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16. Abstract

Due to the increasing number of the elderly population in the United States, more emphasis has been placed on research for elderly adults in the area of private transportation. There has been very little research done in the area of public transportation specifically for elderly people, however. The purpose of this study is to investigate the route guidance information needs of elderly bus passengers. Ten elderly research participants sixty-five years of age or older were asked to use and evaluate an existing information package provided by a bus system. Based on their recommendations and design guidelines suggested by experts, a new information package was designed. This package was then tested by another ten elderly research participants to see if it was a better design than the original information package. Basic design changes from the original information to the new information included color-coding of routes, simplification of the structure of the map, larger prints, and more messages to inform the users.

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Design of Route Guidance Information for Elderly Bus Passengers

A Research Study
by
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INTRODUCTION

The over sixty-five age group is the fastest growing segment in the United States population. This group constitutes about ten percent of the American population. This figure will increase to twelve to sixteen percent over the next fifty years. If there is no population growth within the next fifty to sixty years, there will be one person over sixty-five for every person under twenty. About one-third of the population will be over seventy-five. For a person who is now thirty-five years of age, the chances are eight out of ten that he will live to sixty, if he is a man. If the person is female, the chances are nine out of ten. When he or she reaches sixty-five, the life expectancy will be sixteen more years; at seventy-five, another ten. The nation is facing unique problems which it has never encountered before due to this phenomenon. One of the major problems of the elderly population is mobility (Barakat and Mulinazzi, 1987).

In order to study the problem of mobility of the elderly population, one must first investigate the physical, psychological, and social aspects of being an elderly person. In general, biological changes due to aging involves the body's loss of ability to renew itself. Body functions begin to slow down, and vital organs become less sensitive. The senses tends to decline with age. Psychological changes due to aging include changing of sensory processes, perception, motor skills, and problem-solving abilities (Barakat et al., 1987). The reaction time of elderly people tend to be slower and they take longer to learn new things (Barakat et al., 1987; Evans, Brannan, Skorpanich, and Held, 1984). Most studies agree that there is little or no decline in elderly people's short-term memory capacity (Barakat et al., 1987). Even so, long-term memory research indicates that elderly adults have less ability to recall information (Evans et al., 1984). Other members of the society often have misconceptions about the elderly population. Elderly people are believed to be senile, unhappy, unable to function, and unable to engage in outside activities. The fact is that most elderly people are not senile. Only about two or three percent of the elderly population are institutionalized due to some types of psychiatric illnesses. Less than ten percent of the them are disoriented. Most people over sixty-five live at home and perform most daily activities without the assistance of others. Although the rest of the population tend to believe that growing old is a very unpleasant experience, this view is not shared by the older population itself. Most elderly people are able to change and adapt to new conditions and environments. Their social and political views tend to change with the rest of the society, although at a slower rate (Barakat et al., 1987). This indicates the need for elderly people to get around freely and independently. One of the transportation tools available to most elderly people is a public bus. Unfortunately, many people do not use bus systems because the maps and schedules provided are difficult to read and understand (Ellson and Tebb, 1978a). This problem is magnified within the elderly population. This study attempts to

design bus route guidance information so that they may be readable and easily understood by elderly adults.

In order to investigate the most effective bus route guidance information, two issues must be addressed. The first issue is the spatial behavior and cognition of elderly adults. Secondly, specific guidelines relating to information design must also be studied. Easterby (1984) states, "As designers and evaluators of displayed information we are primarily concerned with the communication of the messages; indeed this occurs at the intersection of the disciplines of psychology and graphic communication with the technologies of engineering, ergonomics and printing. If we ask ourselves--what are the defining characteristics of the optimum printed page, the optimum technical instruction, the optimum sign or machine facia?--the answers must be at once psychological, graphical and technological." In general, people try to make sense of their surroundings by converting the environment into simple geometric forms. It is important for people to not only know where a location is, but also what a location is (Canter, 1984). Halpern (1984) reports that verbal abilities remain high as a person ages while spatial abilities begin to decline at an earlier age. Elderly people have less complete information of their geographical surroundings than their younger counterparts. Sketched maps by elderly people tend to be disorganized, simple, inaccurate, and smaller than those sketched by younger people. Evans et al. (1984) list some destination characteristics which are particularly helpful to elderly people in way-finding. These characteristics include high usage intensity, major symbolic significance, more natural settings, locations with direct and easy access, and places which are unique in style.

Gender differences between elderly males and females must also be considered. While in general males have higher abilities in spatial visualization and orientation, there is little gender difference in other spatial tasks (Evans et al., 1984; Gilmartin and Patton, 1984). Research shows that there is no difference between males and females in the particular task of map usage (Evans et al., 1984).

Research consistently reports maps to be the most effective way to present environmental information (Booher, 1975; Kirasic and Mathes, 1990; Lloyd, 1989). People who learn about a city through maps are faster and more accurate at performing experimental tasks than those who learn the city through experience (Lloyd, 1989). Lloyd (1989) states, "The encoding of spatial information about an environment through navigation occurs in discrete chunks, which must be put together to form a whole cognitive map, usually over a relatively long period of time. In contrast, studying a cartographic representation allows holistic impressions of the spatial relationships of the elements of interest within the environment to be efficiently encoded in a relatively short time". Kirasic and Mathes' (1990) study indicates that maps are superior to other forms of information presentation as a tool for elderly women to learn about an environment. Studies comparing graphic representation and verbal instructions show that graphics are better for presenting static information while words are better for presenting action (Booher, 1975). These

findings clearly indicate that maps are the best form of presentation of spatial information.

Two areas must be considered in the study of map and schedule design for bus systems. First, many studies give guidelines on the most effective map and timetable design (Bartram, 1984; Christ, 1984; Ellson et al., 1978a; Ellson and Tebb, 1978b). Also, specific issues concerning readability, legibility, and comprehensibility of information must be investigated (Ellson et al., 1978b; Hartley, 1984; Moriarty and Scheiner, 1984; Murrell, 1965; Reynolds, 1984; Smith, 1984; Sorg, 1985; Tinker, 1963). Bartram (1984) compared four formats of representing bus routes: alphabetical listing of the routes, sequential listing of the routes, road map showing all streets, routes, and geographical attributes of the area, and schematic map showing major streets and routes which are related to each other by straight lines. The most effective map is a combination of road and schematic maps. This map gives information about important landmarks and points of interest to allow easier way-finding for people who are not familiar with the area. At the same time, it includes some degree of schematization to simplify the complex structure of roads in urban areas in order to avoid giving too much information and causing confusion. Bartram (1984) and Ellson et al. (1978b) suggest that a complete road map also be given to bus passengers if space allows on the information leaflet.

Some guidelines that apply specifically to map design are presented by Bartram (1984), Christ (1984), and Ellson et al. (1978b). Research participants using color coded maps are much more effective at finding the beginning and end points of routes. They are faster and more accurate at finding the most efficient routes. They are also much more comfortable with color coded maps as opposed to ones which are not color coded. A different color must be used for each service number. At bus interchange points, it is important to show the exact location where the buses stop. Names of interchange sites are to be clearly shown and distinguishable, perhaps by using bold or all capital letters. The accessibility of major points of interest shall be highlighted. Symbols used must be consistent everywhere throughout all the maps. Finally, the map shall be accompanied by a legend which explains the symbols as well as the color coding scheme.

In general, people do not like using timetables, nor do they understand how to use them. Some people tend to use only the maps and ignore other information provided by the bus system. As a result, their plans sometimes include non-existing stops and transfers. To help passengers better understand timetables, specific guidelines are given for the design of timetables. It is important that people know the exact time that a bus meets its counterpart at an interchange. For passengers who must make transfers, it is important to know the bus number which he/she must transfer to. The use of a twenty-four hour clock on timetables confuses people, the use of "a.m." and "p.m." also confuses some people. The best way to represent time on timetables is by specifying "morning journeys", "afternoon journeys", and "evening journeys". Finally, inserting bold lines between morning, afternoon, and evening

journeys aid in readability of the timetable and reduces confusion (Bartram, 1984; Ellson et al., 1978b).

In the design of maps and timetables, some important issues to be considered in the area of legibility are: type size, length of line, word spacing, line spacing, color of ink, color of paper, quality of paper, and the printing process (Ellson et al., 1978b; Hartley, 1984; Moriarty et al., 1984; Murrell, 1965; Reynolds, 1984; Smith, 1984; Sorg, 1985; Tinker, 1963). In Murrell's 1965 report, a reasonable letter size for legibility is .035 inches for each foot of viewing distance. According to MIL-STD 1472D (1989), noncritical data may be as small as 1.3 to 5.0 mm, regardless of luminance. Reynolds (1984) and Tinker (1963) report that letters that are wider are more legible than those which are narrower. Serif type letters are better than san serif type letters. Times Roman and Universe are the best fonts. Most people with poor vision prefer demi-bold face type. Bold face type does not slow down reading speed. This type should be used for important information which requires extra attention. Most people do not like Italics and it tends to retard reading ability. However, the usage of Italics for emphasis is appropriate. The best character sizes are between nine and twelve points, with the optimum being around ten or eleven point. Words in lower letters can be read faster and more easily than words in all capital letters. In a study investigating type face and type size preferred among elderly adults, however; Sorg (1985) states that elderly people prefer fourteen point Helvetica in all capital letters. Tinker (1963) suggests that legibility of letters can be improved by simplifying letter outlines, emphasizing distinguished characteristics of the letters, use of open counters, and avoid using letters with extremely heavy or thin strokes.

With regard to line length, it may be varied within broad limits without affecting legibility. However, lines which are very short prevent maximum use of peripheral vision. Lines that are extremely long causes difficulty in locating the beginning of each successive line (Moriarty et al., 1984; Reynolds, 1984). Moriarty et al. (1984) report that texts with less spacing than regular text can be read with greater speed. Even so, very close spacing may cause confusion in letter recognition. Very wide letter spacing may cause the words to be read as individual letters rather than words. Although there is no significant difference in legibility or speed between materials which are right-justified and those which are not, unskilled readers tend to find unjustified materials easier to read and understand. Finally, texts which have lines that start at different points along the left margin reduces readability and thus must be avoided (Reynolds, 1984).

Some research has been done on the type and quality of ink and paper to be used for presenting information. Tinker (1963) concludes that text printed in black ink with reflectance of at least seventy percent is equally legible on white as well as tinted paper. The best combination of ink and paper is black on white or black on yellow. Although there is generally no difference in legibility, readers prefer matt paper to medium or glossy paper. Sorg (1985) reports that elderly people tend to prefer blue paper, although it tends to reduce legibility. She suggests that white or

yellow paper be used for reading material and blue paper be used for cover or unimportant material in order to attract elderly adults.

In conclusion, elderly adults generally lead satisfied lives and want to perform normal daily activities and be independent (Barakat et al., 1987). Having a bus system for those elderly people who do not or cannot drive helps them to get around without depending on other people for their transportation needs. Ellson et al. (1978b) conclude that the lack of use of bus systems are mostly due to the lack of adequate information to bus passengers. This indicates a need of elderly population to receive better designed bus information from their local bus systems. This study attempts to present a bus information package which is more attractive, easier to read, and easier to understand by the elderly population.

Objectives

The objectives of the study were to:

1. Discover difficulties elderly people may have with utilizing route guidance information provided by a bus system at the present time.

2. Make any changes necessary to develop a more effective way to present route guidance information to elderly bus passengers.

3. Test to see if and how the changes help elderly people in using route guidance information to successfully reach desired destinations in a city.

METHODS

Research Participants

Twenty people sixty-five or older were asked to participate in this study research. Ages of the nine male and eleven female participants ranged from 67 to 79 years, with an average age of 70.85 years. A group of ten participants were asked to test the original bus information, the other ten participants were asked to test the redesigned bus information. Elderly people were chosen at random to participate in either group. The average age of the four males and six females participating in the testing of the original information was 71 years. The average age of the five males and five females participating in the testing of the redesigned information was 70.7 years. The average experience in public bus usage was higher for those testing the original information in comparison to those testing the redesigned information. Table 1 shows a profile of the research participants' age, gender, education, and frequency of public bus usage. Those participants who frequently used bus systems were classified as frequent users. Occasional users were those who have not used public buses recently but have been frequent users in the past. This category also includes those participants who utilize public buses occasionally when they travel. The participants who have ridden public buses less than five times in their lives were classified as seldom bus users. The last category of bus users are those who have never used public buses.

Materials

Materials generally provided to the County Connection bus passengers by Central Contra Costa Transit Authority in Walnut Creek, California were presented to each research participant during the initial phase of the study. This particular bus system was chosen because it is relatively complex and provides a good information package as compared to other bus systems. Since the experiment was conducted in College Station, Texas, research participants were not likely to have prior knowledge of the Walnut Creek area, which avoids the confounding effect of different amounts of similarity with the system. Another reason for choosing this area was that the person conducting the research and her study chairman both have some familiarity with the area. The information package contained a large map which includes the cities of Concord, Danville, Lafayette, Martinez, Moraga, Orinda, Pleasant Hill, San Ramon, and Walnut Creek. This large system map was accompanied by a street and points of interest index. This system map is shown in Figure 1.

TABLE 1

Profile of Research Participants

Tested original information:

Participant	Age	Gender	Education	Frequency of Use
1	73	M	Ph.D	frequently
2	68	M	M.S.	occasionally
3	67	F	high school	seldom
4	72	M	M.S.	occasionally
5	71	F	B.S.	occasionally
6	70	F	high school	occasionally
7	70	F	tech school	seldom
8	68	F	M.S.	seldom
9	72	M	MBA	never
10	79	F	high school	occasionally

Tested redesigned information:

Participant	Age	Gender	Education	Frequency of Use
11	75	F	B.S.	never
12	69	M	B.S.	seldom
13	74	M	B.S.	never
14	69	M	MBA	seldom
15	68	F	B.S.	never
16	68	F	high school	never
17	70	M	M.S.	seldom
18	72	M	M.S.	seldom
19	71	F	high school	never
20	71	M	M.S.	never

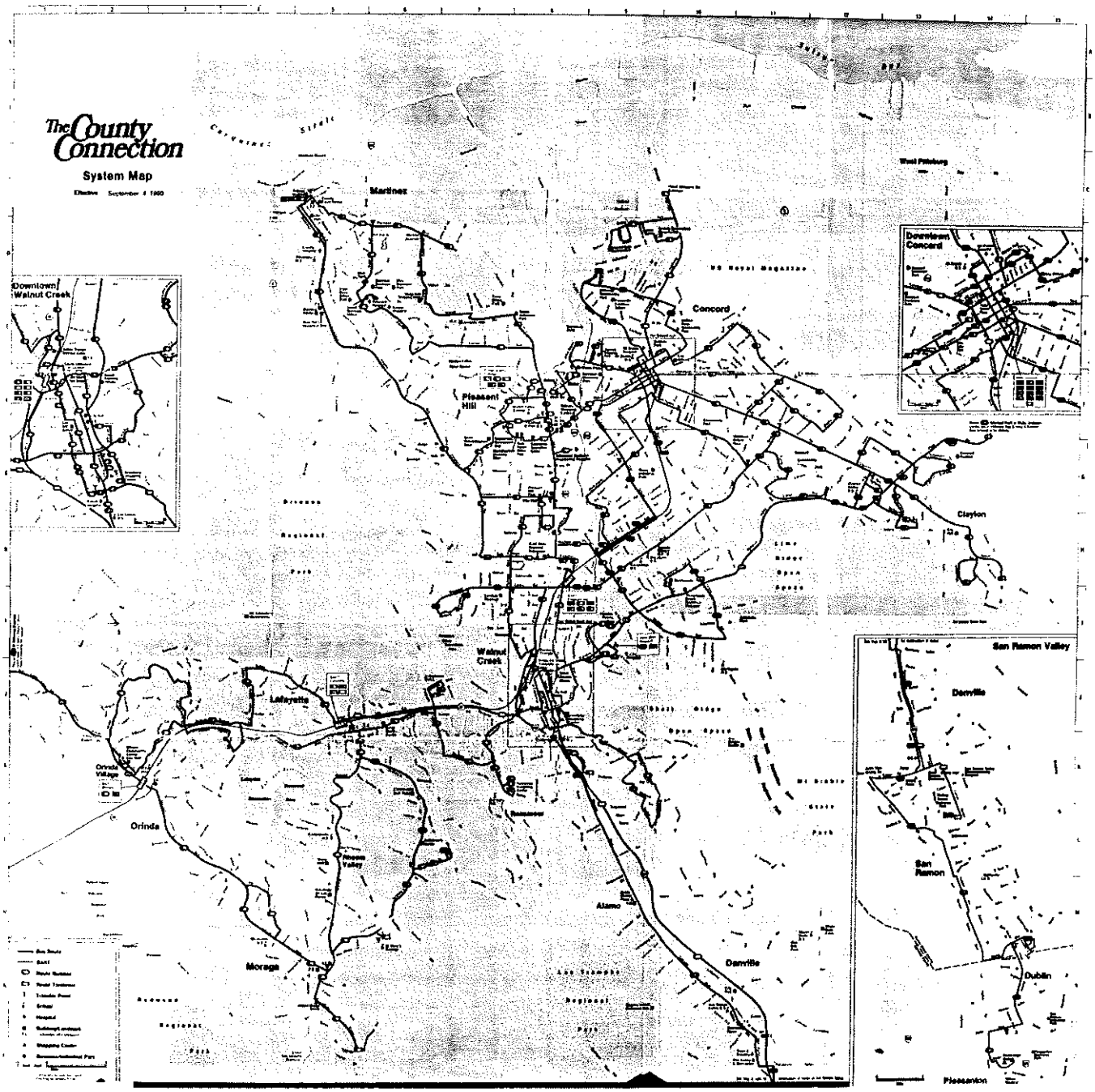

Figure 1. The County Connection Bus Service System Map

Note: Original in color

The information package also included twenty-six bus route schedules and some information which may be helpful to the passengers. All bus routes are indicated by their numbers on the maps. On each route schedule, times of arrival and departure of destinations are indicated. A small map of the area covered by each route is also provided. Some additional information on how to use the schedules, fare information, hours of operation, helpful telephone numbers, and other transit services are provided as well. A sample of these schedules is shown in Figure 2.

Procedure

The research study occurred in three phases. In Phase One the research participants used the current information provided by Central Contra Costa Transit Authority. Given some proposed starting points and desired destinations, the participants were asked to find the most efficient bus routes. An efficient bus route was defined as one which requires the least amount of time and the smallest number of transfers. The research participants were informed that the study was not designed to test their ability to use map information, but simply to obtain their opinions on how they believe the information may be improved. Some participants were unable to finish the entire route-planning process because they were given a thirty-minute limit. The reason for this limit is because the experiment was designed to familiarize the participants with the information package in order to obtain redesign suggestions. The limit was also set so as to avoid keeping the participants at the experiment for too long and thus becoming upset. Participants were asked to talk about their route-finding process, which was recorded by an audio tape recorder. The duration of the route-finding process was also noted. A semi-structured interview containing questions about any difficulties the participants encounter and suggestions they have on improving current information package was given to them after their attempts to use the information package.

Phase Two involved the redesigning of the current information package. Changes were made on the current information package based on research and data collected from Phase One. Information from research publications on cognitive performance of elderly people relating to spatial orientation and navigation and design of maps and route guidance information were used in the redesigning of the current information package as well. Finally, information packages of other bus systems were studied.

Some design considerations included 1) color coding and highlighting to give a more striking representation of routes, 2) symbols showing the exact location of

The times published in CCCTA timetables and brochures do not anticipate service disruptions, but are approximations for normal trips. All timetables are subject to change without notice.

105

Walnut Creek BART/Broadway/Creekside

The County Connection

105		Monday-Friday					105
Leave BART Walnut Creek	Civic/ North Broadway	Mt Diablo Blvd South Broadway	Arrive Creekside	Leave Creekside	Mt Diablo Blvd/ South Broadway	Civic/ North Broadway	Arrive BART Walnut Creek
				5:27	5:35	5:39	5:45
5:53	5:58	6:02	6:10	6:11	6:19	6:23	6:29
6:30	6:35	6:39	6:47	6:48	6:56	7:00	7:06
7:10	7:15	7:19	7:27	7:28	7:36	7:40	7:46
7:50	7:55	7:59	8:07	8:08	8:16	8:20	8:26
8:30	8:35	8:39	8:47	8:48	8:56	9:00	9:06
9:09	9:14	9:18	9:26	9:27	9:35	9:39	9:45
9:49	9:54	9:58	10:06	10:07	10:15	10:19	10:25
10:28	10:33	10:37	10:45	10:47	10:55	10:59	11:05
11:06	11:11	11:15	11:23	11:24	11:32	11:36	11:42
11:46	11:51	11:55	12:03	12:04	12:12	12:16	12:22
12:26	12:31	12:35	12:43	12:44	12:52	12:56	1:02
1:06	1:11	1:15	1:23	1:24	1:32	1:36	1:42
1:48	1:53	1:57	2:05	2:06	2:14	2:18	2:24
2:31	2:36	2:40	2:48	2:49	2:57	3:01	3:07
3:08	3:13	3:17	3:25	3:26	3:34	3:38	3:44
3:48	3:53	3:57	4:05	4:06	4:14	4:18	4:24
4:28	4:33	4:37	4:45	4:46	4:54	4:58	5:04
5:08	5:13	5:17	5:25	5:26	5:34	5:38	5:44
5:48	5:53	5:57	6:05	6:06	6:14	6:18	6:24
6:30	6:35	6:39	6:47	6:48	6:56	7:00	7:06
7:15	7:20	7:24	7:27				

A.M - Light type P.M.- Bold Type

105		Saturday					105
Leave BART Walnut Creek	Civic/ North Broadway	Mt Diablo Blvd/ South Broadway	Arrive Creekside	Leave Creekside	Mt Diablo Blvd/ South Broadway	Civic/ North Broadway	Arrive BART Walnut Creek
9:52	9:57	10:00	10:08	10:09	10:17	10:20	10:25
10:52	10:57	11:00	11:08	11:09	11:17	11:20	11:25
11:52	11:57	12:00	12:08	12:09	12:17	12:20	12:25
12:52	12:57	1:00	1:08	1:09	1:17	1:20	1:25
1:52	1:57	2:00	2:08	2:09	2:17	2:20	2:25
2:52	2:57	3:00	3:08	3:09	3:17	3:20	3:25
3:52	3:57	4:00	4:08	4:09	4:17	4:20	4:25
4:52	4:57	5:00	5:08	5:09	5:17	6:20	5:25
5:52	5:57	6:00	6:08	6:09	6:17	6:20	6:25

Not all stops are listed. CALL 676-7500 for the stop nearest you.

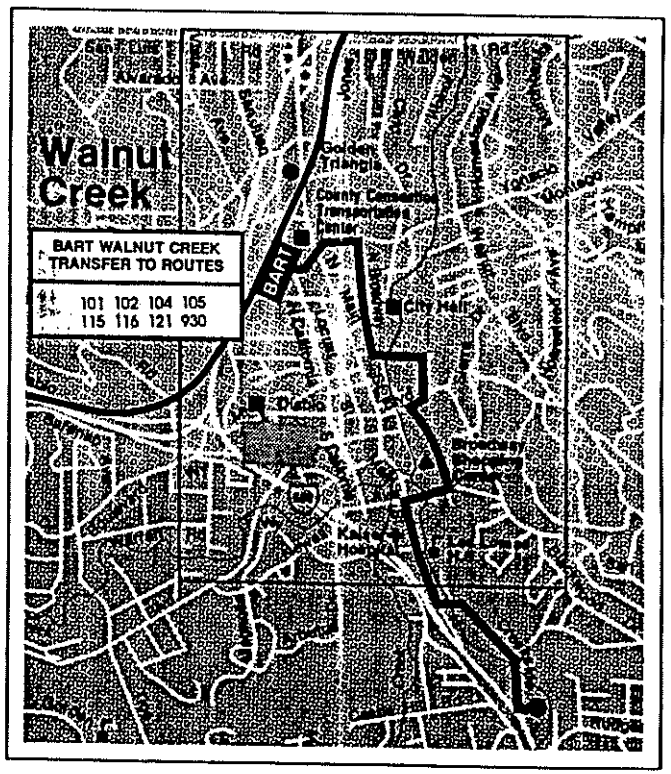

Figure 2. Sample County Connection Bus Service Schedule

stops, 3) highlighting the accessibility of all major destinations, 4) words in all capital letters versus lower case letters, 5) line length, type face, letter size, type and quality of ink and paper.

Phase Three was a repeat of Phase One in order to test the effectiveness of the changes from the original information package. A different group of people from those who participated during Phase One were asked to participate in a tryout which was conducted exactly like the one conducted in Phase One, except that the new redesigned information package is used during Phase Three.

Data Analysis

Two measures were made. The first measure was the time required to complete a route-finding task from a starting point to a destination. Another measurement was the deviation from the optimum route in terms of additional transit time and additional number of transfers required. The results of the study are presented in tabular form. These tables include complaints in using both original and redesigned packages, recommendations for redesign, improvements resulting from the redesigned package, and the comparison between the original and redesigned packages in terms of the two variables mentioned above.

RESULTS

Phase One--Evaluation of Original Route Guidance

The data from Phase One of this research study includes time required to complete each route-planning process for each research participant, additional travel time and number of transfers required due to non-optimum plans, and suggestions and complaints from the participants on the design of the information package. A sample data sheet and questionnaire form which were used to collect information during the experiment are included in Appendices C and D. Table 2 shows the time required to complete the route-planning process. Additional travel time required due to non-optimum plans are summarized in Table 3.

The average time required to complete the planning for Route One was 19.4 minutes, this included one incomplete plan. An incomplete plan is one in which the research participant is unable to complete the route-planning from the starting point to a destination within the thirty-minute time limit. For Route Two, the average planning time was 20.7 minutes with three incomplete plans. The optimum travel plan for Route Two required one transfer. Among the participants who completed the travel plans, one research participant's plan included two transfers instead of the optimum of one transfer. The other participants' plans included one transfer only. Route Three resulted in an average of 27.8 minutes planning time with 6 incomplete plans. The optimum travel plan for Route Three required two transfers. Among the participants who completed the travel plans, all but one participant planned two transfers. One participant planned three transfers instead of the optimum two transfers. Efficiency of a travel plan is shown in two ways: efficiency of the plan with respect to travel time, and the efficiency of the plan with respect to number of transfers. Efficiency of the plan with respect to travel time is equal to the optimum travel time divided by the planned travel time. Efficiency of incomplete plans or plans which are not feasible (one cannot get to the destination following the plan) is zero. Efficiency of the plan with respect to transfers is equal to optimum number of transfers divided by planned number of transfers. The results of the calculated efficiencies are shown in Table 4.

TABLE 2

Time Required to Complete the Route-Planning Process during Phase One (Original Information Package)

	Research Participant												
	1	2	3	4	5	6	7	8	9	10	% of success	Mean Time	Standard Deviation
Route 1	22	13	18	12	28	11	21	20	30	-	90	19.4	6.7
Route 2	18	15	20	30	-	24	24	-	14	-	80	20.7	5.7
Route 3	23	30	30	-	-	-	-	-	28	-	40	27.8	4.4

Note: "-" symbolizes incomplete plans (over 30 minutes).
Note: Times are recorded in minutes.

TABLE 3

Additional Travel Time Required Due to Non-Optimum Travel Plans during Phase One (Original Package)

	Research Participants									
	1	2	3	4	5	6	7	8	9	10
Route 1	0	0	0	0	0	0	0	0	0	-
Route 2	1	0	20	3	-	6	0	-	13	-
Route 3	0	7	-	-	-	-	-	-	43	-

Note: Additional travel time above are recorded in minutes.
Note: Additional travel time = planned travel time - optimum travel time.
Note: "-" symbolizes incomplete plans (Planned travel time is greater to 30 minutes).

TABLE 4

Efficiencies of the Travel Plans with Respect to Travel Time and Number of Transfers (Original Package)

Efficiencies with Respect to Travel Time:

	Research Participants									
	1	2	3	4	5	6	7	8	9	10
Route 1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Route 2	0.98	1.00	0.76	0.96	0	0.92	1.00	0	0.83	0
Route 3	1.00	0.92	0	0	0	0	0	0	0.67	0

Efficiencies with Respect to Number of Transfers:

	Research Participants									
	1	2	3	4	5	6	7	8	9	10
Route 1	1	1	1	1	1	1	1	1	1	-
Route 2	0.5	1	1	1	-	1	1	-	1	-
Route 3	1	1	-	-	-	-	-	-	1	-

Note: "-" symbolizes incomplete plans.

Complaints from research participants on the design of the original information package are listed in Table 5. Based on these complaints and suggestions on the questionnaire form, redesign considerations for Phase Two are summarized. These design considerations for the system map, the leaflet maps, and the timetables are listed in Table 6, 7, and 8, respectively. All of the participants felt that they could not distinguish between individual routes because all 26 of the routes are represented by the same color on the system map. Eighty percent of the participants reported that they were unable to identify bus stops and transfer points. Fifty percent of the people said that they could not identify the direction of the bus routes on the small leaflet maps. Regarding the size of the print on the system map, forty percent of the people felt that some of the print was too small.

Phase Two--Redesign

Phase Two of the research study consisted of the redesign of the information package. The criteria for redesign were based on the questionnaire and the comments of the research participants. The questions on the questionnaire were based on the information gathered during the literature review. The design suggestions from various journal articles were taken into consideration when the questionnaire was constructed and the original information package was evaluated. The questionnaire was drawn up based on the items in the package which were not designed according to the suggestions in journal articles. The information was then summarized in the design consideration tables. Each design consideration was evaluated based on the number of participants who have made the particular suggestion as well as its feasibility. A schematic map instead of the original topographic map was chosen because it simplifies the map and provides more space for larger symbols and prints. In choosing the technique to color code the routes, color makers, pens, and pencils of various types as well as color tape were considered. The participants were unable to identify the bus stops because they are not noted in the information package. The stops are not marked because frequent users are expected to know that the buses stop at every street corner along the routes they serve. This piece of information is not conveyed to first-time users and therefore causes confusion. Instead of cluttering the map with numerous bus stop and transfer point symbols at each street corner, a note stating that buses stop at every street corner was placed on the top of the redesigned map where it may be clearly seen. The print sizes were enlarged and street names were placed as close to the streets they represent as possible. The "See inset map" messages were placed next to the city names and highlighted in purple so they may be more visible.

TABLE 5

Research Participants' Complaints in Phase One

	Research Participants										
	1	2	3	4	5	6	7	8	9	10	Percent Reporting
Unable to identify bus stops.	X	X	X	X		X		X	X	X	80
Unable to identify transfer points.	X	X	X	X		X	X	X	X		80
Individual routes cannot be identified on the system map because all routes are represented by the same color.	X	X	X	X	X	X	X	X	X	X	100
Some prints sizes are too small on the system map.		X	X		X					X	40
Fail to notice the "See inset map" message.		X				X					20
Unable to identify direction of the routes on the leaflet.		X	X	X	X		X				50
Some street names are not listed close enough to the street which they represent on the system map.			X								10
Glossy paper used for the system map reflects too much glare.					X						10
Not enough contrast between print and background on the system map.					X		X				20
Cannot understand the correlation between system and inset maps.										X	10

TABLE 6

Design Considerations for the System Map (Based on the Questionnaire)

Design Categories	Design Suggestions	Participants Who Support the Suggestion									
		1	2	3	4	5	6	7	8	9	10
Color Coding	Color code routes	X	X	X	X	X	X	X	X		X
	Color bus stop symbols	X									
	Color transfer point symbols	X									
Listing of Stops	List all bus stops	X	X	X	X		X	X	X	X	X
	List all transfer points	X	X	X	X		X	X	X		X
	Place transfer points at intersection of routes		X								
Size of Print	Larger print sizes		X	X		X		X			X
Clarity of Information	Make "See inset map" message more noticeable by placing it next to city names or use a different color		X								
	Place street name next to corresponding street			X							
Contrast	Use darker color print					X					X
	Use white paper					X					X
Type and Quality of Paper	Use matt paper instead of glossy paper					X					X

Note: The X indicates that the participant felt that the particular design suggestion would be helpful to other users. These suggestions are drawn from participants's complaints (see Table 5) and from the literature search.

TABLE 7

Design Considerations for the Leaflet Map (Based on the Questionnaire)

Design Categories	Design Suggestions	Participants Who Support the Suggestion									
		1	2	3	4	5	6	7	8	9	10
Leaflet Format	Wherever possible, place the map and timetable for the same days on the same page	X	X								X
	Place legend on each map	X									
Clarity of Information	Direction of Routes should be indicated by arrows		X	X	X	X		X			
	Use light background							X			
	Street names should not be covered by dark lines				X						
Listing of Stops	List all bus stops	X	X	X	X		X	X	X	X	X
	Number all bus stops	X									
Color Coding	Color bus stop symbols	X		X							

Note: The X indicates that the participant felt that the particular design suggestion would be helpful to other users. These suggestions are drawn from participants's complaints (see Table 5) and from the literature search.

TABLE 8

Design Considerations for the Leaflet Timetable (Based on the Questionnaire)

Design Categories	Design Suggestions	Participants Who Support the Suggestion									
		1	2	3	4	5	6	7	8	9	10
Clarity of Information	Direction of routes should be indicated		X	X	X	X		X			
	The availability of weekday-weekend, morning-afternoon, and peak-off-peak schedules should be indicated by the use of bold print, different fonts, or different color of print							X			
Listing of Stops	List all bus stops		X	X	X	X		X	X	X	X

Note: The X indicates that the participant felt that the particular design suggestion would be helpful to other users. These suggestions are drawn from participants's complaints (see Table 5) and from the literature search.

In the area of contrast, black ink on white paper was used to obtain the best contrast. Color ink was used only for the purpose of emphasizing important information. Finally, matt paper was used in place of glossy paper to avoid glare. The redesigned system map is shown in Figure 3.

The two main concerns of the leaflets are the lack of bus stop symbols and the absence of route direction indicators. The leaflets were kept in its original form. The message that buses stop at every street corner and direction arrows which indicate the flow of the bus routes were simply added onto the leaflets. Because the maps on the leaflets represent a smaller area than the system map, red circles symbolizing bus stops were added to the maps as well. The messages "Buses will stop at every street corner. Not all stops are listed. Red circle signifies bus stops." were placed inside a red box and added to a visible area on the leaflet. Not all stops were listed on the schedule because buses stop at every street corner. There is simply not enough space to list times of arrival and departure at every street corner. This caused problems for many participants because they assumed that all stops were included in the schedule. For this reason the message "Not all stops are listed" was added to the leaflet. A sample of a redesigned leaflet is shown in Figure 4.

The index of streets and points of interest was simplified by eliminating the streets which are not included in the schematic system map. Bus routes serving each street or point of interest were also listed at the end of each line of this index. This added feature allows users to plan their trips more efficiently by identifying the buses which serve the destinations of interest. The redesigned street and points of interest index is shown in Figure 5. The schematic map was improved by eliminating non-essential information. For the users who may want a detailed map showing all streets in the area, a road map including all topographical information could be provided.

Phase Three--Results of Evaluation of Redesigned Route Guidance

Phase Three was a repeat of Phase One using the redesigned information package instead of the original information. Data from Phase Three again included time required to complete each route-planning process, additional time and number of transfers required due to non-optimum trip plans, and complaints and suggestions from using the new information package. The same three routes used in Phase One were again used in Phase Three. The average time required to complete Route One is 14.2 minutes with no incomplete plans. Route Two required an average planning time of 23.4 minutes with two incomplete plans.

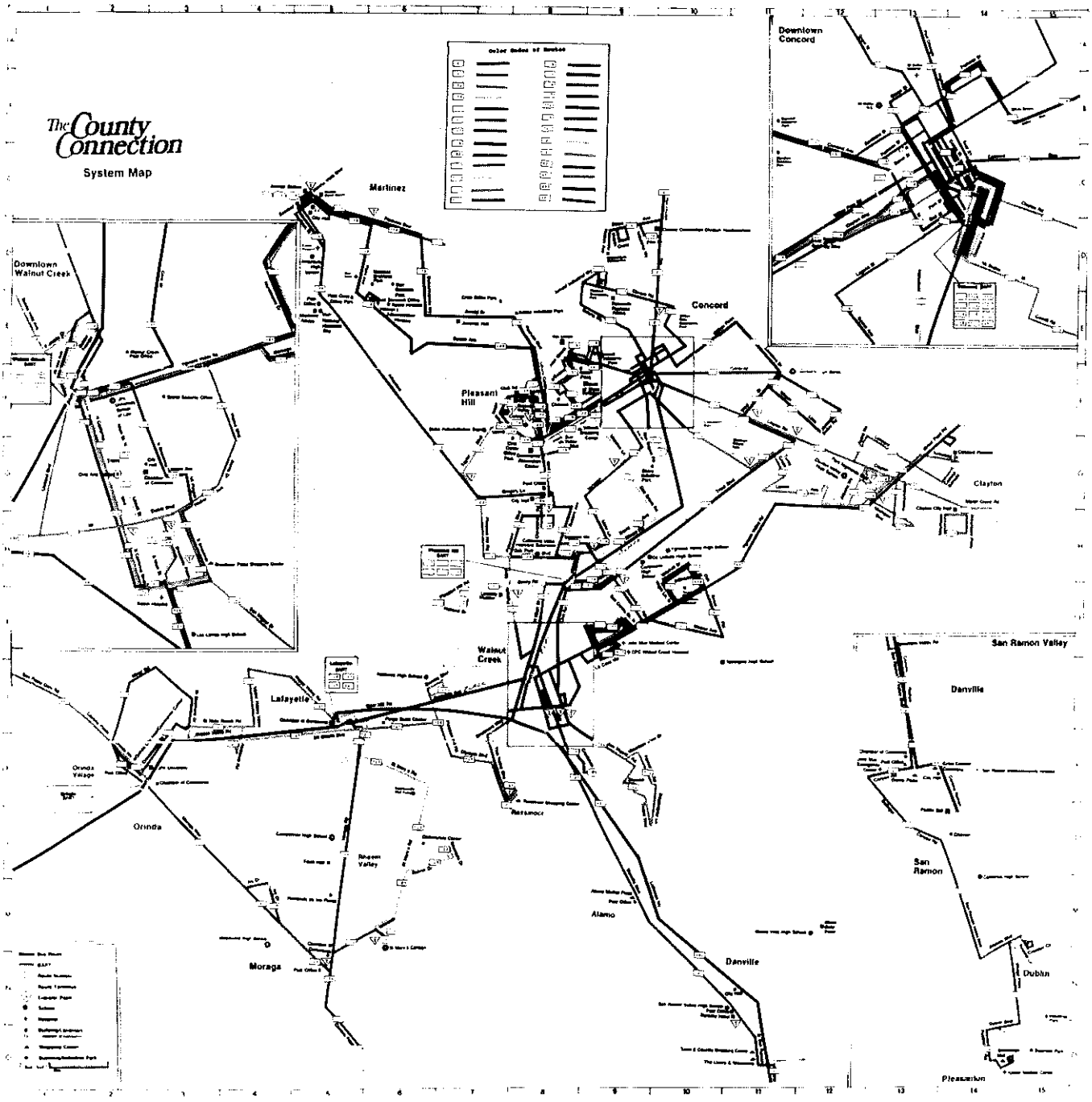

Figure 3. Redesigned County Connection Bus Service Map

Note: Original in color

The times published in CCCTA timetables and brochures do not anticipate service disruptions, but are approximations for normal trips. All timetables are subject to change without notice.

Buses will stop at every street corner.
Not all stops are listed.
● represents bus stops.

105

Walnut Creek BART/Broadway/Creekside

The County Connection

105		Monday-Friday					105
Leave BART Walnut Creek	Civic/ North Broadway	Mt Diablo Blvd South Broadway	Arrive Creekside	Leave Creekside	Mt Diablo Blvd/ South Broadway	Civic/ North Broadway	Arrive BART Walnut Creek
5:53	5:58	6:02	6:10	5:27	5:35	5:39	5:45
6:30	6:35	6:39	6:47	6:11	6:19	6:23	6:29
7:10	7:15	7:19	7:27	6:48	6:56	7:00	7:06
7:50	7:55	7:59	8:07	7:28	7:36	7:40	7:46
8:30	8:35	8:39	8:47	8:08	8:16	8:20	8:26
9:09	9:14	9:18	9:26	8:48	8:56	9:00	9:06
9:49	9:54	9:58	10:06	9:27	9:35	9:39	9:45
10:28	10:33	10:37	10:45	10:07	10:15	10:19	10:25
11:06	11:11	11:15	11:23	10:47	10:55	10:59	11:05
11:46	11:51	11:55	12:03	11:24	11:32	11:36	11:42
12:26	12:31	12:35	12:43	12:04	12:12	12:16	12:22
1:06	1:11	1:15	1:23	12:44	12:52	12:56	1:02
1:48	1:53	1:57	2:05	1:24	1:32	1:36	1:42
2:31	2:36	2:40	2:48	2:06	2:14	2:18	2:24
3:08	3:13	3:17	3:25	2:49	2:57	3:01	3:07
3:48	3:53	3:57	4:05	3:26	3:34	3:38	3:44
4:28	4:33	4:37	4:45	4:06	4:14	4:18	4:24
5:08	5:13	5:17	5:25	4:46	4:54	4:58	5:04
5:48	5:53	5:57	6:05	5:26	5:34	5:38	5:44
6:30	6:35	6:39	6:47	6:06	6:14	6:18	6:24
7:15	7:20	7:24	7:27	6:48	6:56	7:00	7:06

A.M - Light type P.M.- Bold Type

105		Saturday					105
Leave BART Walnut Creek	Civic/ North Broadway	Mt Diablo Blvd/ South Broadway	Arrive Creekside	Leave Creekside	Mt Diablo Blvd/ South Broadway	Civic/ North Broadway	Arrive BART Walnut Creek
9:52	9:57	10:00	10:08	10:09	10:17	10:20	10:25
10:52	10:57	11:00	11:08	11:09	11:17	11:20	11:25
11:52	11:57	12:00	12:08	12:09	12:17	12:20	12:25
12:52	12:57	1:00	1:08	1:09	1:17	1:20	1:25
1:52	1:57	2:00	2:08	2:09	2:17	2:20	2:25
2:52	2:57	3:00	3:08	3:09	3:17	3:20	3:25
3:52	3:57	4:00	4:08	4:09	4:17	4:20	4:25
4:52	4:57	5:00	5:08	5:09	5:17	5:20	5:25
5:52	5:57	6:00	6:08	6:09	6:17	6:20	6:25

Not all stops are listed. CALL 676-7500 for the stop nearest you.

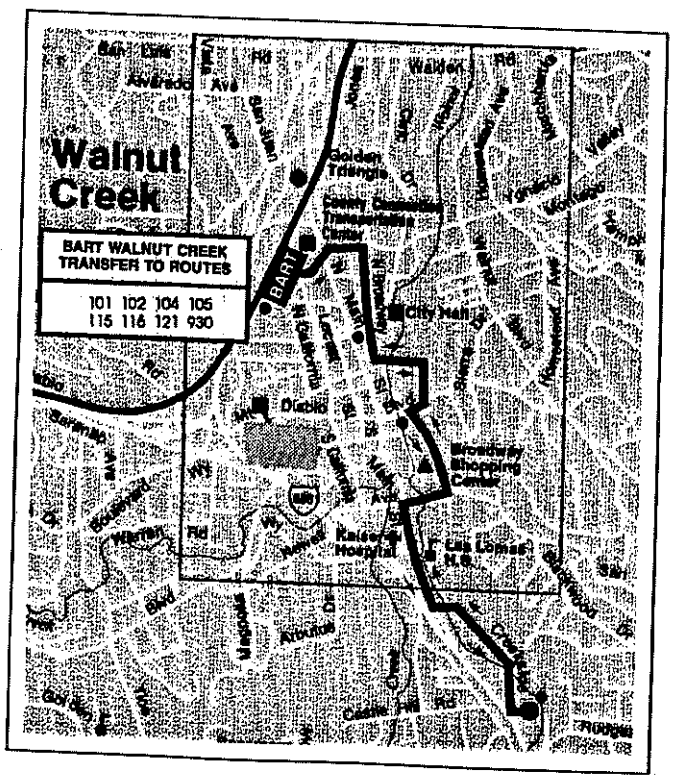

Figure 4. Revised County Connection Bus Service Schedule.

**Bus routes serving each street or point of interest are listed at the end of each line of this index.

Abbreviations

(C)....Concord
(CCo)....Contra Costa County
(Cley)....Clayton
(Dan)....Danville
(Dub)....Dublin
(L)....Lafayette
(Mar)....Martinez
(Mor)....Moraga
(O)....Orinda
(PH)....Pleasant Hill
(PL)....Pleasanton
(SR)....San Ramon
(WC)....Walnut Creek

The Street Index contains only those streets shown on the map. The named streets are those on which buses travel or stop, or which assist in general orientation to the community.

Numbered Streets

1st Ave (WC)....I-7, 8: 102
1st St (L)....J-6: 125
2nd Ave (WC)....I-7, 8: 102
2nd St (C)....B, C-14: 113
3rd Ave (WC)....I-7, 8: 102
5th St (C)....C, D-15; F-10: 110
6th St (C)....C, D-15; E, F-10: 110
6th St, N (C)....A, B-15; E-9, 10: 115, 117

A

Acalanes Ave (O)....K-4: 125
Acalanes Rd (L)....J-6, 7: 125
Alberta Wy (C)....G, H-12: 112
Alcosta Blvd (SR)....K, L-14; M-15; M, N-14: 121
Alhambra Ave (Mar)....C, D-5; E-5, 6; F-6: 116
Arnold Dr (Mar)....E-6, 7: 118
Ayers Rd (C)....F-12, 13: 110

B

Bacon St (C)....B-13: 117
Bailey Rd (C)....C-13, F-12: 113
Bancroft Rd (WC)....H, I-9: 107, 111, 114
Bates Ave (C)....D-9, 10: 108
Berellesa St (Mar)....C, D-15: 116
Bisso Ln (C)....E-9: 113
Bonifacio St (C)....B-13, 14; C-12; E, F-9: 115, 117, 119
Boulevard Way (WC)....J-7, 8; K-7: 101
Boyd Rd (PH)....H-7, 8: 109
Broadway Plaza (WC)....K-3: 101, 104
Broadway, N (WC)....J, K-7: 101, 103
Broadway, S (WC)....H, I-3: 101, 105
Buena Vista Ave (WC)....E-1; I-8: 102
Buskirk Ave (PH)....H-8: 116

C

California Blvd, N (WC)....F, G-2; J-8: 102, 104, 116, 121
California Blvd, S (WC)....H, I-2; J-8: 101, 102, 121
Camino Estrada (C)....G-3, 14: 110
Camino Pablo (Mar)....C-5: 106
Camino Pablo (O)....J, K-2: 950
Camino Ramon (Dan)....I, J, K-13; K, L-14: 121, 990
Camino Ramon (SR)....K, L-14: 990
Camino Verde (WC)....I-7: 111
Center Ave (CCo)....E-8: 108
Center Ave (Mar)....E-5, 6, 7: 108
Cherry Ln (WC)....H-9: 111
Civic Dr (WC)....D, E, F-3; I, J-8: 101, 115
Clayton Rd (C)...C-13, 14, 15; D-11, 12, 15; F-9, 10, 11; G-12, 13; H-14: 110, 111, 112, 115, 116
Cleveland Rd (PH)....G, H-8: 109
Club Rd (PH)....F-8: 109
Coggins Dr (PH)....H-8: 116, 126
Colfax St (C)....B-13; C-14: 113, 117, 118
Concord Ave (C)....B-11; C-12, 13, 14, 15; D-13; E-8, 9; F-8, 9: 119, 991
Contra Costa Blvd (PH)....F, G, H-8: 102, 108, 109, 110, 119
Craydon Cir (SR)....N-15: 121
Creekside Dr (WC)....K-8, 9: 105
Crow Canyon Rd (SR)....K-12, 13, 14, 15; J-15: 121, 990

D

Danville Blvd (CCo)....K, L, M-9; N-10: 121
Danville Blvd (Dan)....N-10: 121
Dapplegray Ln (WC)....K, L-10: 102
David Ave (C)....H-9: 111, 116
Deer Hill Rd (L)....J-5, 6: 990
DeNormandie Wy (CCo)....D-6: 116
Detroit Ave (C)....B-13; C-14: 113, 117, 118
Diamond Blvd (C)....F-8: 108, 118, 119, 991
Dublin Blvd (Dub)....O-14, 15: 121

E

East St (C)....A, B-13: 100, 111, 117
El Nido Ranch Rd (L)....J-3, 4: 125
El Nido Ranch Rd (O)....J-3: 125

F

Fircrest Ln (SR)....M-15: 121
Foothill Rd (Pl)....O-14: 121

G

Galaxy Way (C)....F-8: 119, 991
Galindo St (C)....C, D-13: 109, 110, 111, 114, 118, 119
Gateway Blvd (C)....D-12: 110
Geary Rd (PH)....H, I-7: 102, 111, 116
Geary Rd (WC)....H-8: 102, 111, 116
Grant St (C)....A-12, 13; B-13; E, F-9: 117
Gregory Ln (PH)....G-7, 8: 102, 109, 116

H

Happy Valley Rd (L)....I-4; J-4, 5: 125
Hidden Valley Rd (L)....J-3, 4; K-4: 125
Hidden Valley Rd (O)....J, K-3: 125
Holland Dr (WC)....I-7: 111
Honey Hill Rd (O)....J-3: 106

I

Ivy Dr (Mor)....K-4: 106
Ivy Dr (O)....K-4: 106

K

Kirker Pass Rd (C)....G-13, 14: 110, 112
Kirkwood Dr (C)....G-13, 14: 110

L

Laguna St (C)....D-12, 13; F-9: 114
Landana Dr (C)....E-11: 115
Larwin Ave, N (C)....G-11, 12: 112
Larwin Ave, S (C)....G-11, 12: 112
Lincoln Ave (WC)....G-2: 105

M

Main St, N (WC)....F, G, H-2; H, I, J-8: 101, 104, 105
Marchbenks Dr (WC)....D, E-4; I-9: 101, 107
Marsh Creek Rd (CCo)....I-14, 15: 101
Marsh Creek Rd (Clay)....H-14: 110
Mason Circle (C)....D-9: 100
Mayhew Wy (PH)....H-8, 9: 114, 116
Meadow Ln (C)....F, G-9: 111, 114
Michigan Blvd (C)....G, H-13: 110, 112
Miner Rd (O)....J-2, 3; K-2: 106, 950
Mitchell Dr (WC)....H-10: 107
Mohr Ln (C)....G, H-9: 111, 114
Montego (WC)....E-3; I, J-9: 101, 107
Monument Blvd (C)....G-9; D, E-13: 111
Mountain View Dr (L)....K-5: 102
Mountaire Cir (CCo)....H-13: 110
Mountaire Pkwy (CCo)....H, I-14: 110
Mt Diablo Blvd (L)....K-4, 5; J-6: 106, 123, 125
Mt Diablo Blvd (WC)....H-1, 2, 3; J-8: 101, 102, 104, 105, 121
Mt Diablo St (C)....D-14, 15; F-10, 15: 112
Mt Pisgah (WC)....F, G-2: 105

N

N Broadway (WC)....F-2; G-3; J-8: 103
N California Blvd (WC)....F, G, H-2; J-8: 101, 102, 104, 103, 115, 116, 121
N Main St (WC)....F, G, H-2; H, I, J-8: 101, 104, 105, 115

O

Oak Grove Rd (C)....G-9; H-9, 10: 111, 114
Oak Park Blvd (PH)....H-8: 102, 109
Oak Rd (CCo)....I-8: 111, 115
Oak St (C)....C-13, 14; D-14: 111
Oakland Ave (C)....C, D-14: 110, 112, 115
Oakland Blvd (WC)....F, G, H-1: 101
Olivera Rd (C)....D-9; E-9, 10: 100, 117
Olympic Blvd (L)....K-7: 101, 125
Orinda Wy (O)....K-2: 106
Orindawoods Dr (O)....J, K-3: 106

P

Pacheco Blvd (Mar)....C-5; D-5, 6: 108, 116
Pacheco St (C)....B, C-13: 117, 119
Palm Ave (Mar)....D-5, 6: 108
Palmer Rd (WC)....K-9: 102
Park Highlands Blvd (C)....G-12, 13: 110, 112
Park St (C)....C-13, 14: 111
Patterson Blvd (PH)....H-8: 102, 109
Pennsylvania Blvd (C)....G, H-13: 110
Peralta Rd (C)....D-9: 117
Pike Ln (C)....D-9: 110
Pine Hollow Rd (C)....H-12, 13: 110
Pleasant Hill Rd (L)....I, J-6; J, K-7: 111
Pleasant Hill Rd (PH)....G, H-7; I-6: 111
Port Chicago Highway (C)....A, B-13; C, D-10; E-9: 100
Pringle Rd (WC)....F-1, 2: 104
Putnam Blvd (PH)....H-7, 8: 102, 108, 111

R

Riviera Ave (WC)....E, F-1: 102
Rohrer Dr (L)....L-6, 7: 123

S

S Broadway (WC)....H-3: 101, 102, 105
S California Blvd (WC)....H, I-2; J-8: 101, 102, 121
S Larwin Ave (C)....G-11, 12: 112
S Main St (WC)....H-3; J, K-8: 101, 102, 104, 105, 121
St Mary's Rd (L)....K, L, M-6: 106, 123
St Mary's Rd (Mor)....M-5, 6: 106, 123
St Stephens Dr (O)....J-3: 106, 125
Salvio St (C)....A-15; B-14, 15; C-12, 13; E, F-9; E-10: 111, 115, 117
San Miguel Dr (WC)....G-2, 3; K-9: 102
San Miguel Rd (C)....F-9; G-10: 111
San Ramon Valley Blvd (Dan)....I, J, K-13; J-11: 121
Sierra Dr (WC)....F, G-2; J-8: 101
Silverado Dr (L)....L-7: 123
Solano Wy (C)....E-8, 9: 117
Stanley Blvd (L)....J-6, 7: 125
Stanwell Dr (C)....E-9: 119
Stewart Ave (WC)....K-9, 10: 102

T

Tareyton Ave (SR)....M-14: 121
Taylor Blvd (PH)....G-7, 8; H-6, 7; I-6: 102, 116
Tice Valley Blvd (WC)....K-7, 8: 101, 125
Treat Blvd (C)....F-11; G-10, 11; H-9, 10: 107, 110, 111, 112, 114, 115
Treat Blvd (WC)....H, I-8, H-9: 107, 110, 111, 112, 114, 115
Trotter Way (WC)....K, L-9; L-10: 102
Turtle Creek Rd (C)....G-11, 12: 112, 115

U

Upper Happy Valley Rd (L)....J-4: 125

V

Viking Dr (PH)....F-7, 8: 102, 109
Village Pkwy (SR)....N-15: 121
Vine Hill Way (Mar)....E-6: 108

W

Walker Ave (WC)....G-3: 101
Walnut Ave (WC)....I-9, 10: 107
Walnut Blvd (WC)....F-3, 4; I-8; J-8, 9; K-9, 10: 101
West St (C)....F-11: 110, 113, 115
Willow Pass Rd (C)...B-14, 15; C-12, 13, 14; D-11, 15; E-10, 11, 13, 14; F-9, 10: 108, 111, 115, 117, 118
Wilson Lane (C)....F-11, 12: 113, 115

Y

Ygnacio Valley Rd (C)..G-11, 12; H-11: 101, 102, 104, 105, 107, 112, 115, 116, 930
Ygnacio Valley Rd (WC)..E-3, 4; F-1, 2, 3; H-10, 11; I-9, 10; J-8: 101, 102, 104, 105, 107, 115, 116, 121, 930

Major Transfer Points

Concord
BART....C, D-14; F-9: 100, 108, 110, 111, 112, 113, 116, 115, 117, 118, 119, 991
Clayton Rd @ Alberta Wy....G-12: 110, 112
Clayton Rd @ Denkinger Ct/Treat Blvd....F-11: 110, 115
Clayton Rd @ West St/Loeffler Ln....F-11: 110, 115
Monument Blvd @ Oak Grove Rd/Meadow Ln....G-9: 111, 114
Port Chicago Hwy @ Olivera Rd....E-9: 100, 117
Treat Blvd @ Cowell Rd....G-11: 112, 115
Ygnacio Valley Rd @ Michigan....G-12: 110, 112, 930

Danville
S Hartz Ave @ Prospect Ave....N, O-11: 121

Lafayette
BART....J-5: 106, 123, 125, 990

Martinez
Amtrak Station....C-5: 108, 116, 118
Pacheco Blvd @ Shell Ave/Bush St....D-5: 108, 116, 118

Moraga
Moraga Rd @ Moraga Wy....N-5: 106
St Mary's College....M-6: 106, 123

Orinda
BART....K-2: 106, 930

Pleasant Hill
BART....H-8: 102, 109, 111, 114, 115, 116
Contra Costa Blvd @ Viking Dr....F-8: 102, 108, 109, 110, 119
Diablo Valley College....F-8: 102, 108, 109
Gregory Ln @ Contra Costa Blvd....G-8: 109, 116
Pleasant Hill Rd @ Taylor Blvd....G-7: 102, 116
Putnam Blvd/Buena Vista Ave @ Geary Rd....I-8: 102, 111

San Ramon
Village Parkway @ Alcosta Blvd....M-14: 121
Dublin Blvd @ Golden Gate....O-14: 121

Walnut Creek
BART....F-1; J-8: 101, 102, 104, 105, 115, 116, 121, 930
Bancroft Rd @ David Ave/Minert Rd....H-9: 111, 114
Bancroft Rd @ Pomar Wy....H-9: 107, 111, 114, 115
Broadway Plaza @ Nordstrom....H-3; J-8: 101, 104
California Blvd @ Newell Ave....H-2: 102, 121
John Muir Hospital....I-9: 101, 107
N California Blvd @ Mt Diablo Blvd....H-3; J-8: 101, 102, 121
Rossmoor Shopping Center....K-7, 8: 101, 125
S Broadway @ Broadway Shopping Center....H-3; J-8: 101, 102, 104, 105
Putnam Blvd/Buena Vista Ave @ Geary Rd....I-8: 102, 111

Business/Industrial Parks

Adobe Industrial Park (Mar)....E-8: 118
Airport Plaza (C)....F-8: 119, 991
Bishop Ranch Business Park (SR)....K, L-13, 14: 121, 990
Chevron....F-8; L-14: 121, 990, 991
Civic Center Office Park (PH)....G-8: 109
Crest Office Park....E-7: 118
Ellinwood Business/Residential Complex (PH)....G-8: 109
Galaxy....F-8: 102, 991
Golden Triangle (WC)....E-11; I-8: 102, 104, 116
Martinez Business Park (Mar)....D-6: 108
Meridian Business Park (C)....C-11; F-9: 119
Muir Tech (Mar)....D-5, 6: 108
Pacific Bell (SR)....L-14: 990
Shadelands (WC)....H-10: 107
Sharp Industrial Park (C)....G-9: 111, 114
Stanwell Industrial Park (C)....B-11: 108, 116
Vista Oaks Office Park (M...E-5: 106

Hospitals

CPC Walnut Creek Hospital (WC)....I-9: 101, 107
John Muir Emergency Center (SR)....K-13: 121
John Muir Medical Center (WC)....I-9: 101, 107
Kaiser Hospital (Mar)....E-6: 108
Kaiser Hospital (WC)....G-2; K-8: 101, 102, 105, 121
Kaiser Medical Center (PL)....O-14: 121
Mt Diablo Medical Center (C)....D-14; E-9: 100, 117
San Ramon Intercommunity Hospital (SR)....K-14: 990
Veteran's Administration Hospital (Mar)....E-6: 108

Schools

Acalanes High School (L)....J-6: 125
Alhambra High School (Mar)....D-5: 116
California High School (SR)....M-14: 121
California State Hayward Extension (PH)....H-8: 109
Campolindo High School (Mor)....L-5: 106
Carondelet High School (C)....H-9: 115
Clayton Valley High School (C)....G-12: 112
College Park High School (PH)....F-8: 102, 109
Concord High School (C)....F-11: 113, 115
De LaSalle High School (C)....H-9: 115
Diablo Valley College (PH)....F-8: 102, 108, 109, 119
JFK University (O)....K-3: 106
JFK University, School of Law (WC)....F-2; J-8: 101, 105
Las Lomas High School (WC)....H-2; K-8: 103, 121
Monte Vista High School (Dan)....M-12: 121, 990
Mt Diablo High School (C)....B-13: N-9: 117
Northgate High School (WC)....J-10: 107
San Ramon Valley High School (Dan)....N-11: 121
St Mary's College (Mor)....M-6: 106, 123
Ygnacio Valley High School (C)....H-10: 115

Shopping Centers

Alamo Market Plaza (CCo)....K-9: 121
Broadway Plaza Shopping Center (WC)....H-3; J-8: 101, 102, 104, 105
Crow Canyon Commons (SR)....K-13: 121, 990
Diablo Plaza (SR)....K-13: 121
Rossmoor Shopping Center (WC)....K-8: 101, 125
Stoneridge Mall (PL)....O-14: 121
Sun Valley Mall (C)....F-8: 108, 109, 110, 118, 119
Town & Country Shopping Center (Dan)....O-11: 121
Village Oaks Shopping Center (Mar)....E-6: 118
Willows Shopping Center (C)....F-8: 110, 118, 119

Parks and Open Space

Acalanes Ridge Recreation Area (WC)....I-7: 111, 125
Arbolado Park (WC)....I-11: 107
Baldwin, John F. Park (C)....A-14; E-9, 10: 100, 115, 117
BART Park (C)....E-14: 111
Briones Regional Park (L)....G-4, 5; H-4, 5: 102, 111, 126, 125
Castle Rock Recreation Area (CCo)....J-11, 12: 107
Concord Community Park (C)....F-10: 110, 112
Diablo Foothills Regional Park (CCo)....K-11: 102, 107
Ellis Lake Park (C)....D-12: 110, 111, 114, 118
Heather Farms Park (WC)....I-9: 101, 107
Hidden Lakes Open Space (Mar)....E, F-7: 108
Hillcrest Community Park (C)....E-9: 117
Huckleberry Regional Preserve (CCo)....K-2; H-3: 106
John F. Baldwin Park (C)....A-14; E-9, 10: 100, 115, 117
Lafayette Community Ball Field (L)....K-6: 123
Las Trampas Regional Park (CCo)....N-8, 9; O-8, 9: 121
Lime Ridge Open Space (CCo)....H-11: 107, 112, 930
Markham Nature Area (C)....F, G-11: 110, 112, 115
Martinez Marina (Mar)....C-5: 108, 116, 118
Martinez Municipal Park (Mar)....C, D-4: 116
Mt Diablo State Park (CCo)....I-14: F, L-12: 110
Newhall Community Park (C)....G-11, 12: 110, 112, 115
Oak Hill Park (Dan)....M-11: 121, 990
Pleasant Hill Park (CCo)....G-8: 109, 116
Redwood Regional Park (CCo)....H, O-3: 106
Robert Sibley Volcanic Regional Park (CCo)....N-2: 106
Shell Ridge Open Space (WC)....J-10: 102, 107
Sugarloaf Open Space (WC)....L-9: 102, 121, 990
Todos Santos Plaza (C)....C-13: 108, 110, 111, 118
Willow Pass Community Park (C)....E-10: 115, 117

Points of Interest

Alamo Post Office (CCo)....M-9: 121
Amtrak Station (Mar)....C-5: 108, 116, 118
Buchanan Air Field (C)....F-8: 119, 119
Civic Arts Gallery (WC)....G-2: 102, 104, 121
Clayton City Hall (Clay)....H-14: 110
Community Recreation Center (PH)....G-8: 109
Concord Chamber of Commerce (C)....B-13; F-9: 111, 117, 119
Concord City Offices (C)....B-14; K-10: 115, 117
Concord Main Post Office (C)....F-8: 119
Concord Pavilion (C)....G-14: 110, 930
Contra Costa County Court House (Mar)....C-5: 108, 116, 118
Danville Chamber of Commerce (Dan)....O-11: 121, 990
Danville City Hall (Dan)....N-11: 121, 990
Danville Hotel (Dan)....O-11: 121
Danville Post Office (Dan)....O-11: 121
Dept of Motor Vehicles (C)....F-8: 119, 991
Employment Development Dept (PH)....G-7: 102
Eugene O'Neil Historical Site (Dan)....N-10: 121
Fernando Pacheco Adobe (C)....K-9: 117
Forge Guild Center (L)....J-6: 123
Hacienda de las Flores (Mor)....M-5: 106
Juvenile Hall (Mar)....E-7: 118
Lafayette Chamber of Commerce (L)....J-5: 106, 123, 125, 990
Lafayette City Hall (L)....K-5: 106, 123, 125
Lafayette Community Center (L)....L-6: 123
Lafayette Post Office (L)....K-5: 125
Lindsay Museum (WC)....I-7: 102, 111
Martinez Adobe (Mar)....E-5: 116
Martinez Chamber of Commerce (Mar)....C-5: 108, 116, 118
Martinez City Hall (Mar)....C, D-5: 116
Martinez Post Office (Mar)....E-5: 116
Moraga Chamber of Commerce (Mor)....N-5: 106
Moraga Post Office (Mor)....N-5: 106
Moraga Town Hall (Mor)....L-5: 106
Muir National Historical Site (Mar)....E-5: 116
Old Borges Ranch (CCo)....K-11: 102, 107
Orinda Chamber of Commerce (O)....K-3: 106
Orinda City Hall/Community Center (O)....K-2: 106
Orinda Post Office (O)....K-2: 106
Pleasant Hill Chamber of Commerce (PH)....G-8: 109, 116
Pleasant Hill City Hall (PH)....G-8: 109, 116
Pleasant Post Office (PH)....G-8: 109, 116
San Ramon Chamber of Commerce (SR)....K-13: 121
San Ramon City Hall (SR)....K-13: 121
San Ramon Post Office (SR)....K-13: 121
Shadelands Ranch Historical Museum (WC)....I-7: 107, 930
Social Security Office (WC)....F-3; J-8: 101, 115
Social Services Office (Mar)....E-6: 108
State Rehabilitation Dept (PH)....G-7: 102
The County Connection Division Headquarters (C)....D-10: 100
The County Connection Transportation Center (WC)..F-2; J-8: 101, 104, 115, 116
The Livery & Mercantile (Dan)....O-11: 121
U. S. Naval Magazine (C)....D-11: 101, 115
UC Leuschner Observatory (L)....I-4: 125
Unemployment Insurance Office (PH)....G-7: 102
Walnut Creek Chamber of Commerce (WC)....G-2: 104, 105
Walnut Creek City Hall (WC)....G-2; J-8: 104, 105
Walnut Creek Post Office (WC)....F-2: 101, 104, 105, 115
White Gate Farm (Dan)....M-12: 121, 990, 115, 116

Figure 5. Revised Street and Points of Interest Index

Finally, Route Three required an average of 27.8 minutes to complete with four incomplete plans. With the exception of Route One, time required to complete Route Two and Three was actually longer for the redesigned information when compared to the original information. An analysis of variance (ANOVA) was made of the time data, with two iterations. Iteration one took in only those research participants that actually finished.

Iteration two involved all 20 participants, with the missing data points consisting of the mean for all those who finished their trip plan, plus 3 standard deviations of that same sample. This is a "conservative" assumption that participants who did not finish would have done so within the time span of 99 percent of that sample. The mixed model repeated-measures (one factor between-routes, and one factor nested within subjects-packages) design was employed. The results are shown in Table 9 below. The alpha level was assumed to be $p < 0.05$.

Table 10 summarizes the means and standard deviations of the time data. The origin of the significant interaction of routes and packages can be seen in this table (Iteration Two).

Note that the original package route 1 time is larger than the revised package time for route 1, but the revised package route 2 time is contrary to that trend; it is longer than the original package. The improvement with the new information is shown in the number of incomplete plans. The original information includes a total of 10 incomplete plans versus 6 incomplete plans when the new information package is used. The use of the redesigned information also results in an improvement of 62 minutes of additional travel time due to non-optimum trip plans versus 93 minutes when using the original information. Comparing to two extra transfers when using the original information, the new information requires no extra transfers. These data are shown in figures 6, 7, and 8. Histograms showing the differences between the results of Phase One and Phase Three with respect to route-planning time as well as planned travel time are shown in tables 11, 12, and 13. These results may indicate that the participants take longer to learn the redesigned information. The redesigned information then results in more successfully completed and efficient plans once the participants have become familiar with it. Another factor which must be considered is the participants' frequency of bus usage. Due to a shortage of available elderly adults, the participants were chosen at random as they became available. A completely random selection is not feasible in this case.

TABLE 9
ANOVA of the Time Data

Factor	Iteration	MS	DF	F	Significance
Routes 1, 2, 3	1	509.40	2	16.73	$\leq$ 0.0001
Routes 1, 2, 3	2	1128.10	2	36.14	$\leq$ 0.0001
Package O, R	1	3.59	1	0.08	0.779 N.S.
Package O, R	2	45.94	1	0.04	0.534 N.S.
Routes * Package	1	73.77	2	2.42	0.113 N.S.
Routes * Package	2	116.55	2	3.73	0.034

Note: The complete SAS output is provided in Appendix H.

TABLE 10

Mean and Standard Deviation Summary of Time Data

Iteration One: Incomplete Research Participants Dropped

Package	Route	N	Mean	Standard Deviation
original	1	9	19.44 min	6.74
original	2	7	20.71 min	5.68
original	3	4	27.75 min	3.30
revised	1	10	14.20 min	6.76
revised	2	8	23.30 min	6.48
revised	3	6	27.83 min	4.40

Iteration Two: Incomplete Planning Time = Mean + 3SD

Package	Route	N	Mean	Standard Deviation
original	1	10	21.35 min	8.77
original	2	10	24.87 min	8.14
original	3	10	32.90 min	4.82
revised	1	10	14.20 min	6.76
revised	2	10	27.01 min	9.56
revised	3	10	32.66 min	7.04

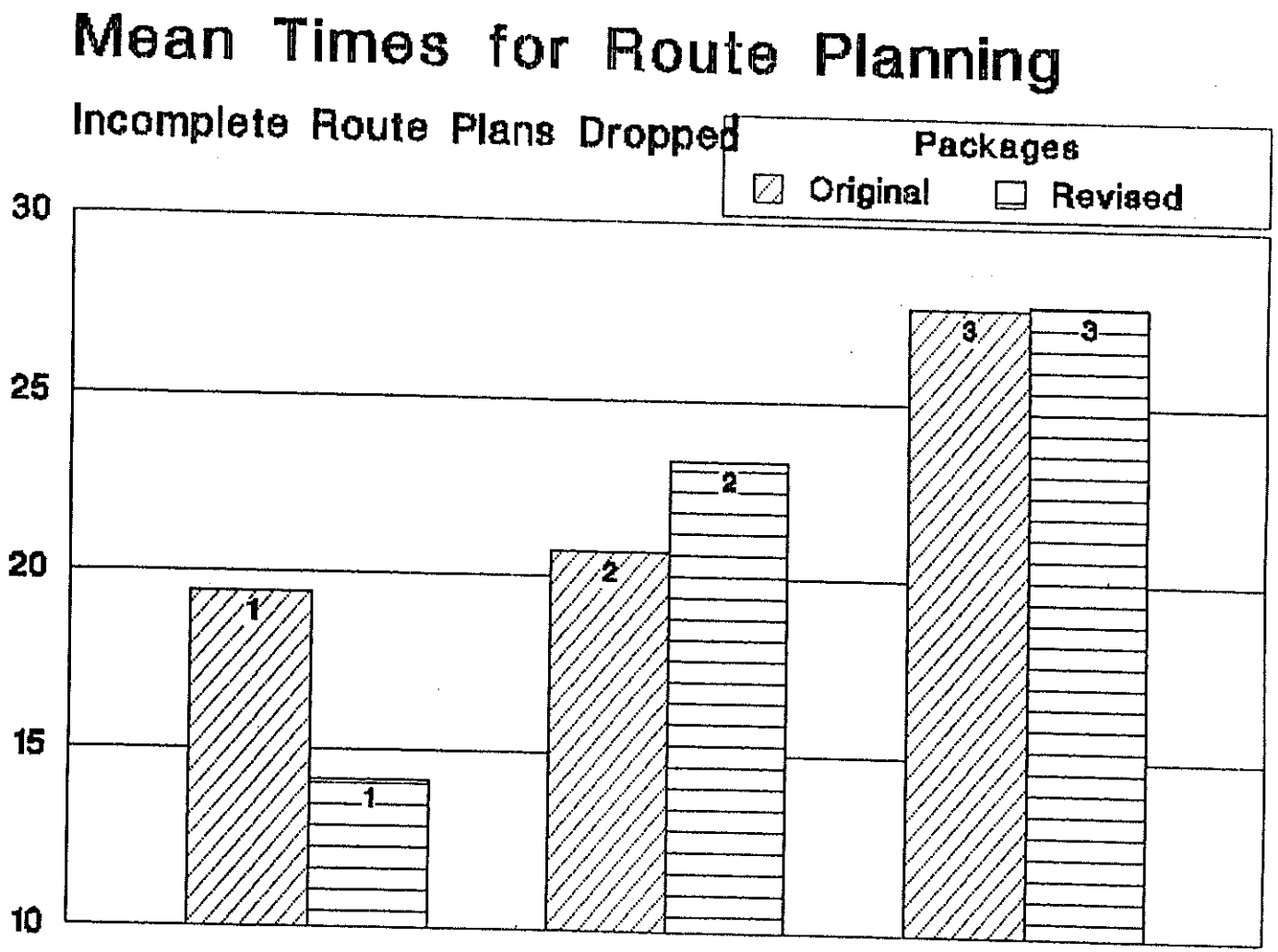

Figure 6. Mean Time for Route Planning with Incomplete Route Plans Dropped.

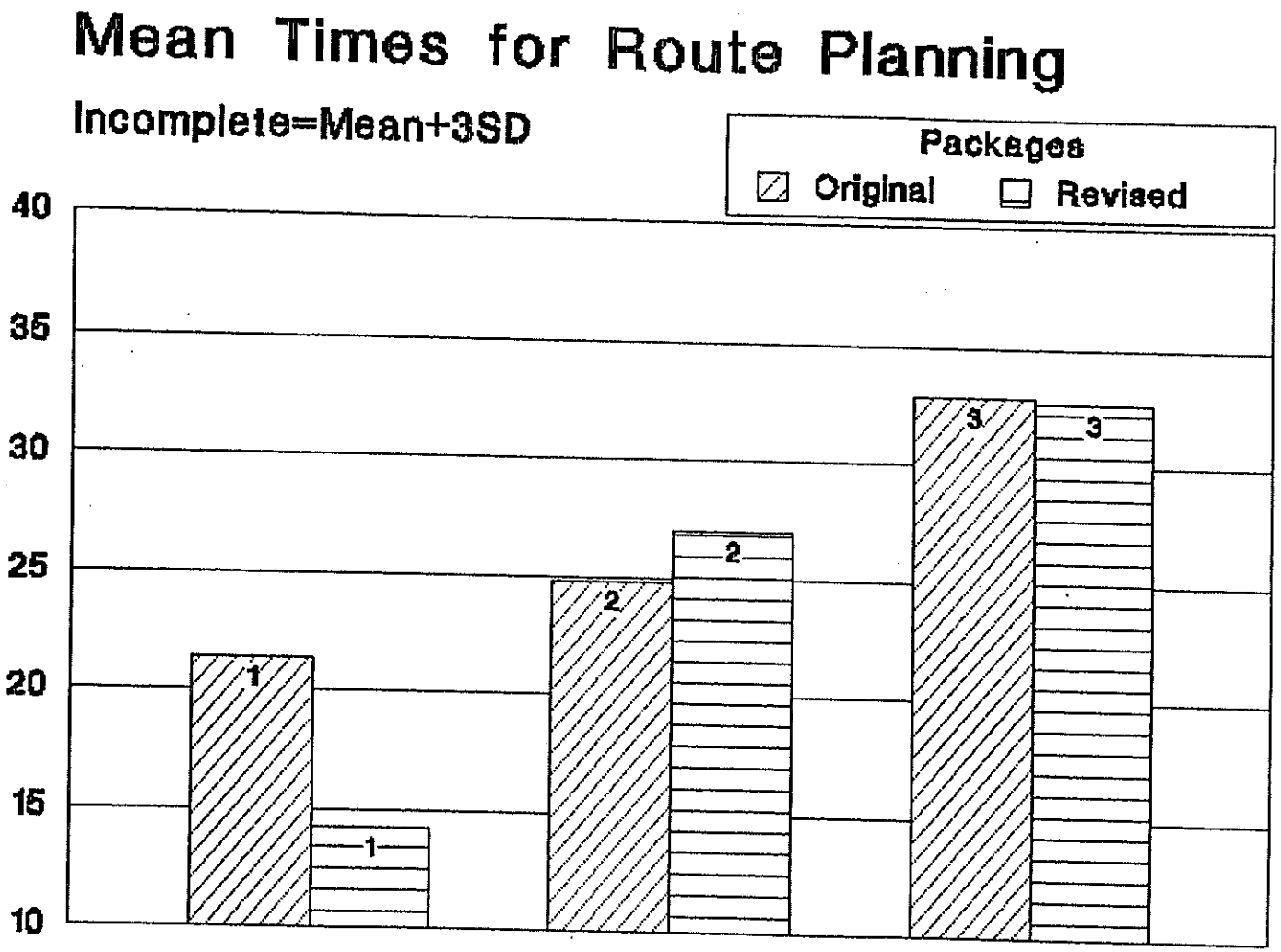

Figure 7. Mean Time for Route Planning Including Incomplete Plans.

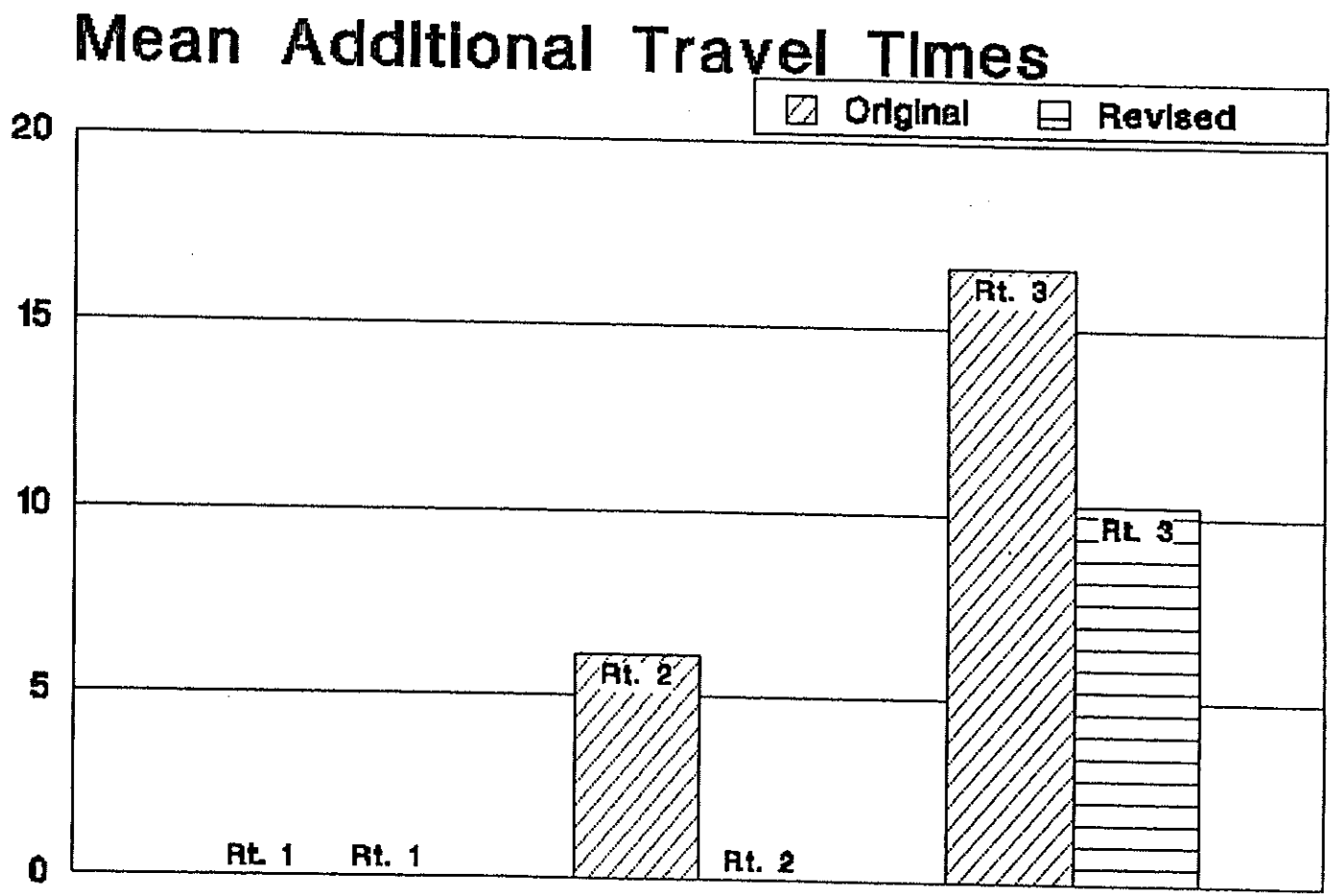

Figure 8. Additional Travel Times for Original and Revised Information.

TABLE 11

Time Required to Complete the Route-Planning Process during Phase Three (Redesigned Information Package)

	Research Participant												
	1	2	3	4	5	6	7	8	9	10	% of success	Mean	Standard Deviation
Route 1	15	10	15	9	10	19	16	6	30	12	100	14.2	6.8
Route 2	30	18	-	30	16	22	26	15	-	30	80	23.4	6.5
Route 3	30	30	-	30	19	-	-	28	-	30	60	27.8	4.4

Note: "-" symbolizes incomplete plans (over 30 minutes).
Note: Times are recorded in minutes.

TABLE 12

Additional Travel Time Required Due to Non-Optimum Travel Plans during Phase Three (Redesigned Package)

	Research Participants									
	1	2	3	4	5	6	7	8	9	10
Route 1	0	0	0	0	0	0	0	0	0	-
Route 2	0	0	-	0	0	0	0	0	-	0
Route 3	0	0	-	0	0	-	-	62	-	0

Note: Additional travel time above are recorded in minutes.
Note: Additional travel time = planned travel time - optimum travel time.
Note: "-" symbolizes incomplete plans (Planned travel time is greater to 30 minutes).

TABLE 13

Efficiencies of the Travel Plans with Respect to Travel Time and Number of Transfers (Redesigned Package)

Efficiencies with Respect to Travel Time:

	Research Participants									
	1	2	3	4	5	6	7	8	9	10
Route 1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Route 2	1.00	1.00	0	1.00	1.00	1.00	1.00	1.00	0	1.00
Route 3	1.00	1.00	0	1.00	1.00	0	0	0.58	0	1.00

Efficiencies with Respect to Number of Transfers:

	Research Participants									
	1	2	3	4	5	6	7	8	9	10
Route 1	1	1	1	1	1	1	1	1	1	-
Route 2	1	1	-	1	1	1	1	1	-	1
Route 3	1	1	1	1	1	-	-	1	-	1

Note: "-" symbolizes incomplete plans.

Among the group who participated during Phase One, one person frequently used buses, five people occasionally rode buses, three seldom encounter bus usage, and one person had no experience in bus usage. They were much more experienced than the group in Phase Three, in which six people had no experience and four seldom rode buses.

There were also fewer complaints on the redesigned information in comparison to the original information. Three people were still having difficulties because not all bus stops are listed on the schedule. Two people again failed to notice the availability of inset maps. These complaints are listed in Table 14. Improvements on the information after it was redesigned is shown in Table 15. The redesigned package improvements in Table 15 were derived from research participants' feedback when the redesigned package was evaluated. During Phase Three of the study, the original as well as the redesigned information was presented to the participants after they finished the route-planning process. The participants were given time to study both packages and make comments on what they believe to be improvements due to the redesign.

TABLE 14

Research Participants' Complaints in Phase Three

	Research Participants									
	1	2	3	4	5	6	7	8	9	10
On a street where many buses travel, the many color lines are confusing because they look like different streets rather than different routes.		X	X							
Not all bus stop times are listed on the schedule.			X		X				X	
Fail to notice the "See inset map" messages.						X			X	

TABLE 15

Redesigned Information Improvements

	Research Participants									
	1	2	3	4	5	6	7	8	9	10
Converting from a topographical map to a schematic map reduced confusion and made the map easier to read.	X	X	X	X	X	X	X	X		X
Color coding of the system map resulted in easier identification of the routes.	X			X	X	X	X	X		X
Street index listing the bus routes resulted in easier trip planning.				X		X	X	X		X
The message "Buses will stop at every street corner" helped to reduce confusion on where the buses stop.	X	X		X	X	X	X	X		X
Larger print sizes made the prints easier to see on the system map.	X	X	X	X	X	X	X			X

CONCLUSIONS AND RECOMMENDATIONS

This research study was a small sample study in which two unmatched groups of participants were used. The result indicated that the group with improved design performed more poorly in some cases. A possible reason was that Phase One participants were more experienced in using bus systems than Phase Three participants. While using the same participants for both phases was not practical, a more carefully studied and arranged sampling process could have yielded more accurate results. Due to a limited number of elderly adults, a more representative sample of bus users was not available in the area where the study was conducted. In retrospect, actual bus users who frequently made bus transfers should have been used in the study. Perhaps the study should have been conducted in a city where a bus system was used often by its elderly residents. The cities which the Contra Costa County Connection Bus System served should of course be excluded from the study. The semi-structured interview (see Appendix D) contained questions that suggested factors which participants might want to say "yes" to even if they did not note them. A better approach would have been to videotape the participants unobtrusively to see where the long delays were. The person conducting the study might then be able to confer where and when a participant encountered difficulties in the route-planning process.

This research study indicated that the original information package provided by the Contra Costa County Connection Bus System was a relatively well designed package because most research participants were able to get to their destinations using the package; although many did not arrive at an optimum plan. The major design changes required were the color coding of the routes to better distinguish one route from another; the simplification of the map format from topographical to schematic in order to eliminate non-essential information and save space for larger prints and symbols; the message that buses stop at every street corner; and the indication of direction of the routes. For a bus system covering nine cities with twenty-six bus routes, much information was required in order to sufficiently provide its user with a useful package. The problem seen throughout the experiment was that most participants were able to use the information to get from one place to another, but they had to invest a lot of time to learn the information. There was simply too much material for the participants to effectively use every piece of information unless they took a long time to study it (If the thirty-minute limit were not given, most people would have finished the route-planning task). Another problem was that people were conditioned to use information in a "traditional" way. Most participants who discover the redesigned index found the listing of bus routes serving each street or point of interest to be very helpful. Despite a message clearly indicating the availability of this new feature, most participants never discovered its availability because they were not used to using an index as a bus route finder. Among those who found the listing on the index, however some still did not use it because "an index is simply not used in this manner". Four people also did not understand how to use the inset maps even though they knew that the maps were available.

The redesigned information package was constructed according to the structure of the present information, research participants' suggestions, and principles of map and information design in the major literature resources. The participants expressed confidence that they could successfully plan trips using the information. Many felt frustrated because of the overwhelming amount of information to sort through and the time limitation placed on them. Many participants believed that they would feel more comfortable having a telephone service providing them with a travel plan, but that they would still like the information package as a resource.

Because of the large size of this particular bus system, using maps and schedules may not be the optimum method for way-finding. Other forms of information presentation may be considered for further research topics. For example, a computerized system allowing customers to call in with inquiries concerning how to get from one place to another was investigated. This system could consist of many lines of customer service, such as trip planning, ticket purchasing, information package request, and availability of buses. The trip planning service might enable a person to speak to a customer service representative. The representative might then call up a desired destination from a particular starting point. The information of which bus route as well as the departure and arrival times might then be given to the customer. Another way of providing information could be the "you-are-here" maps available at bus stops. These maps, along with bus schedules at the stops, might assist customers in getting traveling information at particular bus stops. These maps would provide information on which buses to take to get to various other cities as well as the buses which serve the city where the bus stop is located. The possibility of having one bus serving inter-city needs between different cities might also be explored. The system would then be broken down into mini-systems serving each city. This could help to reduce the massive amount of information provided to each customer at the present time.

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APPENDIX A
INSTRUCTIONS TO RESEARCH PARTICIPANTS

SCENARIO

You are a newcomer to the Concord-Walnut Creek area near San Francisco in California. You do not have a car but need to get to a few places. The only means of transportation you have at this point is the city buses, which will get you to almost anywhere you would like to go. You wrote the bus company and asked them to send you a complete set of bus schedules and maps that they provide to their customers. A few days later you received a package containing all the information that the bus system provides for their passengers. Because your telephone has not yet been installed, you cannot call the bus system about any questions. This means that you must rely solely on the package of information sent to you to ride the buses.

RULES

1. You will be given some bus schedules and maps for different bus routes. You are asked to use this information to plan how to get from some starting points to three different desired destinations. You will be given some time to familiarize yourself with the schedules and maps before the study begins.

2. I will be happy to answer any questions concerning this study, but you may not ask me questions about how to use the schedule and map information.

3. You may use the Bart Stations on the maps as transfer points, but you may not plan to ride the Barts.

4. Please assume that all buses will arrive on time.

5. Please allow 5 minutes between bus transfers.

6. If you feel that you must do a small amount of walking to get to a transfer point or some desired destination, please allow 5 minutes of walking time.

7. If you find two or more possible routes, please choose the one that requires the least amount of total time.

8. Your route-planning process will be taped by an audio tape recorder. **As much as you can, please verbalize your route-planning process (tell me what you are doing as you go along).**

9. You will be given 30 minutes for each of the three routes. Please work at a pace that is comfortable to you. **The purpose of this study is <u>not</u> to test your abilities to use the information provided to you.** The goal of this study is to find out the types of problems people have in using information provided by bus systems.

APPENDIX B
CONSENT FORM

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System

Human Factors Division
Research Programs in Transportation Human Factors
and Traffic Law Enforcement Operations

INSTRUMENT TO OBTAIN INFORMED CONSENT

You have been asked to participate in a study entitled "Design of Route Guidance Information for Elderly Bus Passengers". This research is funded by the University Transportation Centers Program. The purpose of the research is to make certain that people are able to use the information provided by a bus system in order to get to desired destinations without the assistance of other people.

In the first phase of the study, you will be asked to pretend that you are a newcomer to a city which you have never visited before. You have no private transportation and must use the bus system to get to a few places. You will be given some bus schedules and maps for different bus routes. You are asked to use this information to plan how to get from some starting point to three different desired destinations. I will ask you to talk about how you use this information, which will be recorded by an audio tape recorder. You will be asked to plan these trips without any assistance from anyone, which means that I will not be able to answer any questions about the schedules once we begin. After phase one, I will talk with you about difficulties or problems you might have had while you were planning your trips.

Please remember that the purpose of this study is **not** to test your abilities to use the information provided to you. The goal of the study is simply to find out the types of problems and difficulties people have in using information provided by bus systems.

To reimburse you for your time and trouble to work with us, we will pay you $10 per hour, payable when your participation is complete. This payment is **not** subject to the outcome of your trip planning process. You will be paid regardless of whether you choose to withdraw from the study at a later date.

You may be called again to answer more questions or critique some design features of the information package. You will receive payment again for additional participation.

Other than the repayment of your expenses, there are no other benefits to you for working with us. You are doing a service for the Texas Transportation Institute and me to help us understand how

to design better information for elderly bus passengers.

Other than questions about how to use the route information and maps, I will be happy to answer any questions that you may have to the best of my knowledge.

Once again, you are free to stop any time for any reason. We appreciate your willingness to work with us as a participant in our research, and will be calling on you again, regardless of whether you complete this project or not.

We will be using the information that we get from you for design and statistical purposes only. We will never disclose your identity or allow anyone not on this project to see your data with your name on it. Our files will be kept under lock and key. The tapes used during the study will be kept for five years under lock and key. They will be destroyed after five years.

This research study has been reviewed and approved by the Institutional Review Board--Human Subjects in Research, Texas A&M University. For research related problems or questions regarding subjects' rights, the Institutional Review Board may be contacted through the Office of University Research, (409) 845-1812.

I, the undersigned, have been read the above explanations, and give my consent to my voluntary participation in this research project entitled "Design of Route Guidance Information for Elderly Bus Passengers".

_____ _____

Signature of Research Participant Witness

Date_____

APPENDIX C
DATA SHEETS FOR THE ROUTE-PLANNING PROCESS

ROUTE ONE

Name:
Time Start:
Time Finish:
Total Time:

Do Not Write in this Space

From the Bart Station in Walnut Creek, you want to get to the Civic Arts Gallery in Walnut Creek by 1:30 on Tuesday afternoon.

***Please record the bus(s) you are planning to take and the departure and arrival locations and times below.**

Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____

Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____ Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____ Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____ Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____ Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____

ROUTE TWO Name:

Time Start:
Time Finish:
Total Time:

Do Not Write in this Space

From the Bart Station in Concord, you want to get to CPC Walnut Creek Hospital by 8:00 Wednesday morning.

***Please record the bus(s) you are planning to take and the departure and arrival locations and times below.**

Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____

Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____ Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____ Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____ Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____ Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____

ROUTE THREE Name:

Time Start:
Time Finish:
Total Time:

Do Not Write in this Space

From the Bart Station in Lafayette, you want to get to Diablo Valley College by noon on Friday.

***Please record the bus(s) you are planning to take and the departure and arrival locations and times below.**

Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____

Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____ Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____ Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____ Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____ Route Number:_____

Departure Location:_____ Departure Time:_____

Arrival Location:_____ Arrival Time:_____

APPENDIX D

QUESTIONNAIRE FORM

QUESTIONNAIRE

Name:
Time Start:
Time Finish:
Total Time:
Gender:
Age:
Education:
Frequency of Use:

1. Did you have difficulties with the sizes of print on the maps and schedules?

2. Did you find any size of print in any of the maps or schedules to be most comfortable?

3. Did you have difficulties determining where the bus stops were?

4. Did you have difficulties determining where the transfer points were?

5. Were the availability of inset maps apparent to you?

6. Would you add any new information to the system map?

7. Would you delete any information from the system map?

8. Would you add any new information to the leaflet maps?

9. Would you delete any information from the leaflet maps?

10. Would you add any new information to the timetables?

11. Would you delete any information from the timetables?

12. Did you have difficulties when the leaflet map and timetables were not on the same page?

13. Do you feel that some other maps covering individual cities are needed?

14. Would you delete the system map, the leaflet maps, or the timetables from the information package?

15. Do you feel that color-coding of individual routes would be helpful?

16. Do you feel that the street index and points of interest index were efficient and helpful? If not, what needs to be changed?

17. Did you understand the symbols on the maps and timetables with the help of the legend?

18. Were you able to understand the different weekday-weekend, morning-afternoon, and peak-off-peak schedules as shown on the timetables?

19. Do you feel that you can use this information package alone to take the buses to get to where you want to go? Or do you feel that you must call the bus operations or have someone assist you in using this information?

APPENDIX E

RESEARCH PARTICIPANTS QUESTIONNAIRE SUMMARY

RESEARCH PARTICIPANTS QUESTIONNAIRE SUMMARY

I.Research Participant #1
- A.Personal information
  - 1.Gender:male
  - 2.Age:73
  - 3.Education:Ph.D in Industrial Engineering
  - 4.Frequency of public bus system usage:frequently
- B.Design suggestions
  - 1.All bus stops should be indicated by colored symbols on both system and leaflet maps.
  - 2.All transfer points should be indicated by colored symbols on the system map.
  - 3.A legend should be placed on each leaflet map.
  - 4.Each bus stop should be listed and numbered on both leaflet maps and timetables.
  - 5.Whenever possible, the leaflet map and timetable for the same days should be placed on the same page.
  - 6.Individual city maps should be included in the information package.
  - 7.Color coding of routes should be used.

II.Research Participant #2
- A.Personal information
  - 1.Gender:male
  - 2.Age:68
  - 3.Education:Master of Science in Industrial Engineering
  - 4.Frequency of public bus system usage:occasionally
- B.Design suggestions
  - 1.All bus stops should be listed on the system map, the leaflet maps, and the timetables.
  - 2.Color coding of routes should be used.
  - 3.Direction of routes should be indicated on both the leaflet maps and timetables (Use arrows on leaflet maps and northbound, eastbound, southbound, and westbound on timetables).
  - 4.Some small print sizes on the system map were unclear.
  - 5.All transfer points should be listed on the system map.
  - 6.The availability of inset maps should be made more clear by placing "See inset map" next to city names, use a different color or a different font for the "See inset map" message, or all of the above.

7. Use a grid to divide the system map into squares so that destinations may be located quickly.
8. Whenever possible, the leaflet map and timetable for the same days should be placed on the same page.
9. Individual city maps should be included in the information package.
10. The legend should be placed at the lower right corner of the map.
11. All transfer points should be made clear by placing the symbols at points where two or more buses actually intersect.

III. Research Participant #3
   A. Personal information
      1. Gender: female
      2. Age: 67
      3. Education: Senior status at Texas A&M in Community Health
      4. Frequency of public bus systems usage: rarely
   B. Design suggestions
      1. Color coding of routes should be used.
      2. Some small print sizes on the system map were unclear.
      3. All transfer points should be listed on the system map.
      4. Street names should be indicated closed enough to the streets to which they correspond as to not cause confusion.
      5. All bus stops on the leaflet map should be indicated by color symbols and their directions should be indicated.
      6. Individual city maps should be included in the information package.
      7. The legend should be made more noticeable.
      8. All bus stops should be listed on the system map, the leaflet maps, and the timetables.

IV. Research Participant #4
   A. Personal information
      1. Gender: male
      2. Age: 72
      3. Education: Master of Science in meteorology
      4. Frequency of public bus systems usage: occasionally
   B. Design suggestions
      1. All bus stops should be listed on the system map, the leaflet maps, and the timetables.
      2. All transfer points should be listed on the system map.

3.Direction of routes should be indicated on both the leaflet maps and timetables.
4.Be certain that all street names can be clearly seen and not covered by dark lines on the leaflet maps.
5.Individual city maps should not be included in the information package.
6.Color coding of routes should be used.

V.Research Participant #5
A.Personal information
1.Gender:female
2.Age:71
3.Education:Bachelor of Science in Dietetics
4.Frequency of public bus systems usage:occasionally
B.Design suggestions
1.Some small print sizes on the system maps were unclear.
2.Matt paper should replace the glossy paper for the system map in order to avoid glare.
3.Color coding of routes should be used.
4.More contrast should be added between the background and prints on the system map. Dark print on white background is preferred.
5.Direction of routes should be indicated on both the leaflet maps and timetables.
6.Individual city maps should not be included in the information package.

VI.Research Participant #6
A.Personal information
1.Gender:female
2.Age:70
3.Education:2 years of undergraduate coursework
4.Frequency of public bus systems usage:occasionally
B.Design suggestions
1.All bus stops should be listed on the system map, the leaflet maps, and the timetables.
2.All transfer points should be listed on the system map.
3.Color coding of routes should be used.
4.Individual city maps should be included in the information package.
5.The legend should be made more noticeable.

VII.Research Participant #7
A.Personal information
1.Gender:female
2.Age:70
3.Education:Secretarial school

4.Frequency of public bus systems usage:rarely

B.Design suggestions

1.Some small print sizes on the system map were unclear.
2.All bus stops should be listed on the system map, the leaflet maps, and the timetables.
3.All transfer points should be listed on the system map.
4.Color coding of routes should be used.
5.Background on the leaflet maps should be lighter.
6.Direction of routes should be indicated on both the leaflet maps and timetables.
7.Individual city maps should be included in the information package.
8.Symbol for highway numbers should be added into the legend.
9.The availability of weekday-weekend, morning-afternoon, and peak-off-peak schedules should be indicated more clearly, perhaps by the use of bold print, different fonts, or different colors of print.

VIII.Research Participant #8

A.Personal information

1.Gender:female
2.Age:68
3.Education:Master of Science in Education
4.Frequency of public bus systems usage:rarely

B.Design suggestions

1.All bus stops should be listed on the system map, the leaflet maps, and the timetables.
2.All transfer points should be listed on the system map.
3.All arrival times should be listed on the timetables. (For example, instead of "every 20 minutes thereafter").
4.The order of weekday and weekend schedules on timetables should follow the pattern population stereotype.
5.Individual city maps should be included in the information package.
6.Color coding of routes should be used.

IX.Research Participant #9

A.Personal information

1.Gender:male
2.Age:72
3.Education:Master of Business Administration and complete coursework toward a Ph.D in Agricultural Economics (no dissertation).
4.Frequency of public bus systems usage:never

B.Design suggestions
1.All bus stops should be listed on the system map, the leaflet maps, and the timetables.
2.All transfer points should be listed on the system map.
3.Inset maps should be included for all cities.
4.All bus numbers sharing the same routes should be listed in the same blocks.
5.Names of destinations on timetables should correspond to the names of stops on the maps.
6.Individual city maps should not be included in the information package.
7.Color coding of routes should not be used.

X.Research Participant #10
A.Personal information
1.Gender:female
2.Age:79
3.Education:High School and some business courses
4.Frequency of public bus systems usage:rarely
B.Design suggestions
1.Some small print sizes on the system map were unclear.
2.Some prints on the system map should be darker.
3.Matt paper should replace the glossy paper for the system map in order to avoid glare.
4.White background should be used on the system map.
5.All bus stops should be listed on the system map, the leaflet maps, and the timetables.
6.Use letter coding rather than number coding for the bus routes.
7.Whenever possible, the leaflet map and timetable for the same days should be placed on the same page.
8.Color coding of routes should be used.

APPENDIX F

DESIGN CONSIDERATIONS

The material on the following pages summarizes the design considerations obtained from participant interview and commentary. Items incorporated in the County Connection route guidance redesign are indicated by *. Numbers in () denote number of times design consideration was mentioned by participants.

DESIGN CONSIDERATIONS

SYSTEM MAP

*All bus stops should be indicated by colored symbols on both system and leaflet maps.(1)
*All transfer points should be indicated by colored symbols on the system map.(1)

*Color coding of routes should be used.(9)
Color coding of routes should not be used.(1)

*All bus stops should be listed on the system map.(9)

*Increase the small print sizes on the system map because some small prints sizes were unclear.(5)

*All transfer points should be listed on the system map.(8)

*The availability of inset maps should be made more clear by placing "See inset map" next to city names, use a different color or a different font for the "See inset map" message, or all of the above.(1)

Use a grid to divide the system map into squares so that destinations may be located quickly.(1)

*The legend should be placed at the lower right corner of the map.(1)

*All transfer points should be made clear by placing the symbols at points where two or more buses actually intersect.(1)

*Street names should be indicated close enough to the streets to which they correspond as to not cause confusion.(1)

The legend should be made more noticeable.(2)

*Matt paper should replace the glossy paper for the system map in order to avoid glare.(2)

*More contrast should be added between the background and prints on the system map. Dark print on white background is preferred.(1)

Symbols for highway numbers should be added into the legend.(1)
Inset maps should be included for all cities.(1)

All bus numbers sharing the same routes should be listed in the same blocks.(1)
Color coding of routes should not be used.(1)

*Some prints on the system map should be darker.(2)

*White background should be used on the system map.(2)

Use letter coding rather than number coding for the bus routes.(1)

LEAFLET
MAPS

*All bus stops should be indicated by colored symbols on the leaflet maps.(2)

*A legend should be placed on each leaflet map.(1)

*Each bus stop should be listed and numbered on the leaflet maps.(1)

*Whenever possible, the leaflet map and timetable for the same days should be placed on the same page.(3)

*All bus stops should be listed on the leaflet maps.(9)
*Direction of routes should be indicated on the leaflet maps by arrows.(5)

*Be certain that all street names can be clearly seen and not covered by dark lines on the leaflet maps.(1)

*Background on the leaflet maps should be lighter.(1)

TIMETABLES

*All bus stops should be listed on the timetables.(8)

*Direction of routes should be indicated on the timetables. (Use northbound, eastbound, southbound, and westbound on timetables.)(5)

*The availability of weekday-weekend, morning-afternoon, and peak-off-peak schedules should be indicated more clearly, perhaps by the use of bold print, different fonts, or different colors of print.(1)

All arrival times should be listed on the timetables. (For example, instead of "every 20 minutes thereafter, list all times.(1)

The order of weekday and weekend schedules on timetables should follow the pattern of population stereotype.(1)

Names of destinations on timetables should correspond to the names of stops on the maps.(1)

OTHER CONSIDERATIONS

*Individual city maps should be included in the information package.(6)

Individual city maps should not be included in the information package.(3)

APPENDIX G

SAS OUTPUT FOR ANALYSIS OF VARIANCE

OBS	SS	PK	RT	TIME
1	1	o	1	22
2	2	o	1	13
3	3	o	1	18
4	4	o	1	12
5	5	o	1	28
6	6	o	1	11
7	7	o	1	21
8	8	o	1	20
9	9	o	1	30
10	1	o	2	18
11	2	o	2	15
12	3	o	2	20
13	4	o	2	30
14	6	o	2	24
15	7	o	2	24
16	9	o	2	14
17	1	o	3	23
18	2	o	3	30
19	3	o	3	30
20	9	o	3	28
21	11	r	1	15
22	12	r	1	10
23	13	r	1	15
24	14	r	1	9
25	15	r	1	10
26	16	r	1	19
27	17	r	1	16
28	18	r	1	6
29	19	r	1	30
30	20	r	1	12
31	11	r	2	30
32	12	r	2	18
33	14	r	2	30
34	15	r	2	16
35	16	r	2	22
36	17	r	2	26
37	18	r	2	15
38	20	r	2	30
39	11	r	3	30
40	12	r	3	30
41	14	r	3	30
42	15	r	3	19
43	18	r	3	28
44	20	r	3	30

General Linear Models Procedure
Class Level Information

Class	Levels	Values
SS	19	1 11 12 13 14 15 16 17 18 19 2 20 3 4 5 6 7 8 9
PK	2	o r
RT	3	1 2 3

Number of observations in data set = 44

Dependent Variable: TIME

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	43	2384.795455	55.460359	.	.
Error	0	.	.		
Corrected Total	43	2384.795455			

R-Square	C.V.	Root MSE	TIME Mean
1.000000	0	0	21.0681818

Source	DF	Type III SS	Mean Square	F Value	Pr > F
RT	2	1018.750159	509.375079	.	.
SS(PK)	17	753.296429	44.311555	.	.
PK	1	3.594244	3.594244	.	.
PK*RT	2	147.537302	73.768651	.	.
SS*RT(PK)	21	639.412698	30.448224	.	.

Tests of Hypotheses using the Type III MS for SS(PK) as an error term

Source	DF	Type III SS	Mean Square	F Value	Pr > F
PK	1	3.59424389	3.59424389	0.08	0.7792

Tests of Hypotheses using the Type III MS for SS*RT(PK) as an error term

Source	DF	Type III SS	Mean Square	F Value	Pr > F
RT	2	1018.750159	509.375079	16.73	0.0001

Tests of Hypotheses using the Type III MS for SS*RT(PK) as an error term

Source	DF	Type III SS	Mean Square	F Value	Pr > F
PK*RT	2	147.5373016	73.7686508	2.42	0.1130

General Linear Models Procedure

Level of PK	N	TIME Mean	TIME SD
o	20	21.5500000	6.44388735
r	24	20.6666667	8.30749618

Level of RT	N	TIME Mean	TIME SD
1	19	16.6842105	7.09501101
2	15	22.1333333	6.05765946
3	10	27.8000000	3.79473319

Level of PK	Level of RT	N	TIME Mean	TIME SD
o	1	9	19.4444444	6.74742749
o	2	7	20.7142857	5.67786009
o	3	4	27.7500000	3.30403793
r	1	10	14.2000000	6.76264248
r	2	8	23.3750000	6.47936284
r	3	6	27.8333333	4.40075751

OBS	SS	PK	RT	TIME
1	1	o	1	22.00
2	2	o	1	13.00
3	3	o	1	18.00
4	4	o	1	12.00
5	5	o	1	28.00
6	6	o	1	11.00
7	7	o	1	21.00
8	8	o	1	20.00
9	9	o	1	30.00
10	10	o	1	38.52
11	1	o	2	18.00
12	2	o	2	15.00
13	3	o	2	20.00
14	4	o	2	30.00
15	5	o	2	34.56
16	6	o	2	24.00
17	7	o	2	24.00
18	8	o	2	34.56
19	9	o	2	14.00
20	10	o	2	34.56
21	1	o	3	23.00
22	2	o	3	30.00
23	3	o	3	30.00
24	4	o	3	36.33
25	5	o	3	36.33
26	6	o	3	36.33
27	7	o	3	36.33
28	8	o	3	36.33
29	9	o	3	28.00
30	10	o	3	36.33
31	11	r	1	15.00
32	12	r	1	10.00
33	13	r	1	15.00
34	14	r	1	9.00
35	15	r	1	10.00
36	16	r	1	19.00
37	17	r	1	16.00
38	18	r	1	6.00
39	19	r	1	30.00
40	20	r	1	12.00
41	11	r	2	30.00
42	12	r	2	18.00
43	13	r	2	41.56
44	14	r	2	30.00
45	15	r	2	16.00
46	16	r	2	22.00
47	17	r	2	26.00
48	18	r	2	15.00
49	19	r	2	41.56
50	20	r	2	30.00
51	11	r	3	30.00
52	12	r	3	30.00

53	13	r	3	39.89
54	14	r	3	30.00
55	15	r	3	19.00
56	16	r	3	39.89
57	17	r	3	39.89
58	18	r	3	28.00
59	19	r	3	39.89
60	20	r	3	30.00

General Linear Models Procedure
Class Level Information

Class	Levels	Values
PK	2	o r
RT	3	1 2 3
SS	20	1 10 11 12 13 14 15 16 17 18 19 2 20 3 4 5 6 7 8 9

Number of observations in data set = 60

Dependent Variable: TIME

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	59	5712.639873	96.824405	.	.
Error	0	.	.		
Corrected Total	59	5712.639873			

R-Square	C.V.	Root MSE	TIME Mean
1.000000	0	0	25.4976667

Source	DF	Type III SS	Mean Square	F Value	Pr > F
RT	2	2256.169773	1128.084887	.	.
SS(PK)	18	2053.791573	114.099532	.	.
PK	1	45.937500	45.937500	.	.
PK*RT	2	233.094520	116.547260	.	.
RT*SS(PK)	36	1123.646507	31.212403	.	.

Tests of Hypotheses using the Type III MS for SS(PK) as an error term

Source	DF	Type III SS	Mean Square	F Value	Pr > F
PK	1	45.93750000	45.93750000	0.40	0.5337

Tests of Hypotheses using the Type III MS for RT*SS(PK) as an error term

Source	DF	Type III SS	Mean Square	F Value	Pr > F
RT	2	2256.169773	1128.084887	36.14	0.0001

Tests of Hypotheses using the Type III MS for RT*SS(PK) as an error term

Source	DF	Type III SS	Mean Square	F Value	Pr > F
PK*RT	2	233.0945200	116.5472600	3.73	0.0336

General Linear Models Procedure

Level of PK	N	TIME Mean	TIME SD
o	30	26.3726667	8.7052465
r	30	24.6226667	10.9371940

Level of RT	N	TIME Mean	TIME SD
1	20	17.7760000	8.45753131
2	20	25.9400000	8.71168604
3	20	32.7770000	5.87334398

Level of PK	Level of RT	N	TIME Mean	TIME SD
o	1	10	21.3520000	8.76680203
o	2	10	24.8680000	8.13774853
o	3	10	32.8980000	4.82389147
r	1	10	14.2000000	6.76264248
r	2	10	27.0120000	9.56257613
r	3	10	32.6560000	7.03724252

PROGRAM LOG FOR CHENG CONVERTED DATA (OVER 30 MINUTES = MEAN FOR ROUTE + 3 STD)

```
   67    data try;
NOTE: The PROCEDURE GLM used 7.88 minutes.
   68    infile 'b:cheng2.prn';
   69    input SS $ PK $ RT $ TIME;
   70    proc print;run;
NOTE: The infile 'b:cheng2.prn' is file B:\CHENG2.PRN.
NOTE: 60 records were read from the infile B:\CHENG2.PRN.
      The minimum record length was 40.
      The maximum record length was 40.
NOTE: The data set WORK.TRY has 60 observations and 4 variables.
NOTE: The DATA statement used 9.00 seconds.
NOTE: The PROCEDURE PRINT used 4.00 seconds.
   71    proc glm;
   72    class PK RT SS;
   73    model time=RT SS(PK) PK RT*PK RT*SS(PK);
   74    Test h=PK e=SS(PK);
   75    Test h=RT e=RT*SS(PK);Test h=RT*PK e=RT*SS(PK);
   76    means PK RT RT*PK/duncan;
   77    run;
```