viability from the information highway, includes City of Chula Vista subcontract. *(*http://rohan.sdsu.edu/dept/*intlcomm/smart.html)*

Notes:
$ = Federal Highway Administration funds
- = Funding for planned second phase not available

CONTACT FOR ADDITIONAL INFORMATION
Michael Seaman, Chief, Special Projects Branch, Caltrans Office of Transportation Demand Management. Via telephone at (916) 653-1991, via fax at (916) 654-5452 or via E-mail at mjseaman@mail.macnexus.org

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Pre-Publication Peer Review

San José State University, of the California State University system, and the IISTPS Board of Trustees have agreed upon a peer review process required for all research published by IISTPS. The purpose of the review process is to ensure that the results presented are based upon a professionally acceptable research protocol.

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