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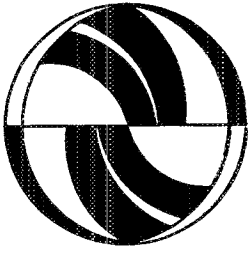
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Earthquake: The Bay Bridge Closure**

Elizabeth Deakin

Working Paper
UCTC No. 294

**The University of California
Transportation Center**

University of California
Berkeley, CA 94720

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**Transportation Impacts of the 1989 Loma Prieta
Earthquake: The Bay Bridge Closure**

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*Working Paper
October 1991*

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The University of California Transportation Center
University of California at Berkeley

Introduction and Overview

The Loma Prieta earthquake of October 1989 damaged highways throughout the Bay Area. For many of the damaged facilities, parallel routes or minor detours provided reasonable alternatives and were quickly put to use by travelers. Although congestion and travel time increased, the alternative routes permitted most trips to be made with relatively little disruption. In the case of the San Francisco-Oakland Bay Bridge, however, no close substitute was available. The Bay Bridge had lost one section of the upper deck during the quake and was closed for about a month while the California Department of Transportation made repairs. With 245 thousand vehicles and nearly 400 thousand people routinely crossing the bridge each day, the closure of the Bay Bridge had the potential to cause substantial disruption.

For the majority of Bay Bridge users there simply was no practical alternative highway route. Other bridges to the north and south could be used,¹ but all would be far out of the way for most Bay Bridge users and, for much of the day, would put them on already heavily congested North Bay or Peninsula commute routes, leading to further delays. A small share of Bay Bridge users from the north and east could and apparently did cross the Bay at the Richmond-San Rafael Bridge, proceeding south through Marin County and across the Golden Gate Bridge to San Francisco. Some from southern Alameda County appear to have used the San Mateo-Hayward Bridge, traveling north through San Mateo County into San Francisco along Route 101. (Caltrans-MTC Commute Summary Data, Oct.-Dec. 1989.) But for most travelers, such routes would be far too time consuming to be seriously considered.

¹ Land routes around the Bay's southern end are another option, but an extremely circuitous one, requiring perhaps 100 extra miles for the typical East Bay commuter formerly using the Bay Bridge. Land routes around the north end of the Bay would be even more circuitous

The East Bay - San Francisco connection thus depended on finding alternative means of access - either alternative modes of transport or alternative arrangements for work and non-work activities. Concerns about work travel were most immediate, since the potential for serious economic dislocation was greatest if work disruptions were severe. Somewhat less dramatic but nonetheless serious damage could also occur if trans-bay shopping, social/recreational activities, cultural activities, and school and medical trips were dislocated. Understanding how travelers viewed their options and changed their travel patterns was important not only in responding to the immediate problems caused by the Bay Bridge closure, but also to inform planning for the region's future preparedness.

In a survey of East Bay transbay commuters and other East Bay residents, we found that alternative modes of transport did, in fact, work well for most travelers. Most experienced only temporary disruptions of their journeys to work, because they were able to quickly shift to other modes for the duration of the bridge closure. Non-work travel fared less well, however, and substantial reductions in such trips were reported, though travel for scheduled appointments such as medical trips was little affected. A brief follow-up survey conducted about 17 months after the quake found that little or no permanent change in travel patterns had occurred as a result of the quake, although a small net increase in rail transit ridership did appear to have been retained.

This paper reports the results of the East Bay traveler survey and follow-up.² The main survey was conducted in mid-November 1989, just before the bridge reopened.

Respondents were all East Bay residents, most of whom worked in San Francisco; a small subsample of East Bay residents who did not work in San Francisco also were interviewed to explore the earthquake's impact on their travel behavior.³ The follow-up

² Numerous data collection activities were carried out in the aftermath of the Loma Prieta earthquake in order to assess its impacts on travel. In addition to this survey, traffic counts and vehicle occupancy counts were conducted on other (unclosed) transbay bridges, on-board surveys were conducted on BART and on ferry services, officials at trucking firms and large employers were interviewed, and small employers in San Francisco were surveyed.

³ Because of time and resource limitations we did not attempt to survey San Francisco residents who commuted to the East Bay via the Bay Bridge, although they too were severely affected by the Bay Bridge closure. Nor were we able to survey travelers affected by other road closures which occurred throughout the region.

survey was conducted in Spring 1991 by re-contacting a small subset of those previously interviewed. It was used to assess whether the earthquake had had any lasting effects on East Bay - San Francisco travel.

In the next section of the paper, we review basic concepts of travel behavior and their implications for traveler responses to disruptions in travel options. We then present our November 1989 survey instrument, discuss the sample frame and sample design, and review survey implementation steps. Our major findings are presented, along with a brief discussion of the follow-up survey and its findings. The final section of the paper presents our interpretation of the results and their implications for future policy and planning efforts.

Travel Behavior: Basic Concepts

A transportation supply disruption such as the Bay Bridge closure can affect travel demand in a variety of ways. Hence we begin with a discussion of travel behavior and the choices that many travelers could make, over the short run and over the longer run.

The theory of travel behavior has developed through the adaptation of concepts from economics and psychology, as well as from practical efforts to forecast travel demand. Travel behavior is understood to result, for the most part, from the pattern of activities undertaken by individuals under constraints imposed by income, personal characteristics, interpersonal relationships (such as household responsibilities), scheduling requirements, the quality of the transportation system, and the pattern of activities themselves. Time and cost - and the compensatory relationship between the two - are critical elements in travel decisions: travel choices are delimited by time and budget constraints. However, comfort, convenience, and habit are also important factors in behavior and shape the utility of travel options.

Travel behavior also exhibits a temporal hierarchy. Far-reaching lifestyle choices determine a household's composition and strongly affect location and living arrangements. Decisions on where to work (or go to school) and where to live set the long-term, daily or weekly activity and travel pattern for the household and its members. Decisions about the number of autos to own are affected by modal availability and the pattern of desired tripmaking, and in turn affect trip rates and mode choices.

Some destination choices, such as where to bank, shop for groceries, or get a haircut, are typically made quite deliberately; preferred destinations become habitual ones, and routine schedules for trips may develop. Other trips, particularly those made on the way to or from "fixed" destinations such as school, work, or home, exhibit a high level of spontaneity; for example, the decision to stop to buy a newspaper or to eat a snack. For the most part, route choices also can be made at the spur of the moment, and although habits do become established, many travelers use several different routes for trips made frequently, varying their route choices in response to traffic levels, time of day, and so on.

Under this paradigm of travel behavior, the loss of a critical facility such as the Bay Bridge could have noteworthy effects at many levels of the behavioral hierarchy:

- **route choice** - Travelers could very quickly switch to different routes, if the alternative routes are a good choice considering time and costs involved. For work trips, the difficulty of switching routes is likely to be low, since for these frequently-made trips many travelers will have identified and tried the alternatives at one time or another. For infrequently made trips and for routes that under ordinary circumstances would not be considered "reasonable" or acceptable, lack of familiarity could be a barrier slowing their use, or leading to a period of experimentation.
- **time of travel** - Travelers with scheduling flexibility could quickly shift trips to other times of day, if doing so reduces dollar or time costs; the greatest shifts would be likely for non-work trips.

- **mode choice** - Travelers could shift to alternative modes (e.g., from auto to rail transit or to ferries), if the time costs and out-of-pocket costs of the alternative modes are competitive with (or more attractive than) other available alternatives.
- **destination choice** - For many shopping, recreation, and similar discretionary trips, people can and do switch destinations with relative ease. The destinations for personal business trips, medical trips, and other trips scheduled with particular individuals or at particular facilities or places are less easily changed, but alternate arrangements, hence destinations, can be made over the medium run. In the case of work trips, people have fixed origins (residences) and destinations (places of employment) in the short run; unless the employer makes special arrangements (e.g., allowing the employee to work at home or at a different location), changing one's work destination ordinarily would mean changing jobs, something that is generally not done quickly.
- **trip chaining** - Travel difficulties could induce individuals to link together trips for more efficient travel. On the other hand, if mandatory trips take so long as to consume the entire "window of time" available for travel and discretionary activity, travelers are likely to eliminate some stops, resulting in fewer linked trips.
- **trip frequency/activity selection** - For work trips, a significant increase in the costs of travel (time or dollar or both) could foster strategies to reduce trip frequency, e.g., through policies permitting employees to work at home or to elect four-day work weeks. A cost increase also could reduce the frequency of discretionary tripmaking, especially among lower-income households. Activities such as shopping and recreation might be reorganized (buying groceries once a week rather than two or three times a week; making greater use of mail order or tele-shopping; jogging in the neighborhood park rather than driving across town to the track.) Certain activities also might be replaced with ones that do not require travel (watching TV instead of going to the movies, cooking at home rather than eating out).
- **auto ownership** - Conditions that directly or indirectly raise the cost of auto ownership or increase the cost of auto use reduce the incentive for multiple auto ownership. In most instances, however, the decision to reduce auto ownership (or expand it) will be made based on consumer expectations of long-term conditions, not in response to temporary changes.
- **residential and employment location** - Significant changes in accessibility may induce households to seek different workplaces or residential locations. For most, location decisions will be based on long-term expectations, considering both personal and external conditions. Younger people, singles, and renters are more likely to change residences and employment than are older people, e married, or homeowners.

- **residential and commercial growth loci** - Changes in accessibility, especially ones that alter residential demand or workforce availability, might shift the locus of regional growth, or perhaps alter the overall rate of regional demographic and economic change.

Since the Bay Bridge closure was expected to be temporary, we did not expect to see detectable levels of changes in auto ownership, residential and employment location, or growth patterns. One possible exception we considered is that employers might permit transbay commuters to work at home, or to report to an alternate work site in those cases where the employer operates several locations in the region. Route choice, as discussed earlier, also was not deemed likely for many travelers, because of the uncompetitive times and costs involved for routes; however, we were interested in evaluating the extent to which travelers would, in fact, seek out and try routes that on nominal time and cost grounds seem improbable. We expected to see considerable shift to the transit modes, especially for work trips, since for many travelers these modes would provide a fairly easy option. Finally, we were interested in determining whether and to what extent travelers also would change destinations, trip frequencies, and trip chaining, and what the consequences of these changes would be.

Survey Design

The main objective of the November 1989 survey was to document how travelers who regularly used the Bay Bridge, especially those who routinely used it to commute to San Francisco, had responded to its sudden closure. Because we wanted to minimize the problems associated with long-term recall of travel behavior, we deemed it necessary to complete all interviews within a few days of the re-opening of the bridge. The resulting tight deadline led us to select telephone interviewing as the preferred method of data collection. It also led us to draw questions from previous surveys conducted in the region whenever possible, in order to reduce the amount of effort

needed in survey design and pretesting. We borrowed from regional travel surveys conducted by the Metropolitan Transportation Commission for demographic and income questions; questions on household and traveler characteristics borrowed in this way had the added advantage of allowing us to compare our sample characteristics to those of "known" samples. The remaining survey questions were developed specifically for this study. All questions but the final two were either close-ended or were designed to require only a brief response, in order to keep survey completion time to a reasonable level (about ten minutes). The final two questions allowed the respondents to voice their personal concerns and relay their experiences to the researchers.

The first two questions were designed to screen for San Francisco workers (deemed the most critical travel group for the survey) and to get the San Francisco worker to the phone or schedule a call-back to that person. In most cases the survey was terminated if there was no San Francisco worker in the household. However, for 12.5% of the telephone numbers, interviewers were instructed to proceed with an interview regardless of the results of the screening. We thus created for comparison purposes a small sample of households without a San Francisco commuter.

Questions on the respondent's household demographics and composition, housing tenure, employment, and auto ownership were included to provide a multidimensional basis for evaluating the sample's representativeness as well as to permit analyses of travel responses as a function of gender, race, income, and employment characteristics. These questions, while detailed, were designed to be briefly answered and took only 2-3 minutes on average.

Travel questions covered pre-quake and post-quake travel behavior. For the work trip, the respondent was asked to provide information on his or her "usual" behavior before the earthquake, including workplace location, mode choice, commute hours, travel

time, stops made on the way to work or on the way home, and availability of employer commute assistance. The same questions were asked about post-quake travel, but were directed at behavior at two separate periods - behavior immediately after the quake, and behavior on the day before the survey day, i.e., after several weeks had elapsed. In addition, respondents were asked to list all the different travel and work options they had tried during the post-quake period, and were asked to report employer assistance both immediately after the earthquake and at the time of (the day before) the survey, several weeks after the earthquake.

The respondent was then asked to report his or her frequency of non-work travel to San Francisco, by trip purpose, before and after the earthquake. Finally, two open ended questions asking the respondent to discuss how the earthquake had affected daily activities were included. (Only this portion of the travel questions was completed by the subsample that did not include a San Francisco worker.)

The draft survey and the survey administration plan were reviewed in detail by experts drawn from the University of California and from local agencies, and some revisions were made on the basis of their comments. Because time was of the essence, only a small pretest of the survey was carried out, in conjunction with the training session for interviewers. The pretest responses (32 completed) did not uncover any serious issues so we proceeded with the instrument as designed. The survey instrument is presented in Appendix A.

A follow-up survey was designed to determine whether any lasting changes in travel behavior had occurred as a result of the earthquake. Because of funding limitations, the follow-up survey instrument was brief (five questions) and the sample size was small. The questions aimed to retrieve information on mode to work, time of travel, and non-work trip frequencies from a small subset of those who had answered the initial survey. The follow-up survey instrument is presented in Appendix B.

Sample Frame and Sample Design

Although the East Bay is home to nearly 20% of San Francisco's work force, only about 9% of East Bay employed residents work in the city (US Census and MTC, 1990). Further, only about one in 15 households in the East Bay had a San Francisco worker (MTC, 1990). Because finding these workers thus would require considerable effort, it was imperative to design sampling strategy to maximize our "hit rate." In addition to the screening questions used at the start of the survey, we decided to sample from those portions of the East Bay where at least 5% of the employed residents worked in San Francisco.

At the time of the study the Metropolitan Transportation Commission (MTC) defined ten East Bay "superdistricts" for traffic analysis purposes and maintained survey data and projections (updates of the survey to current-year estimates) for the superdistricts. These MTC data and projections were used to identify the fraction of employed residents employed in San Francisco in the late 1980s (Table 1).

Table 1. Work Trip Mode Shares to San Francisco from the East Bay

SD No,	Residence Location	Total Work Trips by Employed Residents (000)	Share to SF
18	Oakland - Piedmont - Alameda	261	.18
22	Orinda - Walnut Creek	97	.18
19	Berkeley - Albany - Emeryville	104	.16
20	El Cerrito-Richmond-N. to Crockett	104	.11
21	Concord-Pleasant Hill	134	.06
17	Hayward-San Leandro	190	.06
23	Danville-San Ramon	42	.06
24	Antioch-Pittsburg	57	.03
16	Fremont-Newark	152	.02
15	Livermore-Pleasanton	80	.02

The last three superdistricts made only modest contributions to the transbay commute pool. Given the time constraints we were facing, we decided to eliminate these superdistricts from further consideration in this study. Their exclusion undoubtedly introduced a small bias into the sample, but not enough to cast doubt on its overall validity.

Both zip codes and telephone prefixes could be assigned to these superdistricts and used in the generation of telephone numbers. In the end we used both: randomly generated telephone numbers were generated for the telephone prefixes in the superdistricts to be sampled, and were checked for appropriate zip code. The local telephone company's assignment of prefixes to geographic areas agreed, in general, with the MTC groupings of communities into superdistricts, except in the old core cities of the East Bay (Oakland, Berkeley, Hayward.) There, prefixes were assigned as needed in an area covering superdistricts 18 and 19 as well as parts of superdistrict 17. Fortunately, all the affected communities fall within the intended sampling area, so this lack of geographic specificity in telephone exchanges did not unduly affect the sample design in this case.

A commercial sampling firm was contracted to provide a random sample of 40,000 telephone numbers from the 415 area code⁴ and from the zip codes and exchanges as specified by the author. A listing of the sampled zip codes and exchanges is included as Appendix C. All numbers were 1) checked for against Yellow Pages listings to eliminate known business numbers, with replacement; and 2) checked for unassigned blocks, with replacement.⁵ The telephone numbers were delivered in 80 replicates of 500 each for ease in assignment to survey personnel.

⁴ The 415 area code has subsequently been split and the East Bay now uses the 510 area code.

⁵ We did not check for multiple phones at the same address, but a subsequent review of the responses received did not uncover any instances of this.

Survey Implementation

A survey research firm was contracted to carry out the telephone surveys in the short time available before the Bay Bridge re-opened, using the survey instrument designed by the author and the telephone numbers provided by the commercial sampling firm. The firm trained interviewers, carried out a brief pretest of the survey instrument, and commenced calling.

Surveyors were instructed to complete up to 1000 telephone surveys in the period available to them (Nov. 14-17, 1989), completing up to four call-backs per telephone number in the case of no answer / no potential respondent available. Approximately 15,000 numbers were called in the time available.

In 53% of the cases the number did not generate a household response. About 19% of the phones had been disconnected or were not in working order. For another 19% there was no answer after four call-backs. Answering machines or fax machines were operating for 11% of the numbers, and a business was reached for 4%.

A very high response rate was obtained for the households actually contacted. In two percent of the cases language barriers or hearing difficulties prevented completion of the survey. Only one percent refused to participate outright.

Screening for the presence of a San Francisco worker in the household resulted in termination of about 90% of the remaining calls (except for the subsample for which we suspended the SF worker criterion for inclusion.) Hence about 631 surveys were completed. Survey supervisors validated 10 percent of the completed surveys, resulting in a small number of survey rejections; additional consistency checks were conducted on the resulting data and led to a few more rejections. A total of 534 surveys

of San Francisco workers and 67 surveys of other East Bay residents were retained in the final sample.

1989 Survey Findings

An analysis of the survey results makes it clear that the earthquake and damage to the Bay Bridge disrupted the East Bay to San Francisco journey to work far less than many had feared. Here, we present the key findings of the survey. The findings are all statistically significant at the 5% level unless otherwise noted.

After a couple of days, most survey respondents went to work on their regular schedules. An insignificant number (n=13) reported that their workplaces had relocated due to the earthquake. Only one respondent reported that his workplace remained closed.

Although most commuters reported trying several different ways to get to work, including driving bridge circuits (e.g., across the Bay at Richmond to Marin County, then south and across the Golden Gate Bridge, returning home over the San Mateo Bridge) and testing different forms of transit, the vast majority of commuters quickly settled on an alternative mode of travel - either BART or one of the ferry services that quickly were established. Mode shares before and after the October 1989 earthquake, as reported by survey respondents, are shown in Table 2.

Table 2. East Bay - San Francisco Earthquake Survey, Commute Trips

	Before %	After %
Drive alone	37	10
Shared ride	24	1
Bus	10	1
BART	35	75
Ferry	--	10
Other	8	3

BART clearly absorbed the greatest part of the shifted trips, though the added ferry services also played an important role. Respondents apparently chose these modes mostly on the basis of their own preferences, since only a few reported that their employers had offered any kind of commute alternative incentives either before or after the quake (7% before, 11% after.)

Commuters' time-of-day of travel also shifted somewhat, though formal changes in work schedules were not a big part of the shift (under 10% of the respondents worked for employers who had instituted such changes.) Moreover, relatively few of the respondents had employer programs which supported or imposed shifts in the time of travel; though respondents did report more employer programs after the quake (at the time of the survey, just under 30% reported that their employers allowed them some flexibility in the choice of working hours, vs. only 7% before the quake). Most respondents reported that their work trip travel times changed only marginally (under 15 min.) from the times they had routinely traveled before the earthquake. About five percent reported that they now worked at home and another five percent adjusted their schedules by more than two hours a day to reduce commuting stresses.

Although trip chaining is sometimes a way to save time and reduce travel commitments, respondents reported that their trip chaining dropped off somewhat while the Bay

Bridge was closed. Before the quake about 31% reported making additional stops on the way to or from work; this percentage dropped to just under 20% after the quake.

Overall, most respondents - 69% - felt that their trip had gotten harder, mostly because it now took more time. On the other hand some 15% reported that their trip had gotten easier. Most of these respondents had switched to BART or the ferries and found them fast and less stressful than driving had been before the quake. Interestingly, pre-quake BART and ferry users who continued to use the same mode after the quake were among those most likely to complain about worsened travel conditions. They objected to the greatly increased crowding and, on BART, to passengers who did not understand or observe regular users' implicit "rules" for the use of the system (queuing up instead of crowding in to the cars, not talking to other passengers, etc.)

Although the dominant work travel effect was one of mode shift rather than trip reduction, a different picture appears when non-work travel not linked to work travel is considered. Before the earthquake, respondents reported that they made an average of about .6 trips per week to San Francisco for non-work purposes (social/recreational, shopping, school, medical/dental, personal business.) After the quake the reported nonwork trip-to-SF rate dropped by about 40% among those still traveling to work. The overall nonwork trip rate dropped even more, by about half, if those no longer working in San Francisco also are considered. The greatest losses were in social/recreational trips. In comparison, travelers reported that they found ways to get to scheduled appointments for medical care, though the frequency of such trips is sufficiently small that this finding is indicative rather than statistically significant.

East Bay residents who did not travel to San Francisco for work before the earthquake but did go to work in the East Bay (n= 57) exhibited similar patterns of change, although their drive alone share before the quake was much higher than for the San Francisco commuters and remained so (76% of the East Bay workers in the sample

drove alone to work before the quake.) Many were affected by short-term or longer term closures or repair delays on their usual driving routes; some were affected for the long term by the collapse of the Cypress structure in the Oakland freeway system. Immediately after the earthquake many switched to ridesharing, bus or BART, but as repairs were made and facilities re-opened most went back to driving alone. Those who remained on alternative modes at the time of the survey - 5% more than pre-quake - reported that they had switched modes after trying several alternative routes and finding them too long, too slow, too unpredictable, or simply too "unpleasant." Even fewer of the East Bay employees had employer incentives to switch modes than their counterparts who worked in San Francisco. Also like the San Francisco workers, the East Bay workers reported less trip chaining after the quake than before, and were more likely to cut out non-work travel, especially social and recreational trips, than work travel.

Differences by Location, Gender, Age, Income, Employment Type

Demographic questions allowed us to verify that our sample was reasonably representative of the East Bay communities we chose to examine. There was a slight underrepresentation of renters, persons under 25, and persons who work part time. There also was a slight, marginally significant, overrepresentation of persons in the over \$75,000 income categories.

We were able to conduct some analyses of how the earthquake affected different people and places, though a sample of this size cannot support an exhaustive analysis of these factors. Locations were classified as inner East Bay (Bay side of the Berkeley Hills) or outer East Bay for this analysis. Ages were grouped as 25 or under, 26-39, 40-59, and 60 or over; incomes were grouped as under \$25,000, \$25,000-\$50,000,

\$50,000-\$75,000, and over \$75,000; employment types were grouped into professional/managerial, clerical/ service, and blue collar categories.

Moderate locational differences appeared. The inner East Bay respondents' travel behavior was somewhat more affected by the quake, both because of heavier pre-quake transbay bus use and because these residents made more non-work trips to San Francisco than their outer East Bay counterparts.

Both gender and ethnic differences were significant. Women were more likely than men to report that the earthquake had made their commute trip harder (because it took longer) and that they were able to make fewer shopping and social/recreational trips to San Francisco than before the quake. Men were more likely than women to have tried alternative routes for driving to the city.

Asians and Latinos also reported significantly high cutbacks of non-work trips, and many volunteered that they and their families sharply felt the loss of these social and cultural connections to San Francisco.

No significant differences in mode changes or other travel changes appeared by income group, though as before the earthquake, higher incomes and professional job classifications were much more likely to be allowed to set their own working hours and were more likely to report commute programs at work.

The 1991 Follow-Up Survey

The follow-up survey conducted in March 1991 was done using student volunteers to place the calls, and hence both a simple five question survey instrument and a small random sample of previous respondents were utilized. One hundred surveys were

selected at random from among those who had answered the November 1989 survey and had worked in San Francisco at the time. (For the sake of simplicity, and because of the very small sample size, none of the subsample with no SF worker was re-contacted.) We found that because of changes in telephone numbers, changes in household composition, and residential moves, 42% of those interviewed in 1989 were no longer located at their previous telephone number. No contact was obtained in four attempts in an additional 8% of the cases.

Of the 50 persons who proceeded to respond to the follow-up survey, five no longer worked in San Francisco; two of those who did no longer worked in the same place. These seven interviews were terminated because long-term travel patterns would not relate in a clear way to the behavior reported in the 1989 survey. Of the remaining 41 respondents, 33% drove alone, 28% shared a ride, and 40% used transit, most of them on BART. Give the sample sizes, these numbers are not statistically different from those reported before the earthquake, suggesting that the respondents had settled back into their previous habits once the Bay Bridge and associated transportation modes returned to their pre-quake service levels.⁶ In addition, no significant changes in commute hours or in the number of weekly non-work trips made to San Francisco were reported, suggesting that other activities also may have returned to pre-quake patterns.

Conclusions

The 1989 Loma Prieta earthquake and, in particular, the temporary loss of the San Francisco-Oakland Bay Bridge had far less drastic consequences for East Bay to San Francisco commuters than many had feared, largely because the undamaged BART system provided a well-known and competitive alternative means of travel, and ferries

⁶ BART statistics and surveys show, however, that about 30,000 riders were retained after the earthquake.

were able to quickly add capacity as needed. Few of those we interviewed were able to work at home or at alternative work sites, especially after the first few days. Instead, commuters quickly found and settled into reasonably acceptable travel alternatives. Results of our survey showed that switching modes did, in fact, work well for most travelers; most experienced only temporary disruptions of their journeys to work.

In contrast, non-work travel was cut back substantially, though trips for scheduled appointments such as medical trips were less affected. The loss of non-work travel, especially for shopping and social/recreational purposes, can be attributed to the added difficulties of traveling off-peak and in groups (as is often the case for such trips.)

A brief follow-up survey conducted about 17 months after the quake found that little or no permanent change in travel behavior had occurred (though other studies show that BART did retain riders.) The follow-up survey also illustrated that changes in residential location and other household characteristics are fairly frequent, since we could no longer locate over 40 percent of our sample at their previous phone number and another seven percent had switched jobs.

Redundancy in systems is widely acknowledged to offer a certain degree of assurance against failure of one or more system elements, although the costs of redundancy also are well understood. In the case of the Bay Bridge, redundancy was provided by transit. Obviously the same results might not be achievable in areas where transit alternatives are of poorer quality, as is the case in many urban areas. Moreover, providing redundancy is expensive and can fail as an emergency response strategy if damage in the emergency is sufficiently extensive. The tradeoffs between redundancy, earthquake-resistant design, and costs clearly need to be examined in detail before embarking on a singular course of action.

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The sample of telephone numbers was prepared by Survey Sampling Inc. of Fairfield, CT and the survey itself was pretested and administered by Phase III Research of San Jose. Mahtab Soheily and Kaye Bock were responsible for setting up the database spreadsheets and for initial data entry. Jeff Reigner was responsible for final database design, data checking and correction, and preliminary data analysis, as well as for much of the other follow-up work. Susan Handy also assisted with these efforts.

These individuals and organizations deserve much credit for hard work under pressing deadlines, especially since many of them volunteered their time. However, the author is solely responsible for the contents of the paper and for any errors or omissions that may be noted.

SAMPLE ID.	S.D.	CO.	SEQUENCE						SAMPLE NUMBER			TRAVEL DAY

INTRODUCTION

HELLO, MY NAME IS _____. I AM CALLING FOR THE TRANSPORTATION RESEARCH CENTER AT THE UNIVERSITY OF CALIFORNIA. WE ARE DOING A STUDY OF HOW THE OCTOBER 17 EARTHQUAKE HAS AFFECTED TRAVEL IN THE BAY AREA. YOUR TELEPHONE NUMBER WAS PICKED AT RANDOM. YOUR PARTICIPATION IN THIS SURVEY IS VERY IMPORTANT AS THE RESULTS WILL BE USED IN PLANNING FOR THE BAY AREA.

ARE YOU THE BEST PERSON TO ANSWER QUESTIONS ABOUT YOUR HOUSEHOLD?

ALL THE INFORMATION YOU GIVE ME IS STRICTLY CONFIDENTIAL AND FOR PLANNING PURPOSES ONLY.

SCREENING QUESTIONS:

Did you or any member of your household work in San Francisco during the week before the earthquake?

- 1 no (TERMINATE INTERVIEW UNLESS PHONE NUMBER RED-CODED)
- 2 yes CONTINUE

Did you personally work in San Francisco during the week before the earthquake?

- 1 no MAY I PLEASE SPEAK TO THE PERSON WHO WORKED IN SAN FRANCISCO?
- 2 yes (REPEAT THE INTRO TO NEW PERSON)

I. I WOULD LIKE TO BEGIN WITH SOME GENERAL QUESTIONS ABOUT YOUR HOUSEHOLD.

- Do you live in a
- 1 single family structure
 - 2 duplex unit
 - 3 apartment
 - 4 condominium or townhouse
 - 5 mobile home
 - 6 hotel or motel unit
 - 7 group quarters
 - 8 other _____

How many years have you lived at the present address?

_____ years (00 if less than one year)

zip code _____

Is your residence owned or rented by you or someone in your household?

- 1 own
- 2 rent

How many persons, including yourself, live in your house? (exclude short term visitors)

_____ persons in total

And how many of these persons are five years of age or older?

_____ persons over 5 yrs. old

How many cars, trucks, or vans are owned, leased or used regularly by persons who live here? (Exclude motorcycles, bicycles, and off road vehicles.)

_____ vehicles

SAMPLE ID.	S.D.		CO.		SEQUENCE						SAMPLE NUMBER			TRAVEL DAY	

II. Person Questions

NOW I WOULD LIKE TO ASK YOU A FEW QUESTIONS ABOUT EACH MEMBER OF YOUR HOUSEHOLD.

FOR PURPOSES OF THIS SURVEY I NEED TO IDENTIFY SOMEONE AS HEAD OF YOUR HOUSEHOLD AND THEN I NEED TO KNOW HOW THE OTHER FAMILY OR HOUSEHOLD MEMBERS ARE RELATED TO THIS PERSON (YOUR SON, YOUR SISTER, YOUR FRIEND, ETC.) SHOULD I IDENTIFY YOU AS THE HEAD OF THE HOUSEHOLD?

NOTE TO INTERVIEWER

(ASK ABOUT ALL THE MEMBERS OF THE HOUSEHOLD AND THEIR RELATIONSHIP TO THE PERSON LISTED AS HEAD. BE SURE ALL HOUSEHOLD MEMBERS HAVE BEEN ACCOUNTED FOR.)

NOW ASK THE OTHER QUESTIONS FOR EACH PERSON. SEX IS OFTEN APPARENT FROM THE RELATIONSHIP (son, wife). FOR THE OTHER QUESTIONS ASK, "What is your age?", "Do you have a driver's license?" etc.)

RECORD ON NEXT PAGE

OCCUPANTS OF HOUSING UNIT

SHEET ____ OF ____

NOTE TO INTERVIEWER:

A IDENTIFICATION

TRAVEL DAY

SAMPLE NUMBER

SEQUENCE

CO

SD

RECORD FOR EACH MEMBER OF THE HOUSEHOLD
When this form is completed go to Travel Questions

B Person Letter	C How is each person related to the head of this household (includes visitors)	D SEX (circle)	E What are the ages of each person?	F Which persons in your household have a driver's license?	G (Record For Residents Age 14 Or Over Only)						H (Circle For Employed Residents Only) (See Industry Codes) In what industry is she? (Do you (does he, she) work?)	I What Occupational Category Best Describes What You Do At This Place Or Work? 1 Professional 2 Managerial or Administrator 3 Clerical 4 Crafts 5 Operative 6 Service Worker 7 Other Non farm Labor	J (Record For Employed Residents Only) What is the address where you (he, she) work? Give exact address, intersecting streets, or well-known place and city	K DOES ANYONE IN YOUR HOUSEHOLD HAVE A SECOND JOB? --				
					Employed Full-Time?	Employed Part-Time?	Working	Retired?	Student?	Housewife?					Disabled?	Other?		
A	HEAD	M			Y	U	N	1	2	3	4	5	6	7	8	1 2 3 4 5 6 7 8 9 0		Y
B		M			Y	U	N	1	2	3	4	5	6	7	8	1 2 3 4 5 6 7 8 9 0		Y
C		M			Y	U	N	1	2	3	4	5	6	7	8	1 2 3 4 5 6 7 8 9 0		Y
D		M			Y	U	N	1	2	3	4	5	6	7	8	1 2 3 4 5 6 7 8 9 0		Y
E		M			Y	U	N	1	2	3	4	5	6	7	8	1 2 3 4 5 6 7 8 9 0		Y
F		M			Y	U	N	1	2	3	4	5	6	7	8	1 2 3 4 5 6 7 8 9 0		Y
		M			Y	U	N	1	2	3	4	5	6	7	8	1 2 3 4 5 6 7 8 9 0		Y
		M			Y	U	N	1	2	3	4	5	6	7	8	1 2 3 4 5 6 7 8 9 0		Y
		M			Y	U	N	1	2	3	4	5	6	7	8	1 2 3 4 5 6 7 8 9 0		Y
		M			Y	U	N	1	2	3	4	5	6	7	8	1 2 3 4 5 6 7 8 9 0		Y
		M			Y	U	N	1	2	3	4	5	6	7	8	1 2 3 4 5 6 7 8 9 0		Y

(H) INDUSTRY CODES:

- 1 Agriculture/Fishing
- 2 Mining
- 3 Construction
- 4 Manufacturing
- 5 Transportation/Communication/Public Utilities
- 6 Government
- 7 Retail Trade
- 8 Finance/Insurance/Real Estate
- 9 Services
- 0 Government/ Public Administration

*CIRCLE FOR PERSONS INTERVIEWED OR PRESENT

NOTES

-- If you get back to Call B (Person's letter) Live on the first person Lower after the last household member entry and write in the appropriate Person Letter in the last, under relationship to head (C), write in "Second Job" and printed listing in the last of column

SAMPLE ID.	S.D.	CO.	SEQUENCE						SAMPLE NUMBER				TRAVEL DAY

III. Travel Questions

NOW I WOULD LIKE TO ASK YOU SOME QUESTIONS TO HELP US UNDERSTAND HOW THE OCTOBER 17 EARTHQUAKE AFFECTED YOUR TRAVEL.

BEFORE THE EARTHQUAKE:

What is (or was) the address of your place of work? (Give city and exact street address or nearest intersection)

_____ city

_____ street address or nearest intersection

How did you usually get to your place of work before the earthquake?

- car - drive alone
Which bridge _____
- share a ride, carpool, vanpool
Which bridge _____
Number in vehicle _____
- bus
- BART
- ferry
- work at home
- other: _____

Before the earthquake, what were your usual commute hours?

left home at _____ am/pm
arrived home at _____ am/pm

About how long did it take you to get to work before the earthquake?
_____ minutes

Did you usually make additional stops on your way to work or on the way home?

- no
- yes: (list all that apply)
 - dropped someone off
 - picked someone up
 - shopping
 - social, recreational
 - work-related business
 - personal business
 - none of the above

Did your employer do anything to help you with your commute to work before the earthquake? (What were those?)

- allowed me to choose different working hours
- assigned new working hours for me
- allowed me to work at home certain days
- provided shuttle service or vanpool
- paid all or part of my transit fare
- other: _____
- none of the above

SAMPLE ID.	S.D.	CO.	SEQUENCE					SAMPLE NUMBER			TRAVEL DAY

NOW I WOULD LIKE TO ASK YOU SOME QUESTIONS ABOUT YOUR TRAVEL AFTER THE EARTHQUAKE.

Immediately after the earthquake, did your employer do anything to help you with your commute to work? (What were those?)

- allowed me to choose different working hours
- assigned new working hours for me
- allowed me to work at home certain days
- provided shuttle service or vanpool
- paid all or part of my transit fare
- relocated my workplace where?

city

street address or nearest intersection
- other: _____

- none of the above

AFTER THE QUAKE:

Have you tried different ways of getting to work? (List all that apply)

- no
- yes:
 - car - drive alone
Which bridge _____
 - share a ride, carpool, vanpool
Which bridge _____
Number in vehicle _____
 - bus
 - BART
 - ferry
 - work at home
 - other: _____

SAMPLE ID.	S.D.	CO.	SEQUENCE				

SAMPLE NUMBER	TRAVEL DAY

**AND NOW I WOULD LIKE TO ASK YOU
SOME QUESTIONS ABOUT YOUR
TRAVEL YESTERDAY.**

Did you go to the same place of work
yesterday as before the earthquake?

yes

no Why not?

workplace was forced
to close due to the
earthquake *GO TO **

vacation/illness *GO TO **

no longer employed *GO TO **

worked at home

workplace has
relocated

where?

city

street address or nearest
intersection

other _____

NOTE TO INTERVIEWER:

* is on next page

How did you get to this place of work
yesterday?

car - drive alone

Which bridge? _____

shared a ride, carpool,
vanpool

Which bridge? _____

Number in vehicle _____

bus

BART

ferry

worked at home

other _____

What were your commute hours yesterday?

left home _____ am/pm

arrived back home _____ am/pm

About how long did it take you to get to
work yesterday?

_____ minutes

Compared to your commute before the
earthquake, was your commute yesterday:

easier? In what ways?

harder? If so did it:

take more time (____ min.)

require more miles of travel

require more planning in advance

cut down on the time you spend
on personal activities or with
family or friends

Other: _____

SAMPLE ID.	S.D.		CO.		SEQUENCE					

SAMPLE NUMBER				TRAVEL DAY

Did you make any additional stops on your way to work or on the way home yesterday?

- no
- yes: (list all that apply)
 - dropped someone off
 - picked someone up
 - shopping
 - social, recreational
 - work-related business
 - personal business
 - none of the above

Did your employer do any of the following to help you with your commute to work yesterday? (What were those?)

- allowed me to choose different working hours
- assigned new working hours for me
- allowed me to work at home certain days
- provided shuttle service or vanpool
- paid all or part of my transit fare
- relocated my workplace where?

_____ city

street address or nearest intersection

other: _____

none of the above

*** NOW I'D LIKE TO ASK YOU A FEW QUESTIONS ABOUT OTHER TYPES OF TRAVEL THAT MIGHT HAVE BEEN AFFECTED BY THE EARTHQUAKE.**

Before the earthquake, about how many trips a week did you make to San Francisco for purposes other than work? Please tell me the number of trips you would make in the typical week (count a round trip as one trip for this purpose)

_____ total non-work trips to San Francisco per week before the earthquake. How many of these trips were:

- _____ shopping trips
- _____ school trips
- _____ medical, dental trips
- _____ social, recreational trips
- _____ personal business trips
- _____ other trip purposes

In the past week, about how many trips did you make to San Francisco for purposes other than work? Please tell me the number of trips you made in the past week (count a round trip as one trip for this purpose)

_____ total non-work trips to San Francisco per week after the earthquake. How many of these trips were:

- _____ shopping
- _____ school
- _____ medical, dental
- _____ social, recreational
- _____ personal business
- _____ other trip purposes

SAMPLE ID.	S.D.		CO.		SEQUENCE						SAMPLE NUMBER			TRAVEL DAY	

Has the current transportation situation affected your work-related travel, other than your commute trip?

- no
- yes Please describe: _____

Has the current transportation situation affected your travel for purposes such as shopping, child care, visiting friends or relatives, or other personal business?

- no
- yes Please describe: _____

AND FINALLY, FOR STATISTICAL PURPOSES, I NEED TO KNOW YOUR TOTAL HOUSEHOLD INCOME BEFORE TAXES. I WILL READ SEVERAL RANGES TO YOU. PLEASE STOP ME WHEN I REACH THE RIGHT ONE.

- \$15,000 OR UNDER
- \$15,001 - \$25,000
- \$25,001 - \$35,000
- \$35,001 - \$50,000
- \$50,001 - \$75,000
- \$75,001 - \$100,000
- OVER \$100,000

THANK YOU FOR YOUR HELP.

OCCUPATION DESCRIPTORS

professional, technical or similar worker
e.g., accountant, computer specialist,
lawyer, social worker, actor, musician,
medical personnel, labor or personnel
relations

manager or administrator, e.g., bank
officer or financial manager, buyer or
shipper, or any type of office, personnel,
or sales manager

clerical or similar worker, e.g., bank
teller, counter clerk, bookkeeper,
administrative assistant, vehicle
dispatcher, receptionist or secretary,
typist or keypunch operator

crafts or similar worker, e.g., carpenter,
printer, electrician, mechanic or
automotive repair

operative or similar worker, e.g., clothing
presser, dressmaker, service station
attendant, machine operator, delivery
person, truck or bus driver

sales worker, e.g., real estate agent,
sales clerk, insurance, stocks or bond
seller

service worker, e.g., cleaner, janitor,
waiter or waitress, welfare service aid,
watchman

other non-farm labor (specify)

Follow-Up Survey No. _____
Main Survey No. _____

Loma Prieta Earthquake/ Bay Bridge Effects Follow-Up Survey - Spring 1991

Hello, may I speak to _____ (person surveyed in Nov. '89.)

– Complete if person requested is not available:

_____ no longer at this address / this tel. no. (TERMINATE)

When could I phone back to reach _____? (get date and time of day) _____

Hello, my name is _____ and I am a researcher at the University of California. I am conducting a follow-up to a survey you helped us with in November 1989, on the effects of the Bay Bridge closure as a result of the Loma Prieta earthquake. May I ask you a few questions? This will take under five minutes of your time and will help us better understand how to plan transportation systems that work well here in the Bay Area.

–Complete if respondent can't talk now but agrees to be phoned back:

When could I phone back to reach you?(get date and time of day) _____

Q1. Do you still work in San Francisco?

_____ Yes _____ No (TERMINATE)

Q2. Is this at the same place of employment where you worked in November 1989?

_____ Yes _____ No / Don't Remember (TERMINATE)

Q3. What mode of transportation do you usually use to get to your place of work?

- _____ car - drive alone
- _____ share a ride, carpool, vanpool
- _____ number in vehicle
- _____ bus
- _____ BART
- _____ ferry
- _____ work at home
- _____ other: _____

Q4. What are your usual commute hours?

leave home at _____ am/pm
arrive home at _____ am/pm

Q 5. In the past week, how many trips did you make to San Francisco for purposes other than work? (Please tell me the number of trips you made in the past week, count a round trip as one trip for this purpose.)

_____ total non-work trips to San Francisco

THAT'S ALL! THANK YOU FOR YOUR ASSISTANCE - WE REALLY APPRECIATE IT. GOOD-BYE!

Appendix C . Zip Codes and Telephone Prefixes Used in Sample Selection

1. Zip Codes by District Used in Sample Selection

MTC Superdistrict 18 - Oakland - Piedmont - Alameda
94501
94601-94699

Superdistrict 22 - Orinda-Moraga-Lafayette-Walnut Creek
94563
94549
94556
94570
94595-94598

Superdistrict 19 - Berkeley - Albany - Emeryville
94608
94701-94799

Superdistrict 20 - El Cerrito - Richmond - North to Crockett
94525
94530
94547
94564
94569
94572
94801-94899

Superdistrict 21 - Concord - Pleasant Hill - Martinez
94517-94524
94553

Superdistrict 23 - Danville - San Ramon
94507
94526
94583

Superdistrict 17 - San Leandro - San Lorenzo - Castro Valley
94541-94546
94577-94580

2: Telephone Prefixes by MTC Superdistrict Used in Sample Selection

Superdistricts 18, 19, and Parts of 17 - East Bay Exchange Prefixes

261	482	559	748
263	483	562	762
268	486	568	763
271	521	569	769
272	522	577	832
273	523	596	834
339	524	632	835
351	525	633	836
352	526	635	839
357	527	636	840
420	528	638	841
425	530	639	843
428	531	642	845
430	532	643	848
436	533	644	849
437	534	645	865
444	535	649	869
446	536	652	874
448	539	653	893
451	540	654	987
452	547	655	
464	548	658	
465	549	667	
466		678	

Superdistrict 17 - Hayward Exchanges

276	782	888
278	783	889
481	784	
537	785	
538	786	
581	881	
582	884	
727	886	
732	887	

Superdistrict 20

Crockett
787

Pinole
724
741
758

Richmond		
222	234	374
223	235	529
231	236	620
232	237	
233		

Rodeo
799

Superdistrict 21

Concord		
246	682	827
356	685	
646	686	
671	687	
672	689	
674	778	
675	779	
676	798	
680	825	

Martinez
228
229
370
372

Superdistrict 22

Walnut Creek		
256	939	
746	942	
930	943	
932	944	
933	945	
934	946	
935	947	
937	977	
938		

Lafayette
283
284

Moraga
376
631

Orinda
253
254

Superdistrict 23

Danville

275 842

551 866

820 867

823

828

829

830

833

837