Title

SmartMaps for Advanced Traveler Information Systems Based on User Characteristics

Authors
Southworth, Michael
Issacs, Raymond

Publication Date
1994-08-01

SmartMaps
for Advanced Traveler Information Systems
Based on User Characteristics

Michael Southworth
Raymond Issacs

Final Report
UCTC No. 236

The University of California
Transportation Center

University of California
Berkeley, CA 94720

The University of California Transportation Center

The University of California Transportation Center (UCTC) is one of ten regional units mandated by Congress and established in Fall 1988 to support research, education, and training in surface transportation. The UC Center serves federal Region IX and is supported by matching grants from the U.S. Department of Transportation, the California Department of Transportation (Caltrans), and the University.

Based on the Berkeley Campus, UCTC draws upon existing capabilities and resources of the Institutes of Transportation Studies at Berkeley, Davis, Irvine, and Los Angeles; the Institute of Urban and Regional Development at Berkeley; and several academic departments at the Berkeley, Davis, Irvine, and Los Angeles campuses. Faculty and students on other University of California campuses may participate in Center activities. Researchers at other universities within the region also have opportunities to collaborate with UC faculty on selected studies.

UCTC's educational and research programs are focused on strategic planning for improving metropolitan accessibility, with emphasis on the special conditions in Region IX. Particular attention is directed to strategies for using transportation as an instrument of economic development, while also accommodating to the region's persistent expansion and while maintaining and enhancing the quality of life there.

The Center distributes reports on its research in working papers, monographs, and in reprints of published articles. It also publishes *Access*, a magazine presenting summaries of selected studies. For a list of publications in print, write to the address below.

University of California Transportation Center

108 Naval Architecture Building
Berkeley, California 94720
Tel: 510/643-7378
FAX: 510/643-5456

SmartMaps© for Advanced Traveler Information Systems Based on User Characteristics

Michael Southworth
Raymond Isaacs

with
Glenn Gilbert
Joey Goldman
Gustavo Llavaneras
Anthony Torres

Institute of Urban and Regional Development
University of California at Berkeley
Berkeley, CA 94720

Final Report
August 1994

UCTC No. 236

The University of California Transportation Center
University of California at Berkeley

This project was supported by funds from the California Department of Transportation, New Technology Program, and the Federal Transit Administration

CONTENTS

EXECUTIVE SUMMARY

This project has three emphases: (1) an assessment of the user requirements relevant to the design of effective transit information systems; (2) a reconnaissance of enabling technologies and prototypes for electronic information systems; and (3) a set of conceptual designs for electronic, interactive traveler information systems for public transit.

Literacy and transit surveys indicate that a very large proportion of transit users are likely to have difficulty with textual and numerical information including maps, schedules, fares, and procedures required to use public transit effectively. Transit information can be more effective in reaching these users by acknowledging these deficiencies and by designing information to communicate with people of varied language backgrounds and minimal literacy levels. Computer aided information systems such as SmartMaps would be particularly capable of reaching the diverse users of public transit.

A review of research examines social, psychological, informational, and environmental factors that can help us design more effective transit information systems. It is organized around several broad themes that relate to the use of information systems in urban wayfinding: Stress and Anxiety, Theories of Wayfinding, Visual Representation of Wayfinding Aids, and the Computer/User Interface. Throughout, attention is given to the importance of age, gender, cultural background, cognitive ability, and level of education and literacy in the use of various types of information. A summary of social factors that affect transit information comprehension and wayfinding is presented in a matrix.

Capabilities of the SmartMaps transit information system are explored in a group of scenarios, focusing on different aspects of the system. Existing computer applications relevant to the creation of SmartMaps are summarized, and technological requirements for setting up such a system are outlined. Several non-electronic approaches to presenting environmental information that are relevant to the creation of SmartMaps are also presented. Information management issues including privacy, access, balance, accuracy, monitoring, community representation, and administration are discussed. A program of future research needs is outlined including the testing of a prototype system with typical groups of users.

Michael Southworth is Professor of Urban Design and Planning in the Departments of City and Regional Planning and Landscape Architecture at the University of California at Berkeley.

Raymond Isaacs is an architect and a doctoral student in Environmental Planning.

1 Project Goals and Design Criteria

OVERVIEW

Many travelers find the prospect of travel on multi-modal, public transit systems a forbiddingly complex and unpredictable proposition. Advanced Traveler Information Systems (ATIS) can eliminate some of the guesswork for the rider, but such electronic systems can also add another layer of complexity. One challenge is to develop powerful information systems that are also more transparent and more accessible for the rider. Transparent and accessible information systems can make the transit systems themselves more transparent and accessible and ultimately more attractive to travelers.

This project has three emphases: (1) an assessment of the user requirements relevant to the design of effective transit information systems; (2) a reconnaissance of enabling technologies and prototypes for electronic information systems; and (3) a set of conceptual designs for electronic, interactive traveler information systems for public transit. The principal contributions of the project are its assessment of selected human factors that influence, in general terms, who can use the technologies, how the technologies will be used, and how effective and likely their use will be, as well as the conceptual design of the information system.

Modern, multi-modal urban transit systems are often exquisite in their technological sophistication, but this sophistication can also create for transit riders an atmosphere of forbidding complexity. Seen from the rider's perspective, the systems can be daunting rather than inviting. Advanced technology may be dazzling in its capabilities, but if it fails to serve users and to build ridership, it is not worth the investment. Our sense is that great care must be taken in the design of traveler information systems to ensure that the systems simplify the rider's transit experience, rather than adding another layer of complexity. An interdisciplinary approach to systems development may bring the tools necessary to return the rider to the center of our concerns. The project in this phase therefore draws mainly upon the expertise of designers and social scientists who can help to anticipate the needs, interests, abilities, values, and cultural orientations of prospective transit clients.

Attempts to broaden the use of public transit are confronted with several obstacles: problems of adoption, problems of demand, and problems of diversified use. Information technology can either exacerbate or mitigate each of these problems. A new transit system decked out with the latest traveler information gear may prove inscrutable to many of the riders it needs to win over. The application of expert systems to ATIS might produce a coterie of expert travelers, a clientele increasingly restricted to those in the know, rather than one that reaches out to vast numbers of people who are less knowledgeable in the intricacies of electronic information. Moreover, the wrong kind of communications technology, or technology which is too limited in its use, can put public transit at a disadvantage relative to private vehicles and commercial transportation modes made increasingly versatile and attractive by their incorporation of effective communications devices. While new information technology could weaken public transit on these fronts, it also clearly offers several advantages. If well conceived, the use of Expert systems in ATIS would be transparent to users. They could perform preprocessing of data based on user profiles, and rather than increasing system complexity, they should in fact decrease it.

SOCIAL CHARACTERISTICS OF TRANSIT USERS

Today public transit users in California are very diverse in cultural background, level of education, age, and literacy. A high proportion of these users are in fact foreign born and many have limited skills in reading of text, schedules, and maps and have limited knowledge of the city and region they live and work in. According to the *Southern California Rapid Transit District 1986 On-Board Survey*, transit users in the region were heavily concentrated in lower income levels with 60.5% of riders earning less than $15,000 per year. The majority of riders were Hispanic/Latino (44.2%) and African American (23.2%). Riders cover the age spectrum, but the majority are under 35 with 37.6% of riders 15-24 years old. Although the survey did not directly collect information on language background and skills, respondents had the option of an English or a Spanish version; 28% chose the Spanish.

ON-BOARD SURVEY OF PASSENGERS
Southern California Rapid Transit District, 1986

ETHNICITY	
African American	23.2
Asian/Pacific Islander	7.8
Caucasian	20.9%
Hispanic/Latino	44.2
Other	3.9

INCOME	
Under $10,000	46.0%
$10,000-14,999	14.5
$15,000-24,999	18.5
$25,000 and over	21.0

AGE	
Under 15	2.7
15-24	37.6
25-34	26.8
35-49	18.2
50+	14.7

The *AC Transit On-Board Survey* (1985) revealed that more than half of the passengers were Black, Asian, Hispanic, or American Indian and nearly half had incomes under $20,000. Most passengers were very dependent upon the bus system for transportation; over 80 percent of weekday passengers rode AC Transit buses at least 4 days a week. Almost 20 percent of weekday passengers were teenagers and only about 10 percent were over 64 years old.

AC Transit On-Board Survey of Passengers, 1985

ETHNIC BACKGROUND	Weekday	Saturday	Sunday
American Indian	1.9%	1.6%	2.1%
Asian	9.0	7.3	7.7
Black	44.8	50.2	50.0
Hispanic	8.0	6.8	8.6
White	34.5	32.1	29.9
Other	1.9	2.0	1.7
INCOME			
Under $10,000	25.9%	28.1%	33.2%
$10,000-20,000	21.5	21.8	21.9
$20,000-30,000	13.8	12.6	9.2
$30,000-40,000	7.8	6.0	6.2
$40,000-50,000	4.5	2.4	2.7
Over $50,000	6.0	4.6	3.1
Don't know	20.5	24.5	23.6
AGE			
Under 5	0.5%	0.6%	0.6%
5-12	2.2	3.5	3.4
13-17	17.6	23.5	18.5
18-23	21.0	20.4	21.3
24-29	16.4	15.0	17.2
30-59	33.3	26.5	27.2
60-64	2.3	2.8	2.9
65 and over	6.8	7.8	8.9

The social characteristics of BART and CalTrain passengers are strikingly different; these passengers tend to be white and much more affluent. Based on the 1992 *Passenger Profile Survey* 63 percent of BART passengers were white (which includes 11 percent Hispanic) and 49 percent had incomes above $45,000. In contrast to AC Transit, few teenagers (2 percent) ride BART. According to the 1989 *CalTrain Passenger Survey*, CalTrain weekday passengers had a median annual household income of $50,000 ($32,000 on weekends) and 60 percent were college educated. Based on the literacy surveys discussed below, this group of passengers is likely to be more literate and capable of using abstract, complex transit information systems.

BART Passenger Profile Survey 1993

ETHNICITY	
Asian/Pacific Islander	17%
Black	14
Native American	1
White*	63
Other	5

*11 percent of these said they were Hispanic

AGE	
12 or younger	1 %
13-17	2
18-24	11
25-34	30
35-44	30
45-64	23
65 or over	3

INCOME	
$15,000 or less	12 %
$15,001-$30,000	19
$30,001-$45,000	21
$45,001-$60,000	18
$60,001-$75,000	12
Over $75,000	19

LITERACY AND INFORMATION SYSTEM DESIGN

The *National Adult Literacy Survey* (Kirsch et al, 1993) interviewed nearly 13,600 individuals in the United States, ages 16 and older, randomly selected to represent the adult population throughout the country. The survey evaluated diverse types of literacy organized into 3 broad groups:

(1) **Prose literacy**, which includes the skills needed to understand and use textual material;

(2) **Document literacy**, which includes literacy skills directly relevant to this study--the ability to read and use bus maps and schedules, as well as other common information formats such as job applications, tables, graphs, or payroll forms; and

(3) **Quantitative literacy**, which includes skills needed for arithmetic operations such as balancing a checkbook, figuring out a tip, or calculating interest on a loan.

Literacy skills were classified in 5 levels. In Level I, the lowest, people had very limited skills and at best were able to perform simple tasks involving brief and uncomplicated texts. Level II skills were also quite limited, but included the ability to make low-level inferences using texts, to do simple calculations and compare price differences, or locate a particular intersection on a street map. Of the 5 levels of literacy skill, 21 to 23 percent of the adult population in the survey population performed in the lowest level of prose, document, and quantitative literacy, and another 25 to 28 percent were in the next level; within the 2 lowest levels, the highest percentages of the population were in document literacy. (Table 1) Thus, according to the survey, about half of the adult population in the US has very limited literacy skills, especially in document literacy. This finding has major implications for any organization involved in public communications and information.

Of those in Level I, one quarter were immigrants who knew little English, two thirds had not completed high school, and a third were elderly. Black, Native American, Hispanic, and Asian/Pacific Islander adults were more likely to have skills in the lowest two literacy levels than White adults, and 41 to 44 percent of all adults in the lowest level on each literacy scale were living in poverty. While 16 percent of Whites were in Level I of document proficiency, 43 percent of Blacks, 54 percent of Hispanic/Mexicano, 49 percent of Hispanic/Puerto Rican, 48 percent of Hispanic/Cuban, 53 percent of Hispanic/Central/South, 27 percent of American Indian/Alaskan Natives, and 34 percent of Asian/Pacific Islanders were in Level I. Men and women had the same average prose literacy, but men had somewhat higher document and quantitative skills.

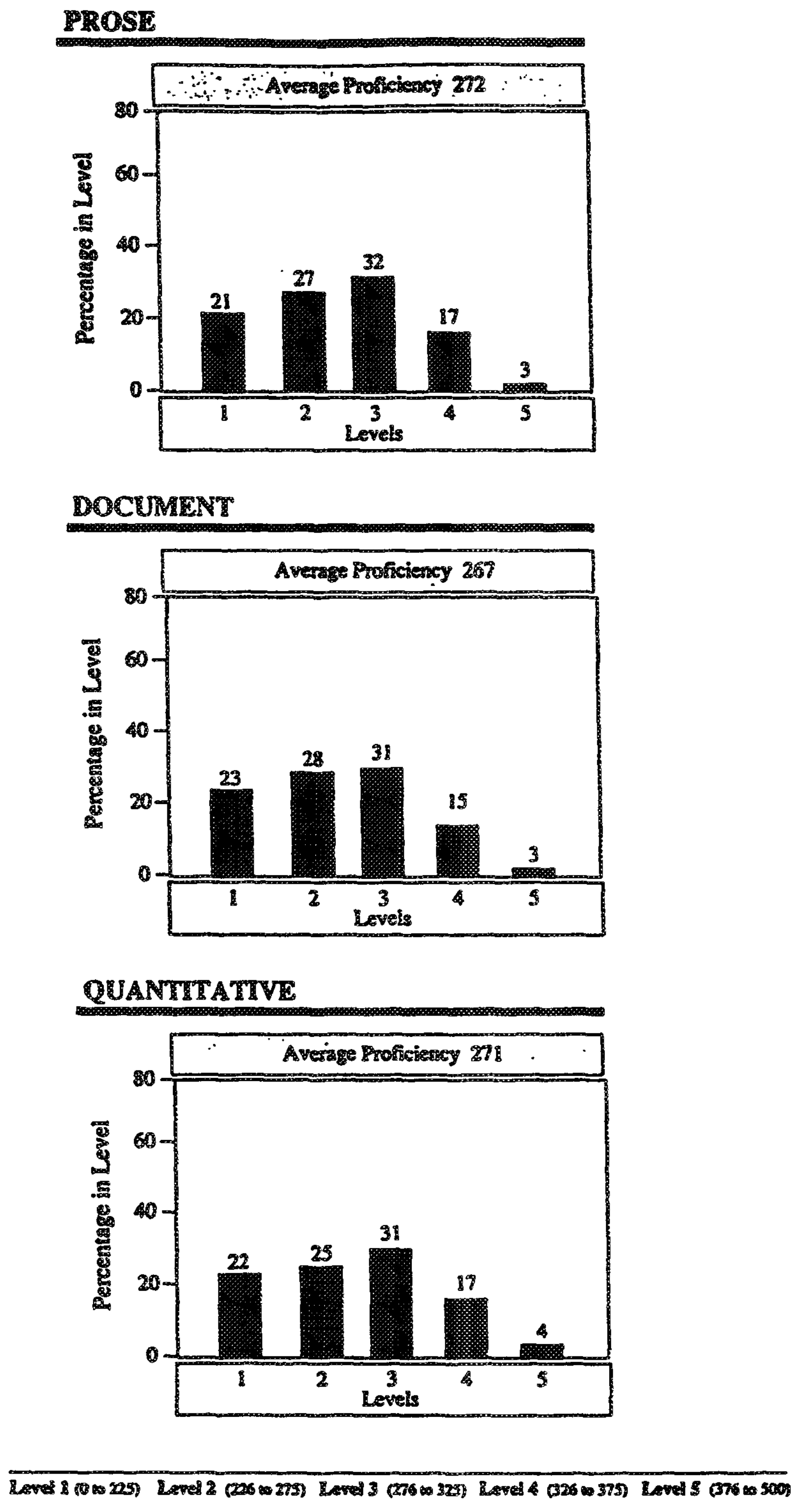


Table 1: Literacy Levels and Average Literacy Proficiencies for the Total Population

Source: US Department of Education, National Center for Education Statistics. 1992. *National Adult Literacy Survey.*

Not surprisingly, deficits in functional literacy are strongly concentrated among the poor, the less educated, and racial and ethnic minorities. (Hunter and Harman, 1979) There is a striking decline in literacy for older age groups, especially after age 55. (Table 2) Part of the explanation is because older adults have fewer years of formal education.

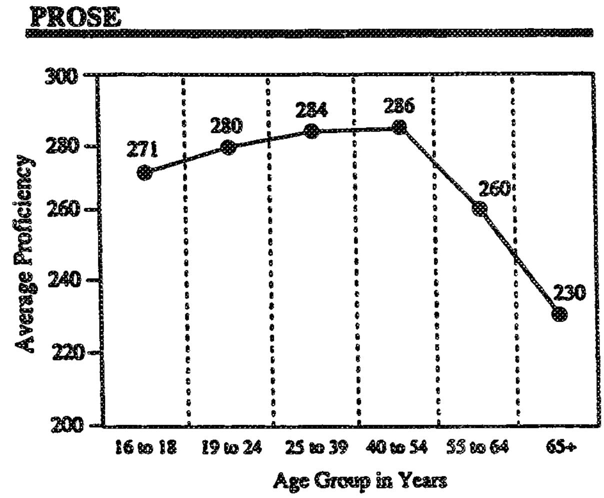
Literacy in California

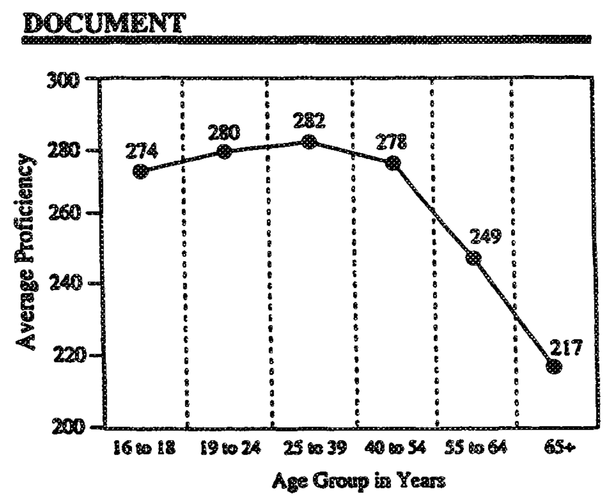
Although National Survey results are not yet available for California alone, they are organized by region: West, Midwest, Northeast, and South. In the West 20 to 22 percent of the adult population falls in Level I and 22 to 24 percent in Level II. In comparison, in the Midwest only 16 to 19 percent are in Level I but 26 to 30 percent are in Level II. Both the Northeast and South have higher percentages of the population in Levels I and II. (Kirsch et al, 1993)

According to an earlier study, *Illiteracy in California: Needs, Services and Prospects* (Dixon et al, 1987) over 43 percent of illiterates in California are white native born Californians. However, in terms of percentages the highest illiteracy rates in California are among minorities: 28.5 percent of Asians, 26.5 percent of Blacks, and 23.9 percent of Hispanics, while only 9.8 percent of Whites have deficiencies. Of all adults classified as illiterate, the study found that 41 percent live in central cities of metropolitan areas, compared with only 8 percent in rural areas. Central cities are, of course, the place where most public transit programs operate. Among native English-speakers classified as illiterate, 70 percent did not finish high school and 42 percent had no earnings in the previous year. Among illiterate adults whose native language is not English, 82 percent were born outside the United States and 86 percent were illiterate in their native language.

These findings were based on interpretation of the NOMOS survey (1979) which assessed 5 general areas of skills: cultural, economic, health and safety, interpersonal, and socio-political. Competency was defined on the basis of performing specific minimal tasks that are needed to function in society today, regardless of social-cultural background. Based on these findings, the report concluded that 15.1 percent of the adult population in California has a significant performance deficit.

Although this number is substantially lower than that of the National Adult Literacy Survey, the findings are based on different time periods, used different means of testing, and had different standards for evaluating competence. Like the National Adult Literacy Survey, the California study also finds significantly higher levels of performance deficits among minorities than whites, although the rankings differ: 23.9 percent of Hispanics, 26.5 percent of Blacks, and 28.2 percent of Asian and other ethnic groups, compared with 9.8 percent of Whites.





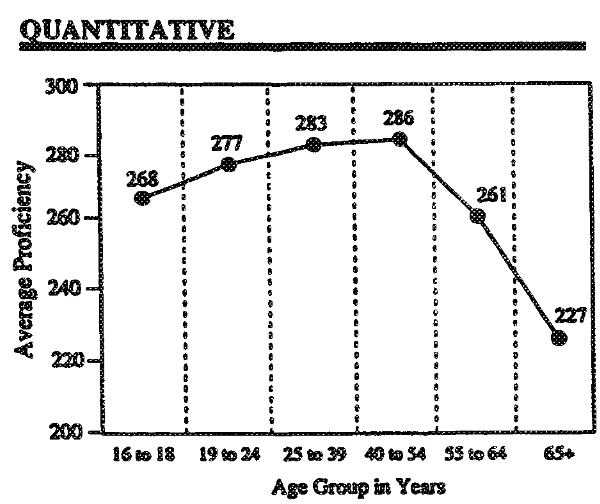


Table 2: Average Literacy Proficiencies, by Age
Source: US Department of Education, National Center for Education Statistics. 1992. ***National Adult Literacy Survey.***

Women were found to be somewhat more competent than men in all areas of literacy except economic.

Implications For Transit Information Systems

Analysis of social and literacy characteristics of the population most likely to use transit has several implications for the design of transit information systems:

- Those who are most dependent upon public transit are also most lacking in literacy skills--the poor, the elderly, racial and ethnic minorities, and the less educated.

- A very large proportion of transit users are likely to have difficulty with textual and numerical information including maps, schedules, fares, and procedures required to use public transit effectively.

- Transit information can be more effective in reaching these users by acknowledging these deficiencies and by designing information to communicate with people of varied language backgrounds and minimal literacy levels.

The Problems of Existing Transit Information Systems

The problems of conventional transit information systems for this diverse audience are numerous:

- They are designed primarily for middle class English speaking adult users who are well educated. The perceptual orientation, literacy skills, and other special needs of young people, elderly, handicapped, less educated, or non-English speaking people are not typically addressed in information systems.

- Information is not selective and oriented to the purposes and needs of users; in order to serve all users, too much information is typically presented creating perceptual overload.

- Information systems are static and non-interactive; each user receives the same generic message which may not suit individual purposes.

- Maps and other information are poorly connected with the larger environment; the focus is on the transit system, but not on understanding the system in the urban and regional context within which the transit user navigates.

The Values of Electronic Media in Transit Information Systems

Emerging electronic media can be uniquely effective in communicating transit and transit-related information to the traveler.

- They can provide information tailored to the individual's personal characteristics and needs in a particular situation, including preferred language, graphic or text orientation, and content.

- They can convey information simultaneously in several media, providing information that is therefore more intuitively, immediately, vividly communicative.

- They can engage the user in an interactive give-and-take, thus permitting harried travelers to obtain what they need, without extraneous information or overload.

- They can provide information sequentially, in a logical chain, and with a level of detail suited to the user's needs.

- Computer based information systems can store a vast base of transit information, as well as information about the city, in the form of text, maps, and images.

The right kind of communications technology--technology that is inviting, simple to use and effective--can help to put more riders onto new transit systems; to put new riders onto old transit systems; and to put before all riders an array of new ways to improve the quality of their trip.

PROJECT GOALS

Policy-Oriented Goals

The aim is to create user systems that:

- Increase transit ridership
- Enhance emerging ATIS systems
- Improve connectedness of urban travel via transit
- Promote urban travel via public transit
- Promote knowledge of the transit system and of the urban environment

User-Oriented Goals

The aim is to create user systems that:

- Are intelligible to a clientele comprising the widest possible diversity of age, ability, and cultural background
- Encourage ridership among the disabled
- Appeal to the senses so that they invite use and exploration

DESIGN CRITERIA

The systems should:

- Be usable with a minimum of prior learning; they must be as self-evident as possible
- Be usable by persons age 10 and older
- Be usable by persons not native to the U.S.
- Be usable by persons not fluent or functionally literate in English
- Be usable by the visually impaired
- Be usable by the hearing impaired
- Be usable by non-ambulatory persons
- Permit interactive use
- Provide customized information tailored to the user's needs
- Be based upon the integration of demonstrated technologies
- Be secure from theft and vandalism

REFERENCES

AC Transit. September 1985. *AC Transit On-Board Survey*. Oakland: AC Transit.

Barnes, R., and G. Henschel. Revised 1986. *Adult Illiteracy Estimates for the States*. Washington, DC: United States Office of Education.

BART Planning Department Office of Strategic Research. May 1993. *1992 Passenger Profile Survey Summary Report*. San Francisco: BART.

California Department of Transportation Rail Management Branch. 1989. *CalTrain Passenger Survey*. San Francisco: California Department of Transportation.

Dixon, Donald A., Merrill Vargo, and Davis W. Campbell. 1987. *Illiteracy in California: Needs, Services & Prospects*. Sacramento: California State Department of Education.

Hunter, Carman St. John, and David Harman. 1979. *Adult Illiteracy in the United States: A Report to the Ford Foundation*. New York: McGraw-Hill.

Kirsch, Irwin S., Ann Jungeblut, Lynn Jenkins, and Andrew Kolstad. 1993. *Adult Literacy in America: A First Look at the Results of the National Adult Literacy Survey*. Washington, DC: National Center for Education Statistics.

Nomos Institute. 1979. *California Competency Survey*. Berkeley: Department of Education.

Southern California Rapid Transit District. 1986. *Southern California Rapid Transit District 1986 On-board* Survey (prepared by Market Research Associates). Los Angeles: SCRTD.

2 Social And Psychological Factors In Transit Information Systems Design

A background study for facilitating urban wayfinding through electronic media

This chapter explores the literature on wayfinding to help understand the human factors relevant to the design of transit information systems and the possibility of using interactive computer displays as a means of facilitating wayfinding in urban transit environments. We hypothesize that readily available, on-site information would make cities more accessible to individuals, and that if these information systems were located at public transit nodes, the use of public transit would be increased (Southworth, 1990). The idea of transit oriented pedestrian districts has been discussed by planners and architects to the point that it is no longer a novel idea. However, implementation has hardly been successful in newer cities. Although electronic information systems alone cannot create a revolution in transit use, we think they could do much to eliminate some of the obstacles to using public transit in urban environments: inconvenience and fear of the unknown, lack of intelligible and interesting information, and insensitivity to the needs of different user groups.

This review of research examines social, psychological, informational, and environmental factors that can help us design more effective transit information systems. It is organized around several broad themes that relate to the use of information systems in urban wayfinding: Stress and Anxiety; Theories of Wayfinding; Map Reading; Visual Representation of Wayfinding Aids; and the User/Computer Interface. Throughout, attention is given to the importance of age, gender, cultural background, cognitive ability, and level of education and literacy in the use of various types of information. A summary of social factors that affect transit information comprehension and wayfinding is presented in the matrix on the following pages.

STRESS AND ANXIETY

It has been suggested that urban environments induce stress and anxiety. SmartMaps can help to minimize some causes of these conditions. Craig Zimring (1981) argues that a "major way that the designed environment may influence stress is by affecting wayfinding and spatial orientation" and gives "anecdotal and systematic evidence" of this problem. According to Zimring, the empirical information is limited. reviews one study in Manchester, England in which, along a complex test route, 40% of the participants got lost and "a high percentage of users reported disorientation and discomfort." In a study of a prison complex, Zimring reports that, in a before and after survey, the addition of directional signs significantly reduced stress among visitors.

MATRIX OF SOCIAL FACTORS IN MAP COMPREHENSION AND WAYFINDING BASED ON LITERATURE REVIEW

	Environment induced stress and anxiety	Environmental Cognition	Orientation: Sense of direction	Wayfinding: getting from point A to point I
General	Spatial orientation and wayfinding in the built environment can be major stressors (Zimring, 1981; Bryant, 1982) Worrying about becoming lost correlates with individual's sense of direction (Bryant, 1982) More reseach is needed on the relationship between stress and environmental form (Zimring, 1981)	Public transit users have less developed spatial understanding of environments than do auto drivers (Appleyard, 1969) Environmental simulation techniques can compensate for lack of familiarity with an environment (Hunt 1984; Cornell and Hay, 1984; Cohen, et al., 1986)	Self report is an accurate indicator of sense of direction (Bryant, 1982)	Wayfinding should be studie as a dynamic process (Passin 1980) Sequential information is most relied upon for the process of wayfinding (Byrn 1979; Thorndyke and Hayes-Roth, 1982; Garling, et al., 1986) Spatial information acquired from aerial views enhances sequential information (Thorndyke and Hayes-Roth. 1982; Zimring, 1981) Landmarks are frequently utilized in wayfinding and visual access to landmarks is an important factor (Garling, et al., 1986) In an unfamiliar environmen people apply "navigation rules" - an alternative to landmarks approach to wayfinding (Peponis, et al., 1990)
Age related differences	Unfamiliarity with an environment induces stress and anxiety in both adults and children (Hunt 1984; Cohen, et al., 1986) Spatial familiarity fosters emotional security in children (Acredolo, 1982)	*No research available*	*No research available*	Wayfinding abilities of 12-year-olds is equivilant to young adults. 6-years-olds a less capable and require specific cues (Cornell, et al. 1989, Cornell, et al., 1992) Young adults perform speci wayfinding tasks better thar elderley adults (Kirasic, et a 1992)
Cultural differences	*No research available*	There appears to be cross-cultural agreement about the essential characteristics of landmarks (Evans, et al. 1982)	*No research available*	*No research available*
Cognitive ability	*No research available*	*No research available*	*No research available*	*No research available*
Gender differences	*No research available*	*No research available*	Males have a better sense of direction (Bryant, 1982)	*No research available*
Education	*No research available*	*No research available*	*No research available*	*No research available*
Visually Impaired	*No research available*	Blind individuals are capable of accurate spatial cognition (Passini, et al. 1988; 1990)	*No research available*	*No research available*

table continues on next page

	Map reading	Map reading and verbal information	Map style: - diagramatic - illustrative	Three dimensional models
General	When viewing a map, individuals assume that up is equivalent to forward (Levine, et al. 1984) Maps not aligned with the terrain are counter productive (Levine, et al. 1984) Making the transition from aerial views to actual eye level views is difficult (Thorndyke, et al., 1982) Learning from maps is less rich than actual navigation experience, but much faster (Thorndyke, et al., 1982) Good map learners have a systematic approach, this approach can be taught (Thorndyke and Statz, 1980) Experience with maps does not necessarily improve map learning ability (Thorndyke and Statz, 1980)	Written directions were found to be easier to use than a map (Kovach, et al., 1988) The mind processes verbal information and visual/spatial information separatly (Paivio, 1986; Amlund, et al., 1985; Abel et al., 1989) Simultaneous input of related verbal and visual/spatial information enhances recall (Shwartz, et al., 1981; Amlund et al., 1985; Abel et al., 1989; Paivio, 1986)	*No research available*	Three dimensional models viewed simultaneously with sequentially arranged slides have been shown to be effective means of familiarization with new environments (Hunt 1984; Cohen, et al., 1986)
Age related differences	*No research available*	The conjoint processing of verbal and map information is consitent across age groups (Amlund et al., 1985)	For 10-12 year old children, pictorial representation may facilitate identification and memory (Amlund, et al., 1985; Southworth, 1990) but diagrammatic maps are easier to use (Southworth, 1990)	The combination of a model and slides has been shown to be effective with both children and elderly adults (Hunt 1984; Cohen, et al., 1986)
Cultural differences	*No research available*	*No research available*	*No research available*	*No research available*
Cognitive ability	Those with higher cognitive ability are faster than those with lower ability (Kovach, et al., 1988) Good readers have better recall from maps than poor readers (Amlund, et al., 1985) Ability to learn map reading techniques is dependent upon visual memory ability (Thorndyke and Statz, 1980)	There is no difference between verbal ability and spatial ability in comprehending directions (Vaneti and Allen, 1988) The conjoint processing of verbal and map information is not affected by reading ability (Amlund, et al., 1985)	*No research available*	*No research available*
Gender differences	*No research available*	*No research available*	*No research available*	*No research available*
Education	23% of U.S. population are not capable of reading maps (Kirsch, et al. 1993)	*No research available*	*No research available*	*No research available*
Visually impaired	*No research available*	*No research available*	*No research available*	*No research available*

table continues on next page

	Sequential/ walk through representation: Still images	Sequential/walk through representation: Film and video	Maps in other media: Tactile and auditory	Computer/User Interface
General	Sequentially arranged slide presentations, when used without other aides, have not been effective tools for familiarization (Hunt, 1984)	Video presentations have not been significantly more effective than slide sequences (Cornell and Hay, 1984) Presentation of transitions along a route may be an efficient alternative to film of entire route (Heft, 1983)	It is possible to process spoken messages while performing a visual task as long as neither the visual task nor the message is complex (Broadbent, 1958)	Approach to task performanece depends upon experience and familiarity (Rasmussen, 1983) Qualitative research models should not be disregarded in this area (Rasmussen, 1983)
Age related differences	Elderly adults make less accurate judgements from slides than do young adults (Kirasic, et al. 1992)	*No research available*	*No research available*	*No research available*
Cultural differences	*No research available*	*No research available*	*No research available*	*No research available*
Cognitive ability	*No research available*	*No research available*	*No research available*	*No research available*
Gender differences	*No research available*	*No research available*	*No research available*	*No research available*
Education	*No research available*	*No research available*	*No research available*	*No research available*
Visually impaired	*No research available*	*No research available*	Reading tactile maps is a complex skill developed with experinece. More research is needed. (Hampson and Daly, 1989)	*No research available*

While much research has been done on the relationship of environmental form and cognitive representation, Zimring advocates studying the "various links between environmental form, wayfinding and stress". He explains that there is a two-way link between cognitive representation and stress. In order to be oriented in space a good cognitive representation of the environment is required. "Being spatially oriented is a need for many people and when this orientation is lost, they become anxious and panicky." On the other hand, studies have shown that under stressful conditions "people are unable to form an accurate cognitive map of their environment." Zimring closes by encouraging more research on the relationship between stress and environmental form and cognitive representation.

Kendall Bryant (1982) also emphasized that "intense emotional upset may result from becoming lost or disoriented. He conducted an experiment designed to reveal correlations between individuals' concerns about becoming lost and their demonstrated sense of direction and orientation. Eighty-five college students, 40 males and 45 females, participated in the experiment. All were familiar with the test site--their own campus. A pointing accuracy test was used to determine the individual's sense of direction. The subject was asked to imagine standing at a particular location on campus facing a particular direction and then was asked to point toward unseen landmarks. The performance on this test was compared with characteristics obtained through surveys asking the subjects to rate their own abilities. From this experiment Bryant concluded that individuals can accurately predict their own sense of direction. He also found that individuals who report a poor sense of direction are likely to be worried about becoming lost and are also likely to perform poorly on the pointing accuracy test. Another correlation, significant but smaller, was found between pointing accuracy and personality traits, such as "Capacity for Status, Sociability, and Self-Acceptance". Finally, men performed better than women on the pointing accuracy test and also reported a better sense of direction.

Information as Mitigation of Stress and Anxiety

In London a pilot test is underway to determine whether providing transit information to users at bus stops will encourage the use of buses. Prior research has shown that uncertainty about waiting times is a major reason for not traveling by bus. London Buses expects that by simply providing the actual arrival times of the buses, continually monitored and updated, more people will use the buses (Clery). This system is similar to those in use in subway systems such as the London Underground and San Francisco's BART. The information has the potential to relieve stress due to feelings of uncertainty and helplessness. Interactive electronic information could take this concept several steps farther. While information about transit can be an integral and essential part of the information provided, other information will be available as well. As transit information reduces the amount of mystery and uncertainty within the transit system, the additional information is expected to reduce the amount of mystery and uncertainty in the urban environment served by the transit system by offering a means for the users to quickly become familiar with the surrounding urban area.

Stress and anxiety can also be mitigated by familiarity with an environment. Appleyard (1969) discovered that people who travel by public transit are less familiar with their city in terms of spatial relationships than those who travel by car. While mystery and complexity are attributes that stimulate us, they must be balanced by others such as legibility and familiarity (Bell, Fisher, Baum and Greene, 1990, pp. 45-51; Kaplan and Kaplan, 1982, pp. 78-88). It is reasonable to assume that, to many people, urban environments are not sufficiently legible and are too mysterious to encourage exploration. Research has shown that lack of familiarity can be compensated for by the use of simulation techniques (Hunt, 1984; Cornell and Hay, 1984; Cohen, Goodnight, Poag, Cohen, Nichol and Worley, 1986). Generally, the results of these studies indicate that when encountering a new environment, those individuals who have been familiarized with the environment through some form of simulation functioned with more comfort and security than those who have not been so familiarized.

Hunt (1984) conducted a study on elderly people about to be moved to a new retirement center. For many people, learning to find their way in an unfamiliar environment often causes stress and anxiety. Previous research has shown that for elderly people these effects are especially acute. Earlier attempts were made to familiarize the elderly through a series of visits to the new facility. Hunt realized that site visits were often not feasible and, for many, not very effective. Consequently, simulation procedures were developed to "essentially bring the building to the residents instead of taking them to the building." (Hunt, 1984, p. 309) The simulation technique used in this study was a small, three-dimensional model and a sequentially arranged series of photographic slides. The slides provided a simulated experience of walking through the building while the model provided an understanding of the spatial relationships within the building. During the development of this technique it was found that the slide presentation alone, though capable of providing identification and sequential information, was not capable of providing spatial orientation. Therefore, the slides and the model were presented simultaneously so that the viewers could assimilate the two different kinds of information into an image of the building.

The experiment involved three groups: a group that viewed the simulation, a group that was taken on a visit to the new building, and a control group that received no prior exposure to the building. As expected, the subjects from both the simulation group and the site visit group had significantly better way-finding ability and overall images of the building than those with no advanced exposure to the building. In addition, the differences between the simulation group and the site visit group were also significant. In terms of overall way-finding ability, the simulation group performed better in general than the site visit group. When asked to perform tasks that involved finding places that had been presented either by simulation or by site visit, the differences were not significant. However, when asked to find their way to rooms that had not been presented, the simulation group performed significantly better. This ability to find unknown places is attributed to the better understanding of the spatial relationships afforded by the simulated presentation.

Hunt also found that subjects from the simulation group had a better mental image of the building than the site visit group. Subjects from the simulation group seemed to have better information about landmarks in the building. More important, the simulation group demonstrated a significantly better understanding of the spatial organization of the building, both horizontal and vertical. When mental image and way-finding ability were compared, Hunt found a very strong correlation between the two, concluding that "efficient mobility is dependent on one's mental image of the environment." (Hunt, 1984, p. 330) The study illustrates that even though the site visit provided a richer, multi-sensory experience of the environment, the simulation resulted in a better, quickly developed mental image of the new environment and is a very effective tool for familiarizing one with a new environment.

In a separate, but similar experiment (Cohen, Goodnight, Poag, Cohen, Nichol, Worley, 1986), the effect of familiarization of a new environment on boys entering kindergarten was studied. As in the above experiment, three groups were used: one group was taken on a walking tour of the campus, another was shown slides of the tour and a three dimensional scale model of the campus, and a third group received no familiarization technique. This study was motivated in part by research suggesting that spatial familiarity fosters emotional security in an environment (Acredolo, 1982).

Two weeks before school started, two groups of boys were either taken on the walking tour, or shown the slide presentation of the walking tour along with the scale model. Two weeks after starting school, the three groups were given an attitude assessment test and a spatial assessment test. The results of the spatial assessment test were mixed and not particularly relevant. However, the attitude test yielded substantial evidence of Acredolo's familiarity-security relationship. Both of the familiarization techniques, site visit and simulation, resulted in significantly higher emotional security than no familiarization. Furthermore, the simulation technique was as effective as the site visit.

While these two studies strongly support the use of environmental simulation techniques for familiarization purposes, a third experiment (Cornell and Hay, 1984) points out some limitations. The theoretical basis of the experiment stems from Gibson's (1979) theory of visual perception. Gibson describes the visual experience of the environment as a "set of continuous transformations" in which "one vista flows into another" (Cornell and Hay, 1984, p. 629) rather than a series of still scenes. Cornell and Hay hypothesized that learning of a route would be more accurate the closer the initial presentation of the route was to an actual walk-through. According to this hypothesis, walking the route would provide more accurate learning than a slide presentation. A video presentation would be expected to be less accurate than a walk through, but more accurate than a slide presentation.

The experiment was conducted on kindergarten and second grade children. The children where shown a route on a university campus. They were divided into three groups with each group experiencing the route through a different medium. After the presentation the children were asked to lead an experimenter through the route. Half of the children in each group were asked to repeat the walk backwards. (Unfortunately, the children repeated the walk in the same medium as presented, so the effect of simulation on performance in the real setting was not tested.) As expected, the walk-through resulted in the most accurate learning of the route. The difference between the slide presentation and the video was not significant. There was a significant interaction between the medium of presentation and the direction of travel. For those who walked the path, repeating the path forward or backward made no difference. However, for those who experienced one of the simulated views, significantly more errors where made by those who repeated the path in reverse than those who repeated the path in the same direction.

From the above studies some general statements regarding familiarization can now be made. An unfamiliar urban environment can induce stress and anxiety. The Cohen experiment suggests that emotional security can be fostered through familiarity and that this familiarity can be afforded through simulated representations of the environment. An increased feeling of security should reduce the levels of stress and anxiety and, hopefully, make the new urban environment less threatening. The Hunt study stresses the importance of a good mental image of a place and the relationship of that mental image to functioning in the environment. In terms of developing a mental image, Hunt suggested that a simulated representation of the environment can be more effective than actually being in the place. However, as demonstrated in the Cornell and Hay study, various simulation techniques have limitations. Sequential presentations alone are not very effective. However, a sequential presentation working in tandem with an overall spatial representation, such as a model, was found to be very effective by assimilating different kinds of information about the environment. This information would be useful not only for newcomers, but for others as well. It is possible that some regular visitors, particularly infrequent ones, who have learned the environment incrementally have a poor cognitive map of the area. A simulated representation of the place would compensate for this lack and perhaps make them feel more confident.

THEORIES OF WAYFINDING

In addition to providing a well-developed mental image of the environment, interactive information systems will also provide directions to specific destinations within the area. In order for the information system to be most effective, it is necessary to understand the process of wayfinding and how it can best be facilitated. Distinctions have been made between the kinds of mental images referred to as cognitive maps and the information used for planning a route to a destination. Consequently, the cognitive process of wayfinding has been generally subdivided into two categories: sequentially arranged images and corresponding sets of decisions; and cognitive maps, or mental representations of spatial relationships. Most researchers agree that primarily sequential information is used for wayfinding. However, as a cognitive map becomes more complete the wayfinding process becomes more streamlined. As the studies presented above illustrate, individuals with a better overall picture of an environment, meaning a better cognitive map, tend to be more adept at finding routes within the environment than those with less developed cognitive maps. A well developed cognitive map does afford more sophisticated wayfinding, allowing one to find shortcuts, or to seek unknown destinations with confidence. Zimring (1981) reiterates this and hints that the development of a cognitive map could encourage more exploration of an environment since deviations from established routes become possible. However, a complete cognitive map is not required for route planning (Byrne, 1979).

Passini (1980) argued that research on cognitive maps and images traditionally has been limited to static spatial situations, while the process of wayfinding "is a dynamic affair". He defined wayfinding as "a spatial problem-solving process". He offered a conceptual framework that de-emphasizes spatial orientation and imagery and focuses on "the dynamic aspect" of wayfinding. The key features of this framework are "decision plans" which "describe the sequence of operations to be performed in order to complete a task". They are anticipated sequences of decisions to be made at key points along the route. The process of wayfinding, according to this framework, consists of three parts. First, spatial information is collected and structured. Second, the decision plans are formulated. Third, spatial behavior is enacted. The execution of the plan is predicated on the "matching-feedback process". This is the ongoing process of matching the expected image with the perceived image in route. If these images do not match sufficiently, then modifications to the decision plans are necessary.

Byrne makes the distinction by describing two different kinds of mental maps. A "vector-map...preserves two-dimensional vector information." On the other hand a "network-map...preserves only topological connectedness (the order of locations and turns)." A vector map is an image similar to that presented by an accurately drawn cartographic map. Byrne questions whether this information can be acquired "purely by experience of route travel" or only by looking at a map. He points to research by Piaget, Appleyard, and others which demonstrated that children unable to read maps and adults in cities for which there were no maps drew maps that were "predominantly unbranched strings" or network maps. Byrne describes a network map as a network of nodes and connections. Distance and precise vector information are not included. These maps are learned sequentially from actual travel within the network. However, even after repeated experience the level of information could never reach that of a vector map. In spite of this shortcoming, Byrne concludes that network maps are sufficient for wayfinding and, while it is likely that mental vector maps can exist, the primary source of information for wayfinding is the network map.

Thorndyke and Hayes-Roth (1982) also studied the different types of information learned from maps and direct navigation experience. Their research demonstrated that more experience in the environment increases a person's awareness of where things are in that environment. This conclusion is obvious. However, it illustrates one of the challenges of the interactive information project - to help individuals overcome their lack of experience in an unfamiliar urban environment. Like Byrne and Passini, Thorndyke and Hayes-Roth describe wayfinding and route planning as a process of sequentially recording "the space between start points, subsequent landmarks, and destinations" coupled with a "sequence of prescribed actions" to be executed at the appropriate points along the route. These sequences, which Thorndyke and Hayes-Roth call "procedural descriptions", are acquired through the experience of direct navigation. Contrasting with procedural descriptions is "survey knowledge", information typically learned from maps. This information includes the locations of and distances between objects based on fixed reference points.

Thorndyke and Hayes-Roth conducted an experiment in an attempt to understand how people make use of the two different kinds of information. For a test site they chose a floor in a large complex corporate office building with a maze-like circulation system. Subjects were divided into 2 main groups. In one group the "map-learning subjects" studied a plan of the building. In the other group the "navigation subjects" learned the building by being inside it for a considerable amount of time. Both groups were further subdivided into different periods of exposure. The issue of periods of exposure is an important one. For the map-learning subjects the time periods were measured in minutes. For the navigation subjects the periods were measured in months, up to 24. Thorndyke and Hayes-Roth reasoned that the method of acquisition would influence the approach to the tasks given to the subjects. The navigation subjects would derive their determinations by mentally retracing a route, while the map-learning subjects would be working with an abstract bird's eye view.

The results support the theory of the two different approaches used to make determinations on tasks such as distance, location and orientation. For example, the map-learning subjects estimated more accurately the vector (as the crow flies) distance between objects, while the navigation subjects estimated more accurately the distance of the route from one object to the other. The map-learning subjects had an advantage in the object location task. However, the navigation subjects performed much better in the orientation tasks. Thorndyke and Hayes-Roth speculate that the change of perspective from the bird's eye view to the view from within the space was a major factor in the poor performance of the map-learning subjects in the orientation tasks. The results also showed that given enough navigation experience, the navigation subjects will eventually outperform the map-learning subjects in all tasks, but this only occurred after one to two years of experience. This study illustrates that learning from maps and learning from direct navigation yield different spatial abilities. However, the two are not incompatible. Learning from maps is perhaps less rich than experience through navigation, but is acquired much more quickly and works in tandem with procedural descriptions and network-maps. While the map learning experience can be easily provided by SmartMaps, it is possible that simulated navigation can also be provided, thereby joining map learning and navigation into a single learning process.

The preceding studies emphasize the sequential process of wayfinding over the cognitive map approach. Garling, Book and Lindberg (1986) agree that wayfinding is a series of actions to be executed sequentially at specific locations and, therefore, call a travel plan an "action plan". They take the information processing approach, "involving primarily choices and decisions", to describe how a travel plan might be formulated. They make important distinctions between those familiar with an environment and newcomers. Individuals familiar with an environment draw upon their memory, a cognitive map or repeated experiences, to find their way to a destination. Newcomers must rely on maps, directions, or other people. They must pay close attention to signs, landmarks, etc. "in order to decide when appropriate action should be taken according to the plan". Such a process is dependent upon the visual analysis of the "physical-setting variables", in other words the layout and form of the environment. Garling, et al. list three attributes of the environment critical to wayfinding: "degree of differentiation, degree of visual access (for example, being able to see from one landmark to the next), and complexity of spatial layout."

The preceding descriptions of wayfinding rely on recognizable features of urban form. Kevin Lynch hypothesized that people conceptualize urban environments as paths, nodes, edges, landmarks and districts (Lynch, 1960). This theory of urban form has been replicated and externally validated by several planners, psychologists and geographers (Evans, Smith and Pezdek, 1982). Paths and nodes are elements that would conceivably make up a route to a destination. Landmarks, as mentioned above, are also important elements along a route. Donald Appleyard (1969) extended the research by analyzing in detail why landmarks are recognized as such. Evans, Smith and Pezdek (1982) extended Appleyard's research. This extension is especially useful because it allows an opportunity to compare different cultural and geographical environments. Appleyard's study was conducted in Venezuela, while Evans, et al.'s study was conducted in Southern California.

Evans, et al. incorporated the same dimensions used by Appleyard to rate the structures found to be landmarks, or "buildings associated with better recall" (Evans, et al., 1982). As for the characteristics that correlate with landmark studies, there was substantial agreement between the two studies. Both studies found the following characteristics to be significant: Movement ("the amount of persons and other objects moving in and around the building"), Contour ("the clarity of building contour"), Size ("vertical height of the building"), Shape ("complexity of shape"), and Use intensity ("extent of building use"). In the Venezuela study, Use Singularity ("uniqueness of building function") was found to be a significant characteristic, but not in the California study. In the California study, Significance ("extent of cultural, political, aesthetic, or historical importance") and Quality ("physical maintenance") were significant, but not in the Venezuela study. These findings are relevant in the selection of elements to represent in maps and other transit information.

While much of the research on wayfinding and environmental cognition has emphasized the role of landmarks, in an article on the exploration aspect of wayfinding, Peponis, Zimring and Choi (1990) propose the idea of a "search structure". Peponis, et al. argue that this is simply because the concept "landmark" is easy to define and understand - "...it is often easier to direct a stranger to a destination by using landmarks as signposts than to convey the more tacit understanding of paths, of shortcuts, and of the economy of the decisions that balance distance against interest, pleasure, a feeling of safety, or other considerations." They believe that "configuration", or pattern of spatial connections is a more important aspect of wayfinding. The idea of a search structure is that individuals will attempt to translate an unfamiliar environment into a configuration and proceed with their search based on "navigation rules" such as "If all else is equal, continue along the same line" and "divert from the line of movement when a new view allows you to see more space and activity..." Peponis, et al. recommend that we shift our attention from a reliance on signs and landmarks to consideration of the overall structure.

The studies above suggest the kinds of wayfinding information that might be provided by interactive information systems. Garling, et al. indicate that differences in the environment, even subtle ones, should be emphasized at key points along the route and that there should be enough landmarks so that the traveler has a goal in sight. Walk-through maps should provide cues so that these differences and landmarks will be recognized. In addition, attempts should be made to de-mystify the configuration or spatial layout, taking into account complicated intersections, etc. Interestingly, Garling, et al. stress the ineffectiveness of signs as aids to wayfinding (Garling, et al., 1982). The characteristics of landmarks provided by Appleyard and Evans should be helpful in selecting the landmarks and describing them, graphically and verbally, to the travelers.

Age Related Differences in Wayfinding

Much of the research on age related differences in wayfinding has focused on the use of landmarks. It is generally accepted that children pass through different stages of development in environmental cognition. An important development seems to occur around the age of ten (Cornell, Heth and Broda, 1989; Cornell, Heth and Rowat, 1992). Children above the age of ten are usually able to conceptualize spatial relationships, while children below the age of ten have not developed this skill. Two experiments were conducted to test the role of this development in wayfinding. In one (Cornell, et al., 1992) 6- and 12-year-old children were compared with 22-year-old adults. They were taken on a walk across a university campus and then asked to find their way back. Some of the members of each age group were told to stop at certain points along the route and look back. Among the two older groups, looking back significantly reduced the amount of wandering off route. However, among the 6-year-olds, the strategy of looking back was not effective. In addition, Cornell, et al., found that the wayfinding performance of 12-year-olds did not significantly differ from that of 22-year-olds. The explanation given in this particular case is that by age 12 children are capable of selecting identifiable landmarks from a scene and using them for orientation and also estimating travel distances between the scenes. Younger children do not have this capability.

In the other experiment (Cornell, et al., 1989) 6- and 12-year-old children were compared in a similar situation. As above, while walking across the campus, some subjects were told to stop and look back. However, this time specific landmarks were pointed out. One group had their attention directed only to "far" landmarks, in the skyline, etc., another only to "near" landmarks, mail boxes, phone booths, etc. Other groups did not look back at all. The 12-year-olds made significantly better use of the landmarks than did the 6-year-olds. The 12-year-olds focusing on far landmarks displayed a better sense of direction and orientation than all other groups. However, both 6- and 12-year-olds focusing on near landmarks made more correct path selections at key decision points compared to others in their respective age groups. These two experiments demonstrate the abilities of 12-year-olds to utilize cues in the environment. As for 6-year olds, it is clear that the cues need to be specifically presented and directly related to their path of travel.

Kirasic, Allen and Haggerty (1992) compared the performance of young (average age of 26) and elderly (average age of 69) adults in tasks designed to test "macrospatial cognitive processes", i.e. "activities involved in acquiring and using information about the spatial structure of environments." Subjects were shown 2 slide sequences, each of a different route. During the first presentation they were asked to select scenes of high landmark value. During the second they were asked to estimate distances to objects in the scenes. The results from these experiments indicate a significant decline in performance among elderly adults in both landmark selection and distance estimation. While it seems the relation of these tasks to environmental cognition is not directly established, the implications for the Smart Maps project are very direct. When viewing a simulated environment, such as slide presentations, elderly individuals are not as adept in making accurate judgments as younger adults.

VISUAL REPRESENTATION OF WAYFINDING AIDS

Many of the experiments discussed above, though designed to test either theories of familiarization and environmentally induced stress or theories of wayfinding, have also been tests of environmental simulation and representation. These tests demonstrate that simulations and representations are effective tools, especially in particular combinations. The findings in this section are more directly related to issues of reading, understanding, and making use of displayed information.

Video Presentation of a Route Sequence

A general conclusion from the experiments pertaining to sequential simulations is that sequential information - slides, video, etc. - is only marginally effective unless coupled with some form of overall representation of the place. However, just how much and what parts of the sequence are necessary to explain a route? Researchers have referred to a route as a "network of connections between choice points" (O'Neill, 1991). Following Gibson's ecological approach to perception, Heft (1983) adopts this idea of routes, but with his own twist: "a route is an invariant sequence of transitions that connect successive vistas." With this in mind, he conducted an experiment to test the effectiveness of film representations of a route. Heft compared an unedited version of the film of the route with two edited versions; one version included only the transitions, the other only the vistas. (Here vista refers to the complete stretch along a walk where the scene is relatively unchanged, i.e. the stretch between 2 transitions.) Undergraduate students participated in the experiment. When finding their way along the actual route, the vistas film group made significantly more errors than the complete film group, while the transitions film group did not make significantly more errors than the complete film group. The transitions film group outperformed the vistas group but, due apparently to poor planning of the experiment, it cannot be presented as significant. There is, however, a strong suggestion that representing only the transitions is an effective, efficient alternative to representing the complete walk.

Map Reading and Prose--the Conjoint Retention Hypothesis

A series of experiments was conducted by educational psychologists in the 1980's to test the interaction of visual information and verbal information. Most of the experiments incorporated a similar hypothesis predicting that subjects who looked at a map of a place while listening to a narrative of the same place would have better recall of both the place and the narrative. This phenomenon is called the "conjoint retention hypothesis" (Amlund, Gaffney and Kulhavy, 1985; Abel and Kulhavy, 1989) and follows from the "dual coding" theory of Allan Paivio (1986), who uses examples from a broad array of experiments to support the theory. According to this theory, "there are two cognitive systems for the storage and retrieval of information: one system emphasizes perceptual image characteristics and one system is primarily verbal in nature" (Amlund, et al., 1985). The first system processes visual images and spatial relationships while the other processes "linguistic units".

The two systems are complementary. "The probability of recalling specific information in one code is highly related to the recall of its other-code counterpart... [Consequently,] presenting visual images concurrently with verbal information leads to more robust memory traces..." (Abel and Kulhavy, 1989). According to Paivio (1986, p. 62) the verbal and non-verbal systems are "functionally independent". One system can be active alone or active in parallel with the other. Information does not flow between the two systems. Rather, "one system triggers activity in the other". Paivio emphasizes this point because it affords flexibility and organized processing "so that [the systems] can function independently and additively for some purposes and coordinate their activities for others."

In an early application of the dual coding theory to map reading, Schwartz and Kulhavy (1981) predicted that the presence of a map while listening to a narrative would increase the memory of the features on the map and the events related to them in the narrative. To test this they devised an experiment consisting of three conditions. The first group of subjects, undergraduate students, were given a map of an imaginary island with sixteen features marked by a symbol and a label. The second group was given a map showing only the outline of the map with the sixteen features, both symbols and labels, listed outside of the island. The third group, control, was given no map at all. After hearing the narrative about the island, the subjects were asked questions about the narrative. There was no significant difference among the three groups for the number of correct responses to questions regarding non-map-feature related events. However, the map group made significantly more correct responses to questions regarding map-feature related events, while there was no significant difference between the other two groups. Schwartz and Kulhavy (1981) emphasized that both the map group and the list group "received the same amount of information - differing only in its spatial arrangement on the map." They conclude that "During recall, when a learner is able to remember a feature within its proper context s/he is also more likely to correctly retrieve the information associated with it."

The results of the above experiment have been replicated in several similar experiments. In some cases written text was distributed rather than a narrative read aloud. The results support the conjoint retention hypothesis (Abel and Kulhavy, 1989) Abel and Kulhavy (1989) conducted a somewhat more sophisticated experiment using only two groups, a map group and a list group using written text. Some of the added twists in this experiment were intended to clarify some details of the conjoint retention hypothesis and are not relevant to the current discussion. However, in addition to the usual question and response portion, which yielded similar results to other experiments, the subjects were asked to reconstruct the map or list and record the order in which the features were recalled. The map group demonstrated superior performance of this task, recalling significantly more features. The order of recall was also different for each group, suggesting that the list group relied more on the text, while the map group developed an image of "the perceptual whole of a map space". Abel and Kulhavy suggest that this is further support of the conjoint retention hypothesis and that the learning of prose and spatial relationships simultaneously is mutually beneficial (Abel and Kulhavy, 1989).

Amlund, Gaffney and Kulhavy (1985) conducted a similar experiment comparing the performance of poor readers with good readers. The subjects were fifth and sixth grade students whose reading abilities were recently tested. Amlund, et al., were testing whether poor readers benefited from the joint retention phenomenon more, or less, than good readers. While the good readers performed better in general, there was no interaction between reading ability and map content or type of representation. Both groups of readers benefited equally from simultaneously learning prose and spatial relationships.

Earlier work on auditory perception has shown that individuals can perform separate listening and visual tasks simultaneously (Broadbent, 1958). However, there are limitations. In his work using airplane pilots as subjects, Broadbent found that performance on visual tasks (performing flight maneuvers using only instruments) was not impaired by simultaneously listening to radio messages as long as the messages were clear and routine. However, as the messages became complicated or distorted, performance on the visual tasks declined. He concluded "that complex non-verbal tasks may be impaired by a simultaneous listening task of some difficulty, though reduction in the difficulty of either may reduce the interference" (Broadbent, 1958, p 77). SmartMaps, with multi-media capabilities, should be developed to take advantage of simultaneous learning without the inhibiting effect of too much information. Not only does this approach support the needs of typical transit users, it assists in complying with the Americans With Disabilities Act (ADA).

Individual Differences in Map Reading Skills

Map learning is unique in that it combines verbal stimuli, objects and places with names in spatial relationships and all the information is presented simultaneously. Thorndyke and Stasz (1980) conducted a pair of experiments to identify different techniques used by individuals when studying a map and the effectiveness of these techniques. They were interested in differences between good learners and poor learners and differences between experienced map users and novices. The first experiment was designed to identify different techniques used by individuals. The small sample of eight subjects consisted of five novices and three experts. The subjects were given maps to learn and were later tested to determine how well they had learned the maps. They were allowed to develop their own strategies. Based on the test results, Thorndyke and Stasz divided the group into "good learners" and "bad learners". They also divided the processes used by the subjects into four categories: attention, encoding, evaluation, and control. Under the category of attention, good learners were found to devise a more systematic approach to learning. They used a partitioning procedure in which they would divide the given information into subsets and focus their attention on the elements within one subset before moving on. As an example, one subject reported learning all of the parallel vertical streets first, then the horizontal. The poor learners relied more on random sampling.

Under the category of encoding a distinction between verbal and spatial learning was noticed. There was little variation in procedures used to learn verbal information. However, for spatial learning, the differences were significant. Poor learners were unable to develop strategies for spatial learning. In contrast, good learners "elaborated and refined their knowledge of spatial location by noticing and encoding explicit shapes (pattern encoding) or spatial relations (relation encoding) among two or more map elements." Under the category of evaluation, two observations were made. First, good learners were able to ignore information they had already learned and focus on unlearned material. Poor learners were less able to make this distinction and continued in a random fashion. In addition, at each stage in the learning trials good learners were more confident about what they knew. Under the category of control, they found that good learners developed a systematic approach and stuck to it, while poor learners, if they did devise a system, frequently abandoned it. Thorndyke and Stasz found that experience in using maps had little influence in this particular case. Of the three experienced subjects, one had the overall highest score; one was ranked sixth; and the third had the lowest score of the eight subjects.

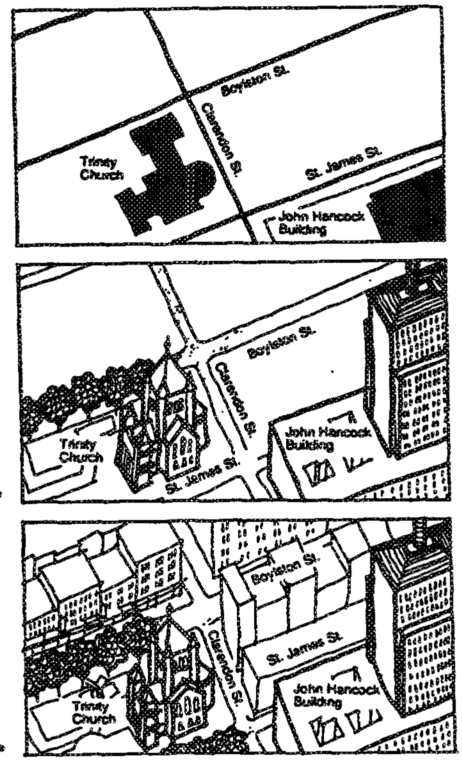
In the second experiment, Thorndyke and Stasz directly tested the effectiveness of procedures discovered in the first experiment. Forty-three subjects were divided into three groups. One group was given training in six "effective procedures": partitioning, imagery, pattern encoding, relation encoding, memory-directed sampling, and evaluation. Another group was given training in "neutral procedures", procedures not expected to be effective. The third group was given no training at all. The subjects trained in using the effective procedures showed significantly better learning from the maps than subjects in the other two groups. Most of this improvement was related to the processing of spatial information. There was little difference among the groups in the processing of verbal information. A separate test was used to determine visual memory ability. The subjects were classified as high, medium and low. The effective procedures training was most successful with the high and medium groups and insignificant with the low ability group. In conclusion, good map learners rely on systematic procedures. These procedures can be taught to others, but are dependent upon the individual's visual memory ability.

Individual differences in following directions have also been studied. Kovach, et al. (1988) also found that subjects with higher cognitive ability were significantly faster than those with lower cognitive ability. In another study, Vanetti and Allen (1988) explored the impact of different levels of spatial and verbal abilities on producing and understanding route directions. They found that spatial ability was more important than verbal ability in producing directions. However, in comprehending directions, they found no differences between those with high spatial ability and those with high verbal ability. All groups displayed a high degree of accuracy.

Map Feature Representation

In addition to the interaction between maps and prose, Amlund, Gaffney and Kulhavy (1985) tested the effect of different styles of feature representation. The subjects, fifth and sixth graders, were given one of three different maps: a label map indicating the features with a label only, a symbolic map with a geometric symbol placed over the label, and a mimetic map with a pictorial representation placed over the label. The subjects using the mimetic map demonstrated a significantly better recall than subjects using the other two maps. There was no meaningful difference between those using the label map and those using the symbol map. However, in a second, somewhat modified experiment no significant differences were found. Only speculative explanations were given.

In his study of ten to twelve year old boys, Southworth (1990) compared three different styles of map feature representation: diagrammatic plan maps, pictorial maps with all features shown in axonometric view, and landmark maps in which only landmark features were shown in axonometric view on a diagrammatic plan. Southworth found that the pictorial map was the most preferred and that the subjects could find familiar places easier on this map. However, route planning was more difficult because the three dimensional buildings blocked the view of the streets. The subjects agreed that the diagrammatic plan was easiest to use for route planning. Southworth suggests that the landmark map may be the best alternative, being a compromise between the diagrammatic plan and the pictorial map.



A. LINEAR MAP

B. LANDMARK MAP

C. PICTORIAL MAP

Map Placement and Orientation

Levine, Marchon and Hanley (1984) predicted that the effectiveness of "you are here" maps depends on their placement and orientation relative to the environments they represent. Two experiments were conducted. One was "a laboratory symbolic wayfinding task" using slides illustrating a map of a college campus and the other "a field, real-space task" in a complex building. Two experiments yielded the same result. Maps that were aligned with the terrain were easier to use than maps that were rotated 90 degrees or more. In fact, they found counter-aligned maps to be counter productive. Levine, et al. also consider the results as confirmation of the "Forward-Up Equivalence" principal. This principal asserts that users assume that maps are aligned and that up corresponds to forward. "Whenever...this naive user-assumption is violated [i.e. the map is not aligned], the user will move off in the wrong direction."

Even though this conclusion seems obvious, Levine, et al. documented several public places where the maps were misaligned. In numerous buildings on the Berkeley campus of the University of California, including the College of Environmental Design, maps are rotated 180 degrees.

Written Directions Versus Graphic Representations

While spatial and route planning information is easily presented on video display terminals, this information can be too much for an individual to remember. Therefore, an individualized set of written directions should be generated. Kovach, Surrette and Aamodt (1988) conducted a study to determine the effectiveness of informal directions. In this study two different styles of directions were used: "a written verbatim set of route directions" and "a [hand drawn] graphic illustration of the same route." Each style was subdivided into three levels of complexity: low, medium and high. Subjects were given a set of directions and told to drive to the destination. Kovach, et al. found that subjects using written directions took significantly less time to reach the destination than those using graphic illustrations. They did not find any significant difference between the levels of complexity, suggesting that a simple set of directions is just as effective as a more complex set.

Wayfinding Aids for the Visually Impaired

Providing wayfinding information for the visually impaired presents a special challenge. Much of the preceding discussion of wayfinding, map reading and environmental simulation presupposes vision as the primary mode of perception. However, in today's world social integration of the handicapped, including the blind, is a standard protocol and must be a part of the SmartMaps program. Recent research has revealed that many assumptions about the spatial cognition of the blind are incorrect. In preliminary research Passini, Dupre and Langlois (1986) learned from interviews with blind subjects that understanding spatial organization is an important factor in achieving independent mobility. Later experiments comparing blind subjects with sighted subjects showed that, through direct navigation experience, blind individuals are capable of developing cognitive representations of environments that are essentially as good as those of sighted individuals (Passini and Proulux, 1988; Passini, Proulux and Rainville, 1990). However, the blind subjects needed more time and approached the task with more attention to detail. Passini, et al. (1986) learned that cues used by blind individuals were smaller in scale than those used by sighted individuals: "posts, fences, walls, stairs, trees, interior plants, etc." Some individuals mentioned the warmth of the sun as an aid to orientation. Given basic information the visually impaired have demonstrated the ability to navigate within a complex environment, even to the level of devising shortcuts (Passini, et al. 1988).

The issue for SmartMaps is what information is required by the visually impaired and how should it be presented. Tactile maps are the traditional approach and range from inexpensive plastic relief maps such as those developed for the Boston (MBTA) transit system, to elaborate computer based technologies. Other non-tactile options include personal wayfinding devices such as cassette recorders and portable GPS receivers. In addition to tactile maps, Passini, et al. (1986) recommend "verbal descriptions at information centers and slightly more technical interactive devices which allow the user to ask questions about a setting." Based on their experimental work, Passini, et al. (1990) recommend that, along with route and landmark information, tactile maps should include "the principle by which the layout is organized." At present little research has been done in regard to the presentation of environmental information to the blind. Hampson and Daly (1989), recognizing the need for this research, caution that conventional approaches to map learning research will not be adequate with tactile maps. They stress that using tactile maps is "a complex task involving coordination of information on many levels." Therefore, reading a tactile map should be treated as a skill that changes with practice. Over time, the many sub-skills become automated and are executed with little attention. Research with tactile maps should be designed with the "skills theory" at its core. Follow-up testing of prototypes is another crucial step in the development of these, and other, wayfinding aids. "All too often, well intended inventions are not carefully thought through and, above all, they are not being sufficiently tested" (Passini, et al. 1986).

COMPUTER/USER INTERFACE

At this time, there is little published research on effective strategies for computer/user interactions that is directly related to this project. However, Jens Rasmussen has developed a general theory of "man-machine interface systems" that is helpful for both future research and conceptual design (Rasmussen, 1983). The theory describes three different levels of task performance - "skills, rules, and knowledge" - based on the individual's familiarity with the task. At the skills level, the individual is very familiar with the task and environment. Performance is smooth, integrated and executed with very little conscious effort. An ability to compose sequences from "a large repertoire of automated subroutines" allows one to be flexible.

At the rules level, the individual may not be familiar with the specific task, or the environment, but will have procedural rules gained from previous experience with other similar tasks or environments, or from instructions communicated from other persons. The performance is goal oriented and structured by the execution of "stored rules". The goal is achieved after a sequence of acts is corrected through direct feedback. The third level of task performance, knowledge, takes place when an individual is unfamiliar with the task and there are no rules available. In these situations, a person formulates a goal and tests different plans against achieving the goal. This can be done "physically by trial and error, or conceptually" by understanding the predicted effects of the plans.

To further develop a theoretical base for designing and evaluating advanced technical systems, Rasmussen considers the value of qualitative models of research. Among researchers, qualitative methods are generally considered to be "premature descriptive models" employed in exploratory investigations which will be followed by and replaced with accepted quantifiable methods. However, Rasmussen argues that qualitative models have "equally important roles for analysis and prediction of performance". He argues that these models are very capable of matching categories of human behavior with certain situations. Therefore, qualitative models should guide the overall design, while quantitative models are used to "optimize the detailed designs".

SUMMARY

An interactive electronic information system has the potential to encourage the use of public transit by reducing the amount of inconvenience, anxiety and stress associated with public transportation and the related urban environment. Research has suggested that familiarity with an environment fosters feelings of security and better spatial cognition. Environmental simulation techniques are capable of familiarizing newcomers with a complex environment very quickly, more quickly than actual experience in the same environment. However, in order for the simulation to be truly effective, different kinds of presentations are required. A sequential, "walk-through" presentation, either animated or a series of still photographs, only seems to be effective if it is coupled with a bird's eye view of the environment. This allows the mind to assimilate two different kinds of information: spatial relationships, or cognitive maps and procedural information, or network maps.

While a good cognitive map facilitates efficient and flexible navigation, it is generally agreed that sequential or procedural information is used for wayfinding. This process has been described as a sequence of actions to be executed at specific locations along the route. Recognition of elements of urban form is a critical part of the process. The information system must present these elements to the traveler in a format that makes their identification in the real environment likely. Garling, et al., Appleyard and Evans, et al. have identified characteristics of structures that make them memorable and identifiable: size, shape, movement, etc. These findings seem to be valid in at least two different cultural and geographical environments. In addition to landmarks the organization of the environment should be emphasized, such as the street pattern. With awareness of this pattern, individuals can develop their own search strategy and proceed with more confidence and flexibility.

Sophisticated multi-media systems have the capacity to present wayfinding information in almost any form or fashion. We should exercise caution as these systems are developed. It has been demonstrated that only limited amounts of information can be processed and that too much information is a hindrance to understanding a map or finding a destination. Studies have been done comparing the effectiveness of various forms of map presentation and certain combinations of media. It has been shown that overly detailed pictorial maps have limited effectiveness. It has also been established that simultaneously processing different inputs becomes ineffective as the inputs become more complex. On the other hand, certain combinations have been found to be productive, such as the combination of a street map with the pictorial presentation of landmarks or spoken descriptions. Only through continued testing will the most effective means of presentation be discovered. It is likely that simple presentations will prevail.

Previous research on wayfinding and urban cognition is important in the development of interactive information systems. This research will increase the likelihood that the SmartMaps information system will become a useful public service. In addition, the system will allow the theories themselves to be tested and extended or modified. This two-way street will have positive consequences for both the public service provided and the continuing research. The information system should be flexible to allow for and take advantage of the changes that should come from years of continued use and research.

DESIGN GUIDELINES FOR TRANSIT INFORMATION SYSTEMS

The literature reviewed in this chapter provides theoretical foundations for the design and development of SmartMaps interactive information systems. With this information it is possible to define some specific criteria for the implementation of the systems. However, it is important to stress that these criteria need to be tested and refined in the context of system prototypes.

- The system needs to be designed for a variety of user groups in terms of age, culture, language and education.

- The kiosks and information should be usable by disabled individuals.

- The system should be interactive to allow the user to make specific requests and avoid being confounded by extraneous information. More research is needed to determine the best method of user input, i.e. track ball, touch screen, joy stick, key pad, etc.

- Different levels of on-screen help should be available to accommodate the range of expertise of the users, from those who have no background with any electronic media to those highly skilled with this specific system. Skilled users should be able to bypass any information they do not need. On-screen tutorials should be available.

- In addition to different skill levels, the system must be prepared for different levels of cognitive ability and perceptual orientation. Some users will have more difficulty comprehending than others.
- Sequentially arranged walk-through images of a route should be coupled with an overview of the environment, such as a map, three dimensional model, or aerial view, to enhance the cognition of the spatial relationships along the route as well as familiarize the user with the environment. When feasible, three dimensional models should be used for the overview.

- Full length videos of the route are unnecessary, time consuming, and provide too much information. Sequential walk-through images may be either photographs or edited animated images. More research is needed to determine whether video images are more effective than photographs.

- Selected walk-through images should include the points along the route where changes occur.

- Landmarks should be emphasized and clearly presented in both the walk-through images and the maps or aerial views.

- Maps and aerial views should show the organization of the streets and paths. This organization should not be obscured by unnecessary graphics such as insignificant buildings. More research is needed to determine the best map style.

- Graphically presented route information should be accompanied by written and spoken descriptions of the route to reinforce learning and recall of directions. Spoken descriptions are more accessible to the general population than written.

- Maps should be properly aligned with the actual environment in accordance with the "forward-up" principal.

- The system should provide the user with printed written directions and a very simple map of the route. More research is needed concerning the level of detail necessary for finding the destination.

- If the user desires, the system should offer directions for the return trip to the transit station.

- The kiosk should allow for user commentary as part of a continuing system improvement program.

- The system must be tested and evaluated on an ongoing basis. It should be flexible in order to take advantage of new findings and information

REFERENCES

Abel, Robert R., and Raymond Kulhavy. 1989. Associating Map Features and Related Prose in Memory. *Contemporary Educational Psychology* 14, 33-48.

Acredolo, L. P. 1982. The Familiarity Factor in Spatial Research. *Children's Conceptions of Spatial Relationships*, ed. R. Cohen. San Francisco: Jossey-Bass.

Amlund, Jeanne T., Janet Gaffney, Raymond W. Kulhavy. 1985. Map Feature Content and Text Recall of Good and Poor Readers. *Journal of Reading Behavior* 17, 4:317-330.

Appleyard, Donald. 1969. Why Buildings are Known. *Environment and Behavior* 1, 131-154.

Bell, Paul A., Jeffrey D. Fisher, Andrew Baum, Thomas C. Greene. 1990. *Environmental Psychology*. Chicago: Holt, Rinehart and Winston, Inc.

Broadbent, D. E. 1958. *Perception and Communication*. Oxford: Pergamon Press.

Bryant, Kendall J. 1982. Personalities Correlates of Sense of Direction and Geographical. *Journal of Personality and Social Psychology* 43, 6:1318-1324.

Byrne, R. W. 1979. Memory for Urban Geography. *Quarterly Journal of Experimental Psychology* 31, 147-154.

Clery, Daniel. 1992. Welcome to Your Talking Bus Stop. *New Scientist* 23 May, 19.

Cohen Robert, Judith A. Goodnight, Chloee K. Poag, Sheila Cohen, Gerry T. Nichol and Patricia Worley. 1986. Easing the Transition to Kindergarten. *Environment and Behavior* 18, 330-345.

Cornell, Edward H., and Deborah H. Hay. 1984. Children's Acquisition of a Route via Different Media. *Environment and Behavior* 16, 627-641.

Cornell, Edward H., Donald Heth and Lorri S. Broda. 1989. Children's Wayfinding: Response to Instructions to Use Environmental Landmarks. *Developmental Psychology* 25, 5:755-764.

Cornell, Edward H., Donald Heth and Wanda L. Rowat. 1992. Wayfinding by Children and Adults: Response to Instructions to Use Look-Back and Retrace Strategies. *Developmental Psychology* 28, 2:328-336.

Ellis, Stephen R., Mary K. Kaiser and Arthur C. Gruwald, (Eds.). 1991. *Pictorial Communication in Virtual and Real Environments*. New York: Taylor and Francis.

Evans, Gary W., Catherine Smith and Kathy Pezdek. 1982. Cognitive Maps and Urban Form. *American Planning Association Journal* 82, 232-244.

Evans, Gary W., and Kathy Pezdek. 1980. Cognitive Mapping: Knowledge of Real-World Distance and Location Information. *Journal of Experimental Psychology: Human Learning and Memory* 6, 13-24.

Garling, Tommy, Anders Book, and Erik Lindberg. 1986. Spatial Orientation and Wayfinding in the Designed Environment. *Journal of Architecture and Planning Research* 3, 55-64.

Gibson, J. J. 1979. *The Ecological Approach to Visual Perception.* Boston: Houghton-Mifflin.

Hampson, Peter J. and Catherine M. Daly. 1989. Individual Variation in Tactile Map Reading Skills. *Journal of Visual Impairment*, December, 505-509.

Heft, Harry. 1983. Way-Finding as the Perception of Information over Time. *Population and Environment: Behavioral and Social Issues* 6, 3:133-150.

Hunt, Michael E. 1984. Environmental Learning Without Being There. *Environment and Behavior* 16, 307-334.

Kaplan, Stephen, and Rachel Kaplan. 1982. *Cognition and Environment.* New York: Praeger Publishers.

Kirasic, Kathleen C., Gary L. Allen and Deana Haggerty. 1992. Age-Related Differences in Adults' Macrospatial Cognitive Processes. *Experimental Aging Research* 18, 1:33-39.

Kovach, Robert C., Jr., Michael A. Surrette and Michael G. Aamodt. 1988. Following Informal Street Maps. *Environmental Behavior* 20, 683-699.

Levine, Marvin, Iris Marchon and Gerard Hanley. 1984. The Placement and Misplacement of You-Are-Here Maps. *Environment and Behavior* 16, 2:139-157.

Lynch, Kevin. 1960. *The Image of the City.* Cambridge: M.I.T. Press.

O'Neill, Michael. 1991. A Biologically Based Model of Spatial Cognition and Wayfinding. *Journal of Environmental Psychology* 11, 299-320.

Paivio, Allan. 1986. *Mental Representations: A Dual Coding Approach.* New York: Oxford University Press.

Passini, Romedi, Andre Dupre and Claude Langlois. 1986. Spatial Mobility of the Visually Handicapped Person. *Journal of Visual Impairment and Blindness*, October, 904-907.

Passini, Romedi, and Guylene Proulux. 1988. Wayfinding Without Vision. *Environment and Behavior* 20, 2:227-252.

Passini, Romedi, Guylene Proulux and Constant Rainville. 1990. The Spatio-Cognitive Abilities of the Visually Impaired Population. *Environment and Behavior* 22, 1:91-118.

Peponis, John, Craig Zimring and Yoon Kyung Choi. 1990. Finding the Building in Wayfinding. *Environment and Behavior* 22, 5:555-590.

Rasmussen, Jens. 1983. Skills, Rules, and Knowledge; Signals, Signs, and Symbols, and Other Distinctions in Human Performance Models. *IEEE Transactions on Systems, Man, and Cybernetics* 13, 3:257-266.

Russell, James A., and Lawrence M. Ward. 1982. Environmental Psychology. *Annual Review of Psychology* 33, 651-688.

Schwartz, Neil H., and Raymond Kulhavy. 1981. Map Features and the Recall of Discourse. *Contemporary Educational Psychology* 6, 151-158.

Southworth, Michael. 1990. City Learning: Children Maps and Transit. *Children's Environments Quarterly* 7, 2.

Thorndyke, Perry W., and Barbara Hayes-Roth. 1982. *Cognitive Psychology* 14, 560-589.

Thorndyke, Perry W., and Cathleen Stasz. 1980. Individual Differences in Procedures for Knowledge Acquisition from Maps. *Cognitive Psychology* 12, 137-175.

Vanetti, Eric J., and Gary L. Allen. 1988. Communicating Environmental Knowledge. *Environmental Behavior* 20, 667-682.

Zimring, Craig M. 1981. Stress and the Designed Environment. *Journal of Social Issues* 37, 1:145-171.

3 Possible Design Approaches for Smart Transit Information Systems

The SmartMaps information system connects often divergent branches of technology. Providing more than the advantages of simple interactive maps, SmartMaps technology responds to the user. Because each user has different needs, presenting information in only one manner would be insufficient. SmartMaps creates customized route maps, electronic advertisements, auditory maps, visual simulation maps, as well as textual information. The system can use a single enabling technology for dissimilar purposes. SmartMaps can customize the manner in which it presents data to suit the disparate populations for which service is intended.

This chapter suggests possible capabilities of the SmartMaps system and the technological inputs that might be utilized to develop them. Examples of practical applications of SmartMaps technologies are included.

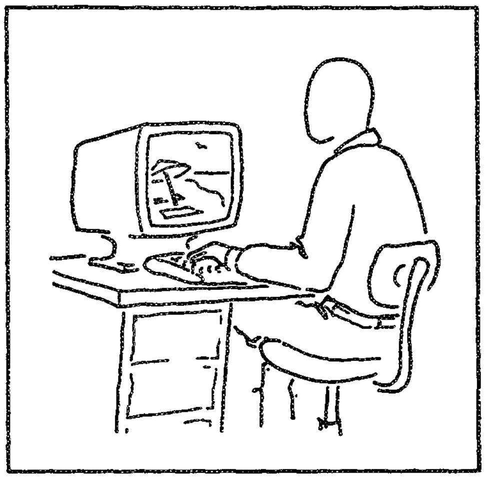
Customized Route Maps

Digital media offer distinct advantages over standardized, printed transit maps. In an attempt to be everything to every user, graphic transit maps heretofore have done too much and not enough: they have overloaded users with a clutter of excess information, none of it tailored to particular interests, needs, or abilities. To an extent, these counterproductive effects have been mitigated through the use of strip maps that depict only the route together with landmarks and points of interest. What makes the strip map comparatively effective is that it has been edited for the user, eliminating unnecessary, distracting stimuli. With modern telecommunications technology, it is now feasible to maximize this advantage by producing a customized, edited map for every use and every user, every time.

Enabling technologies might include video displays, touch screens, and compact laser printing units.

Scenario I: Using a touch-screen display of a transit map, Maria touches the place on the map representing her destination and the screen then displays a point-to-point strip map studded with pictographic renderings of landmarks and points of interest, with major intersections also depicted. Inquiry windows on the touch-screen permit interactive queries aimed at further customization of the map. At the touch of a point along the route map, the program responds with a multimedia tour showing, with still or animated captures and recorded voice and sound, places to go and things to do. A single hard copy of the map may be dispensed at any time, replete with a scrapbook of ground views. It *may be augmented by verbal route directions rendered in textual form, in any of a number of languages, or else conveyed by a recorded or synthesized voice. For the visually impaired, an embossed map with Braille inscriptions may be dispensed, augmented a moment later by voice instructions.*

Scenario II: Mark thinks there is nothing more relaxing than a trip to the beach at the end of long work day. He logs on to the SmartMaps system at his office to find a spot that he hasn't yet visited. After reading commentary and looking at the aerial views of some of the public beaches in the area, he finds one that sounds perfect. But the screen flashes a warning that rain is expected within an hour. He decides to brave it, and the SmartMaps system provides him easy transit directions to the beach from work.



On his way to the coast, a heavy downpour begins. He alights the bus at a shopping mall and spends some time perusing the stores. Because the rain keeps coming, he decides he'd better return home. He approaches a SmartMaps kiosk in the mall, enters his SmartCard, which is coded for his needs, and touches the square that says "home." He receives information on the appropriate route home, including the necessary transfers and the time the next bus will arrive. He also receives an alternative "rainy day" route, listing transfer points with sheltered waiting areas.

Advanced Transit Yellow Pages

"Yellow Pages" have been rendered electronically in the past and currently are on the market in digital form. Traditional Yellow Pages function primarily as directories of businesses accessible via telephone. Transit Yellow Pages can serve as guides to places accessible via public transit. Whereas telephone directories inform the decision to communicate, transit Yellow Pages can inform the decision to travel; moreover, with the much greater array of supporting information made possible by digital media, transit Yellow Pages might also issue travel directions and itineraries with maps and pictures, might offer real-time information on travel conditions and opportunities, and might provide a platform for on-line, transit-related transactions.

User interfaces might be located in kiosks at transit stations, on visual displays at transit stops, or through on-line or aerial services downloaded or downlinked via office-based, home-based, or portable processors.

Scenario I: At her office one morning, Carmen is informed that she must attend a late-afternoon business meeting across town. She would be free to travel straight home after the meeting, rather than returning to her office. She had been meaning to buy some wallpaper on the way home, but now that she will be returning another way, where to buy the wallpaper? She uses the on-line Transit Yellow Pages service on her office computer. Her initial inquiry: "Who's got wallpaper within a ten-minute detour of the most direct commute from Point A [the afternoon meeting place] to Point B [her home]?" The program tells her which stores carry wallpaper; tells her how to get to each of them; tells her how long it will take to get to and from each store and back home again. The program also points out that two of the proposed routes will take her within a three-minute walk of a free concert. She elects to go to ABC Hardware for her wallpaper, because that shop has caught her eye with its electronic advertisements, updated daily, promising discounts on wallpaper that week. The program renders a hard copy of her itinerary.

Scenario II: Alisa learns about the "private sale" on stereo equipment when she is at the SmartMaps kiosk earlier in the day. She has been looking for a compact disc player. This buy is hard to beat.

When she approaches the cash register to pay, she hands her SmartMaps card to the sales clerk. The clerk touches the card to a box on the register and a discount is taken. Meanwhile, other customers nearby are reciting their names and addresses for the sales clerks, but this information was automatically registered for Alisa's purchase.

Access to Multiple Databases

A SmartMaps system allows vast amounts of information to be sorted and retrieved by many users seeking very different types of information. Existing databases might be accessed to supplement what is provided to the user. Databases not traditionally represented by graphic means could be transformed. SmartMaps technology illuminates what otherwise would be complex data matrices. As an interactive and educational tool, schools may introduce programs that allow students to develop data sets for SmartMaps.

Scenario: A high school computer science class has been working on a project to develop a database for the SmartMaps Kids' Guide. Each student is researching information about youth-oriented programs and attractions in different parts of the city. As they obtain facts, they enter them onto the computer in the classroom. Ricardo has been gathering information on an experimental theater program that sponsors after-school activities. He has participated in their programs and believes other students interested in theater should know about them. A description of the theater program, which already *has its activities listed in the SmartMaps community calendar, is retrieved with ease by young people reviewing information submitted by other teenagers.*

Across town, Rachel has been investigating after-school drama programs using the SmartMaps system on her home computer. She reads Ricardo's description of the program and she knows it's the one for her. SmartMaps identifies the bus routes from her school to the theater, and a different route for the ride home. Because Rachel sometimes assists her teacher with a SmartMaps project after school, the system details the last possible bus she could board to reach the theater in time for the program.

Auditory Maps

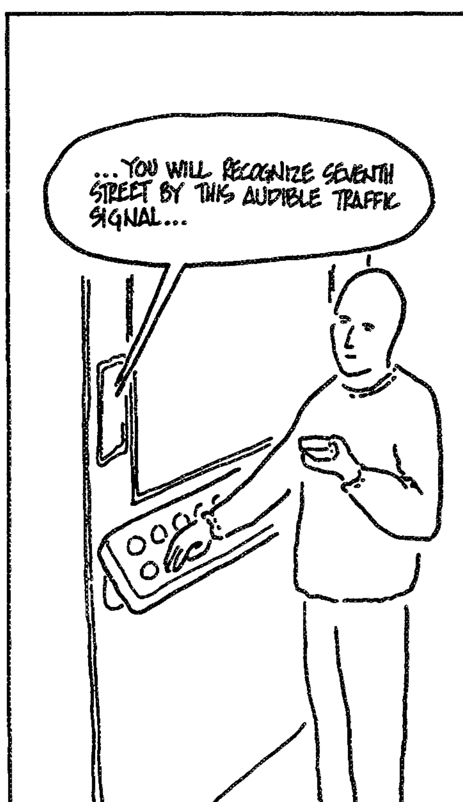
The process of wayfinding can be facilitated by the introduction of auditory information in addition to, or else in substitution for, visual stimuli. Digital multimedia can provide this auditory component. Auditory information can be useful in at least three wayfinding applications: (1) to augment multimedia wayfinding systems; (2) as the principle medium of wayfinding systems for the visually impaired; and (3) as a wayfinding medium for those whose literacy is limited. Our dwelling places are sonic, as well as visual environments, and most of us interpret them audio-visually. Electronic multimedia can restore the sonic dimension to wayfinding systems whose effectiveness heretofore may have been limited by a reliance on information rendered only visually.

Stereophonic peripherals can be used to produce the effect of directional sound, to help orient and guide the wayfinder. The addition of an auditory component provides advantages over purely visual communications, in part because the mind processes auditory stimuli independently of visual and motor stimuli, so that users can listen to some sounds while viewing and doing other things. The multimedia, multi-sensory result is a "thicker" simulation. Even without visual components, auditory maps can provide the visually impaired with relatively dense descriptions of place and location. Informative sounds can include spoken language, incidental noises occurring in the natural and built environment, and synthetic sounds created for effect (e.g. the wholly unnatural sound of a police siren, engineered to alarm the hearer). In some applications these elements may be used in combination to create a rich, auditory description independent of visual media.

Enabling technologies might include multimedia kiosks or flat visual displays with stereophonic speakers; Braille relief printing and Braille keyboards, touchscreens, voice synthesis, multimedia, global positioning systems, hand-held communications devices, or voice recognition.

Scenario I: *Charles, who is blind, has arrived by train at the new Sacramento intermodal station, and wishes to get to the State Department of Rehabilitation, at 8th and K streets, via public transit. At the station a noisy* *kiosk announces in a loud voice, recorded in five languages, that it can dispense travel assistance to the blind. Charles makes his way to the kiosk, comes in contact with its outer frame, and thereby activates a talking touch-screen. The screen asks the same question again and again, but in different languages: "Touch me if you wish to hear Cantonese...Touch me if you wish to hear Spanish...Touch me if you wish to hear Hmong..." Charles understands English, although he speaks it with a strong Hungarian accent. As soon as he hears the question put to him in English, he reaches for the screen. The screen responds with a few recorded instructions:*

The vibrating knob at the middle of the screen represents your present location...the three smooth ridges define our light rail lines and the sharp ridge represents Amtrak, while the grooves represent streets, wide grooves for big streets, narrow grooves for small ones...The bumps are transit stops...When you touch any of those bumps I will tell you the name of the bus or rail line, and the name of the stop...Hold a finger on any bump for a few seconds to designate your destination...press hard on the bumps only if you wish to hear a detailed description of the place you are touching.



Charles touches a number of the bumps on the screen, eventually recognizes the names of some places near his destination, and then finally zeroes in on one of the K Street stops, one close to a 10th Street stop. He presses hard on that spot. The recorded description tells him, among other things, that that is the stop nearest the Department of Rehabilitation. He holds his finger on that spot for a moment, to designate it as his destination. A recorded message gives him directions for the best route. At the outset, the talking screen had pointed out that the kiosk was also equipped with a Braille keyboard and with English-language voice recognition, either of which could be used to serve him more efficiently. But Charles cannot read Braille, and knows that his accented, laborious English would confound the voice recognition device. He does, however, take the extra precaution of recording the final route directions on an inexpensive microcassette recorder he keeps with him for notetaking purposes.

Scenario II: Diego recently immigrated to the United States from Mexico. He is astounded by the unfamiliar words and sounds in his new country. Friends have outlined very clearly the train and bus routes he must take to and from his new job at a small warehouse. Following work one day, he heeds a coworker's advice and wanders several blocks to a nearby market. After shopping, he exits the other side of the market and finds he is at the doorway of an unfamiliar train station. He recognizes a talking kiosk like the one a friend had demonstrated only a few days earlier. He watches an animated finger move over a choice of flashing squares on the screen. Recognizing Spanish, he touches the appropriate square. Simple spoken directions in Spanish accompany a transit map display, where he sees the name of the station where he normally disembarks. He touches the flashing circle by the station on the map. The voice informs him that he can take a train directly from this station. Step-by-step directions on how to get there are provided in Spanish. Before he walks away, SmartMaps prints a personalized transit map of his route in Spanish.

The voice also informs him that he may dial the telephone number printed on the map if he would like to speak with someone in Spanish about using the SmartMaps system or to obtain a user code.

Data Presentation Adapted to the Needs of Special Populations

By entering personal data into the SmartMaps system, the system can respond to the individual user. The equipment can adjust the manner in which it presents information. For young users, the system can operate much as a familiar video game might. Animation and surprising sounds can accent the information that is presented. For elderly users, simplified easy-to-read display screens can present information drawn from a range of community service databases.

Scenario I: Although he retired from his job nearly twenty years ago, Larry volunteers in many communities around the city. Before he leaves his home, he uses the SmartMaps system from his personal computer to provide pictorial displays and spoken directions of his route. Because he has some difficulty walking, and his hearing and vision are not what they used to be, he has coded his access card to request larger and more contrasting type and louder spoken messages. He always gets information on the most direct route to his destination.

While at a volunteer site one afternoon, he is told of a free health screening clinic for senior citizens somewhere nearby. He would like to attend, but nobody knows exactly where it is. After leaving, he approaches a SmartMaps kiosk and enters his SmartCard. The volume of the speaker instantly rises and *a bold, high-contrast typeface appears on the screen. After touching the screen a couple of times, a neighborhood calendar for senior citizens informs him of the local activities. He touches the square next to the listing for the health clinic. He is informed that it is at the shopping center only a few blocks away. Clear directions are printed out for him in a dark, bold typeface. They include the locations of three benches along the way where he can rest, if necessary.*

Scenario II: *Although she is only 12-years old, Bethany rides the bus and train by herself very often. Hesitant at first, her parents are now confident that she knows her way around the city and has access to the SmartMaps information system in many locations. When she touches her SmartCard to the magnetic reader on the SmartMaps kiosk, a colorful, youth-oriented display appears.*

Transit information isn't the only thing she gets from SmartMaps. Bethany uses the system to find out about youth activities, consumer tips for young people and after-school job listings. And she doesn't mind finding out about the SmartMaps discounts that will make her weekly allowance go a little farther at some of her favorite stores in the neighborhood. It's no wonder all of her schoolmates have SmartMaps cards: the system is informative and fun to use.

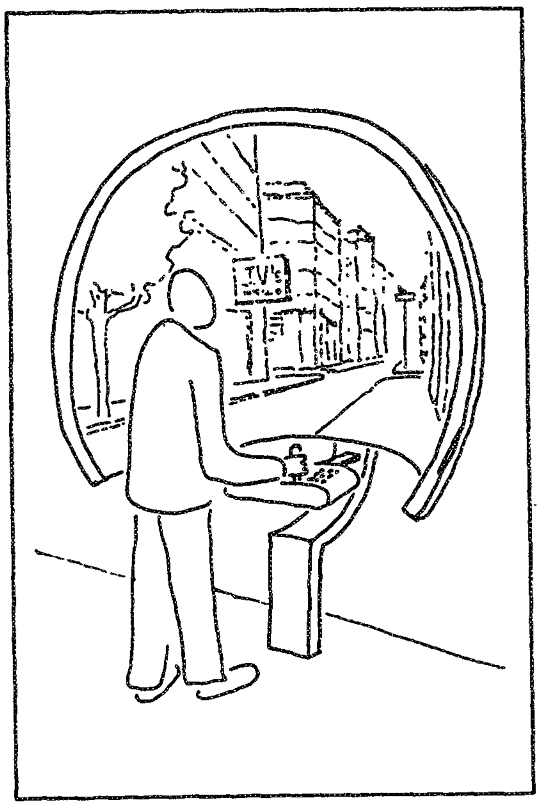
User Tracking

Voice mail systems, cellular communications devices, and personal beepers have permitted individuals to communicate their locations with one another. Because SmartMaps kiosks would be tied to their geographic locations while connected to a centralized data system, a means for tracking transit ridership can be developed. Furthermore, individuals would be able to communicate their location to other users by providing them with their personal access code. Of course individual rights to privacy must be respected, but in certain situations tracking might be justified, as when parents want a sense of when and where their children are traveling. User tracking enables the interactive nature of the system to provide information to users about users.

Scenario: *Amy and Ken were supposed to meet for lunch at a downtown plaza. Ken has been waiting several minutes when he remembers that Amy said she would sign on at a SmartMaps kiosk if she was running late. Ken walks to a nearby kiosk and enters his SmartCard. Because Amy told him her code, he checks to find out the time and location of her last sign-on. He learns that her SmartCard was entered fifteen minutes earlier at a rail station across town. The next train from that station left three minutes later and arrived very nearby two minutes ago. He turns around to find Amy laughing and holding a lunch bag.*

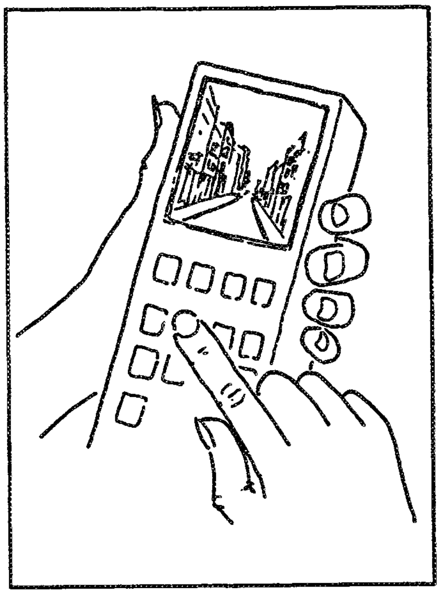
Walk-through transit maps would permit users to navigate through digital representations of real spaces as they might be encountered by pedestrians or via surface transportation. Maps of this kind could inform the decision to travel, could assist in route planning, and could increase familiarity and comfort with the transit mode and destination in the most direct manner possible: by giving the traveler a personalized simulation, a vivid foretaste, of the prospective trip. Because this "pre-trip" would be taken electronically, the user could receive, interactively, not only simulations of spaces but also spatially-referenced information, such as travel conditions and opportunities.

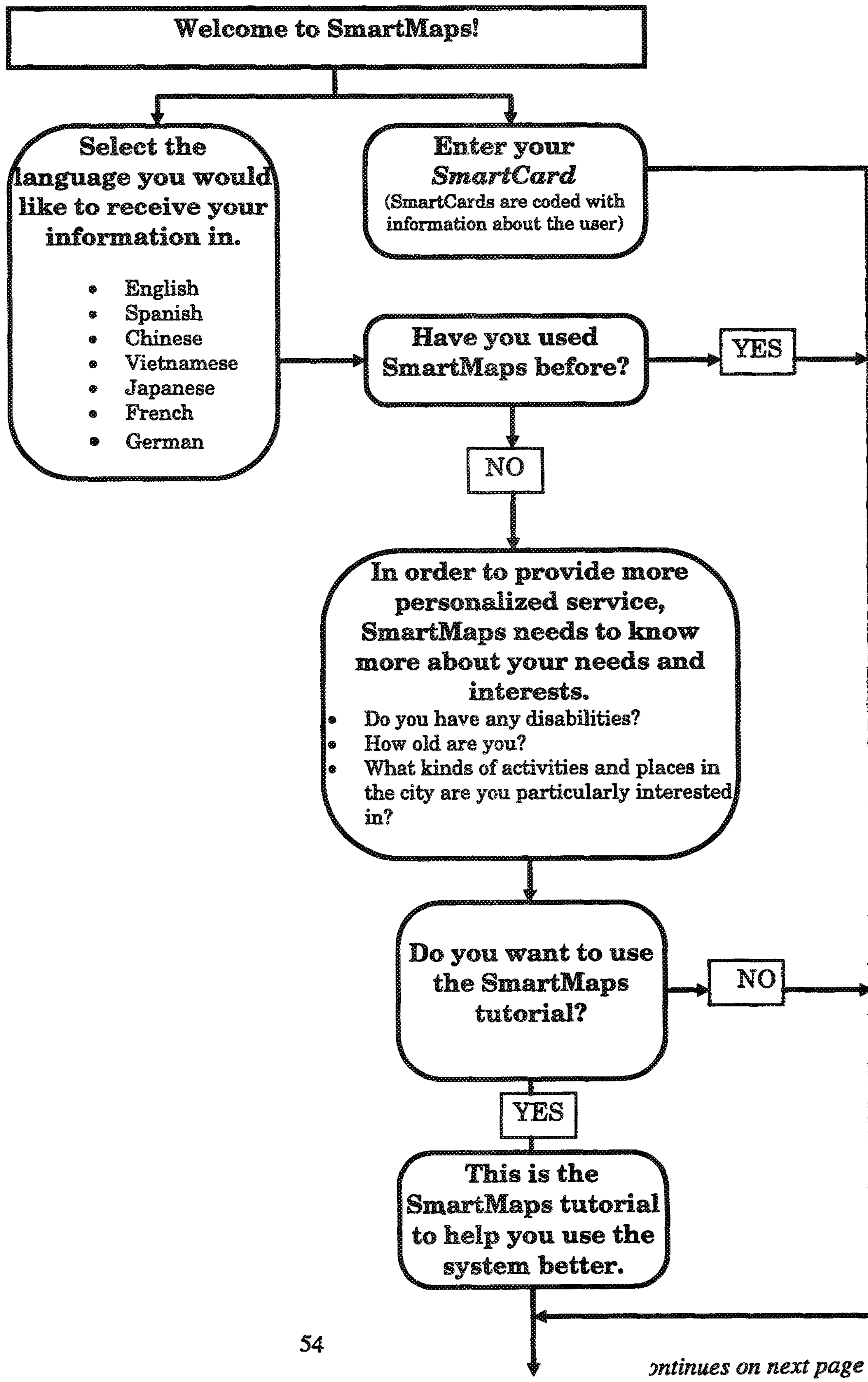
Enabling technologies might include quick-time animation and advanced multimedia simulation programs, geographic information systems, and hand-held telecommunications devices.



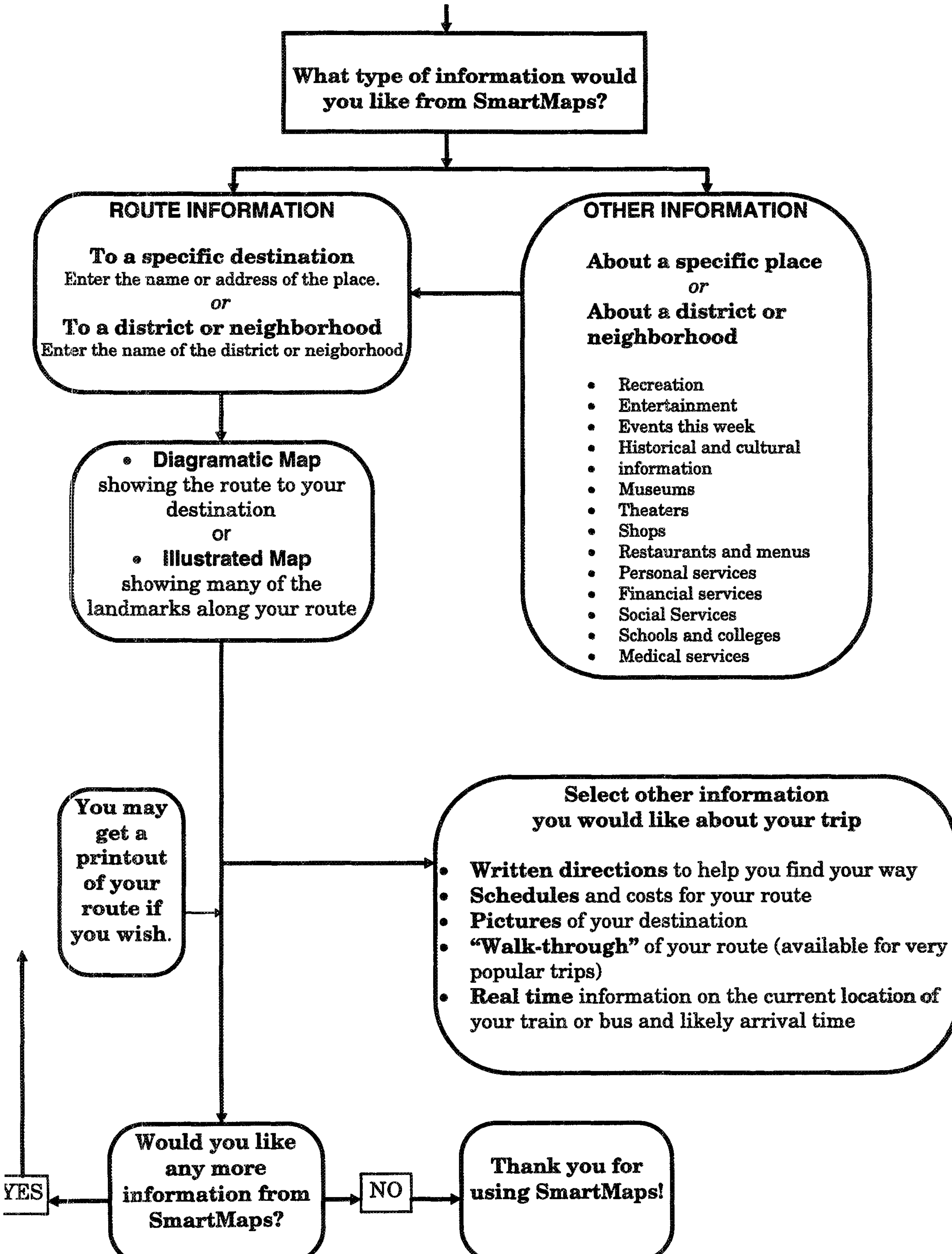
Scenario I: Ted, a prospective traveler, approaches an information kiosk in a transit station. A CRT displays an eye-level view of an actual streetscape. By touching a joystick (or mouse, or track-ball), he activates the program and the images before him unspool: distant buildings and trees come smoothly into view and enlarge with enhanced definition, while "nearby" images pass beyond the periphery. As he manipulates the joystick he finds that he can zoom, pan, tilt, rotate, or fly over the simulated spaces. In effect, he is traveling through the modeled environment, controlling path, speed, angle of approach, and scale. In addition, touch-screen windows permit him to make inquiries to which the program responds with text and/or with voice synthesis.

Scenario II: Rhonda arrived on a flight from Philadelphia and looks forward to spending a few days in town. She stops by the SmartMaps information desk at the airport, obtains a user code and rents a SmartPak -- a hand-held, personal SmartMaps device. She inserts her SmartPak into the slot on the front of the SmartMaps kiosk and enters her code. She provides the name of the hotel where she is staying, as well as what she would like to do while in town. Information is downloaded to her personal SmartMaps device. When it is complete, she puts on her earphones and looks at the small display screen on her SmartPak. Rhonda is greeted by a voice welcoming her to the city. A range of bus, limousine and taxicab options to take her to her hotel are listed on her screen. After she drops off her luggage, her SmartPak guides her on a simulated walking tour. She wanders by the pictured buildings along her way to an Ethiopian restaurant the SmartMaps system recommended to her.





ɔntinues on next page


What type of information would you like from SmartMaps?
ROUTE INFORMATION
To a specific destination
Enter the name or address of the place.
or
To a district or neighborhood
Enter the name of the district or neigborhood
OTHER INFORMATION
About a specific place
or
About a district or neighborhood
• Recreation
• Entertainment
• Events this week
• Historical and cultural
• information
• Museums
• Theaters
• Shops
• Restaurants and menus
• Personal services
• Financial services
• Social Services
• Schools and colleges
• Medical services
• Diagramatic Map
showing the route to your destination
or
• Illustrated Map
showing many of the landmarks along your route
You may get a printout of your route if you wish.
Select other information you would like about your trip
• Written directions to help you find your way
• Schedules and costs for your route
• Pictures of your destination
• "Walk-through" of your route (available for very popular trips)
• Real time information on the current location of your train or bus and likely arrival time
Would you like any more information from SmartMaps?
YES
NO
Thank you for using SmartMaps!

4 Current Technology and Applications

MULTIMEDIA AND MULTIMEDIA INFORMATION KIOSKS

Multimedia, or interactive media refers to the capacity to combine multiple media--text, graphics, sound and video--through computers to create interactive presentations.

Multimedia are not a product, not even a technology. We can better think about it as a platform: a combination of hardware and software elements that together support an environment of multisensorial information.

Multimedia use the computer to integrate and control electronic media as computer and TV screens, CD-ROM drives, videodisk drives and voice and sound synthesizers. If we make logical connections between these elements and make the whole package interactive, we will be working with *hypermedia*, although multimedia has outgrown its basic concept to cover both under its name. So now multimedia defines as many information branches as possible so the user has more feasible ways to get the information s/he needs. This is done using what is called *Hypertext-like* links.

Most of the information management systems today are based in directories that have sub-directories that contain files. These files consist of text in the form of characters. This way of storage and access is called *linear* and is enough for everyday work with computers.

As computers became cheaper, more powerful and more accessible, many new possibilities have emerged and permit the extension of the traditional "flat" files to more complex organizations--or access ways--of information. We now have mechanisms that allow computerized references from one piece of text to another as well as new interfaces that allow us to interact directly with those pieces and to set new relations between them. As a result of these advances, traditional *text has evolved into the general category of hypertext, also known as non-linear text.*

The word *Hypertext* was coined by Ted Nelson, a pioneer in the field, who described it as "*a combination of natural language text with computer capability of interactive branching, or dynamic display...of a non linear text...that cannot be conveniently printed in one page.*"

The hypertext idea is relatively simple: Information is displayed in windows on the screen. These windows are associated with objects in a database and connections are provided between these objects in both ways: graphically (as labeled items) and in the database (as pointers). The essence of hypertext is *connections* (both, into a document and between documents). This connection capability is the one that permits a non-linear text organization. An additional characteristic of hypertext systems is the large use of windows that have a correspondence one to one with the nodes in the database.

The process of moving between these nodes and objects inside the database is called *navigation*. For us to be able to navigate in a multimedia database, *multimedia material* is needed, and the process of using multimedia applications to create multimedia materials for others to view is called *authoring*. Multimedia authoring utilizes a wide variety of tools, from the more familiar text editor to tools for capturing and manipulating video images or editing audio files. Over time, more and more people will probably have some level of multimedia authoring capability.

SmartMaps Multimedia Features

Let us imagine a tourist or any person new to the city who wants to visit an interesting point in the city and doesn't know how to get there. S/he goes to a **SmartMaps Multimedia Information Kiosk** (SMIK) and asks the computer, in her/his native language the way to go there. The computer gives her/him not only the best way to go --walking, by bus or by subway--but also gives the schedules of buses or subways needed to reach places. Moreover, it provides real-time locations of vehicles. It can give a map with the path highlighted, both as a drawn plan or as an aerial photo, and it may play a video on how to get there. Based on the user profile mapped on the user's SmartCard, the SmartMaps computer suggests places near the one the tourist is going, show views of these places, suggest restaurants and show their actual menus, even make reservations!

If the tourist has not decided where to go, the computer may make a whole tour guide through the city or parts of it using the touristic or professional interests of the user and including where to have meals, depending on the tourist's budget and interests. So any user--artist, architect, soap-opera fan, sports fan, gourmet and so forth--may get a special tour defined specially for her/him.

Of course, the computer may give a printout with all needed information. Even selected shots of the videos, comic strip style, so the tourist will not be lost.

This is no fiction --all the aforementioned and more can be stored and retrieved by a computer using multimedia technology. A partial list of what a SMIK can give to an user might be:

- All information in the user's selected language
- A plan of where you are, with surrounding blocks showing touristic interest sites
- The distance from where you are to the place you want to go
- The best way to get where you want to go, using public transportation

- Schedules for these public transportation systems, as well as real-time locations of the vehicles

- The time and place to take the next bus that goes where you want to go

- A plan with the path to where you are going, in case you want to go walking

- A video of the path

- Addresses and views of other interesting sites in the area

- Guide to restaurants in the city including their specialties and price ranges

- A tourist guide according to your interests and budget

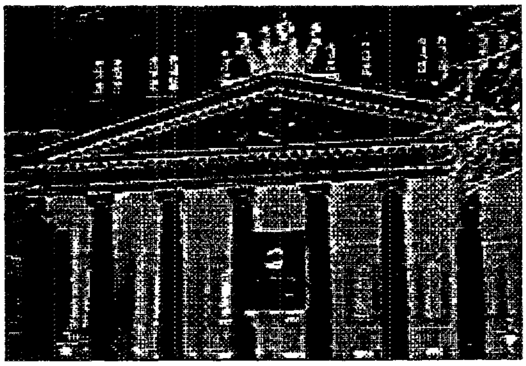
- Printouts of all information, using comic-like strips of views for the videos

- Selected video tours

As an example, the following printout may be given by a SMIK:

You are at the SmartMaps Multimedia Information Kiosk at the corner of **Market and Bolívar**, five blocks east from Washington Square and you want to go to the **Opera House** on **Main Street**. It is 5: 26 PM on Wednesday, June 14, 1995.

You have enough time to walk one block north on this side of Market (north is in the direction of the red pipe sculpture by Jonas). Turn right on Jackson Street and 50 feet East from the corner of Market, you will wait for **Bus 8**, (it is 95 cents, exact change). Please note that you will not cross any street. You will leave the bus at the stop after Main street. You will know it is Main because there is a high silver skyscraper and a plaza with fountains on the corner of Main and Jackson. From the bus stop you will walk one block south on Main to the Opera House. You can't miss it--it is majestic, has a sculpture on the top and a big flag between the two center columns, as you can see in this view:



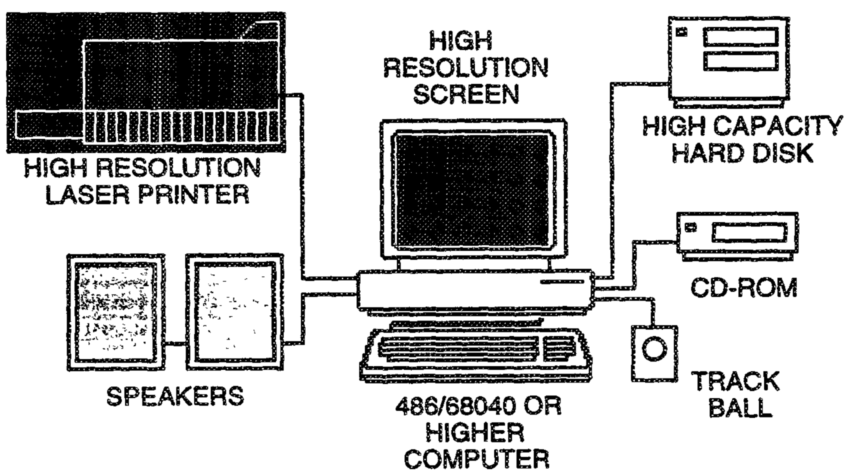
We hope you enjoy your visit to the Opera House. After the concert you may have coffee or tea and cookies in one of the three small cafes that are across the street: *London*, *Eclipse* and *Siberian*. All of them are in the same price range, about five dollars for coffee and cookies for two.

SmartMaps Kiosk: Equipment Required

Although many things can be done by a SmartMaps Multimedia Information Kiosk, in itself it is not large and does not have a lot of equipment. With miniaturization and wide use of computers, all the necessary equipment for the aforementioned features of a SMIK is compact and of a relatively low cost. The size of the equipment varies little regardless of the quantity of information to be stored in any given SMIK.

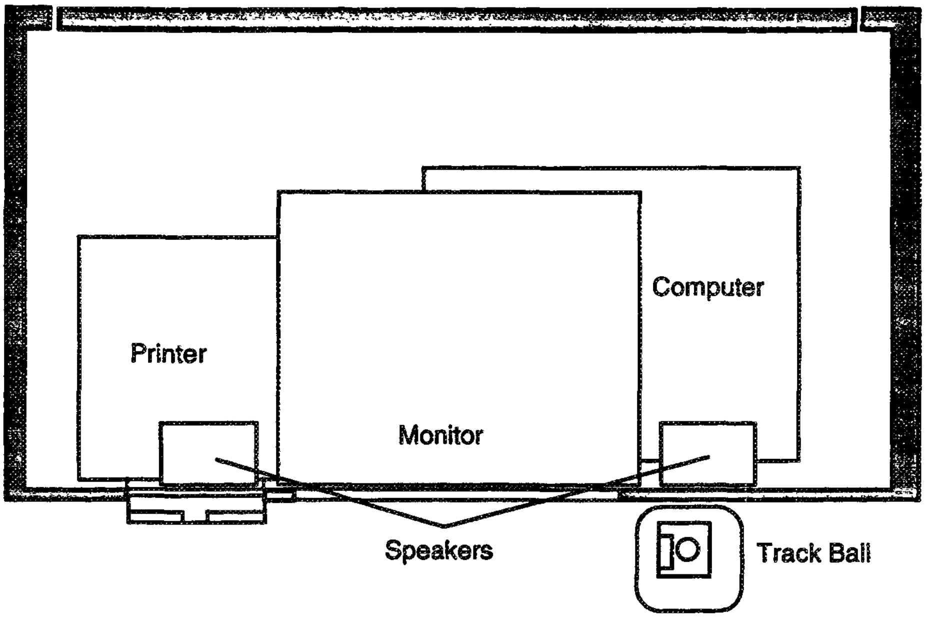
The suggested equipment for a SMIK consists of:

- A fast computer (486 or higher PC compatible or 68040 or higher Macintosh®)
- High resolution color computer screen, not less that 15 inches diagonally
- Large size hard disk (1.5 gigabytes minimum, depends on the quantity of related information)
- CD ROM/CD ROM changer (depending on quantity of information)
- External speakers
- Track ball or touch sensitive screen as a pointing device
- High resolution printer

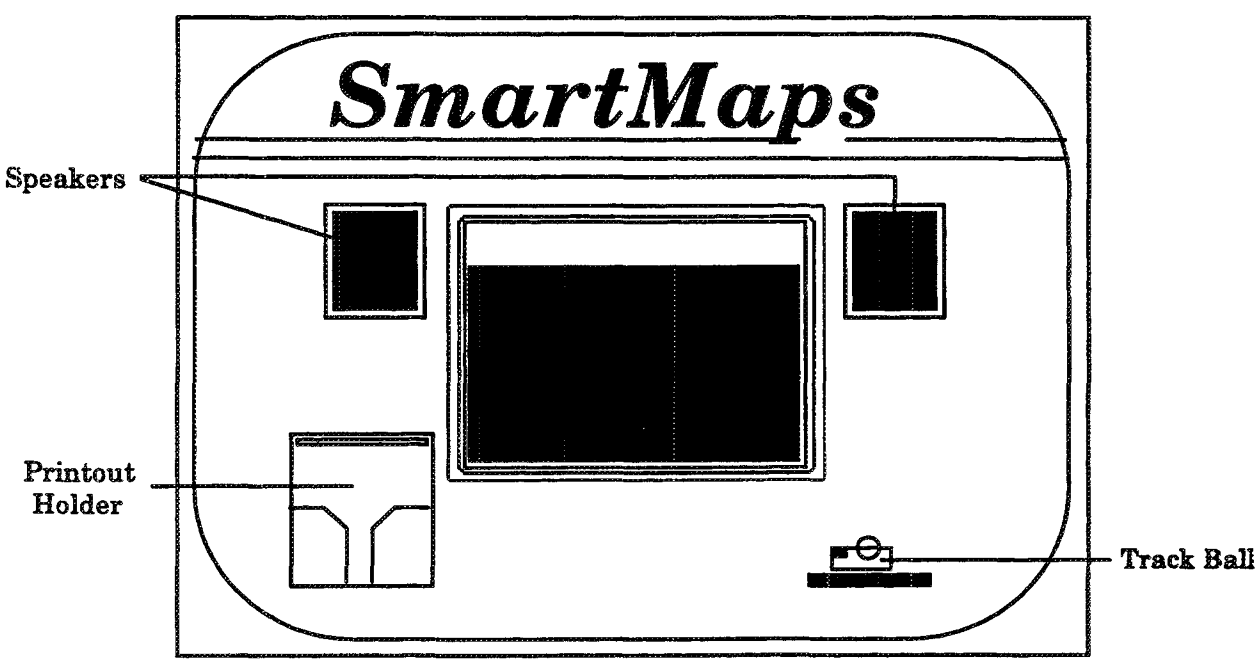


Suggested equipment for a SMIK.
Both hard disk and CD-ROM can be installed inside the computer.

All this equipment set into the kiosk might look like this:



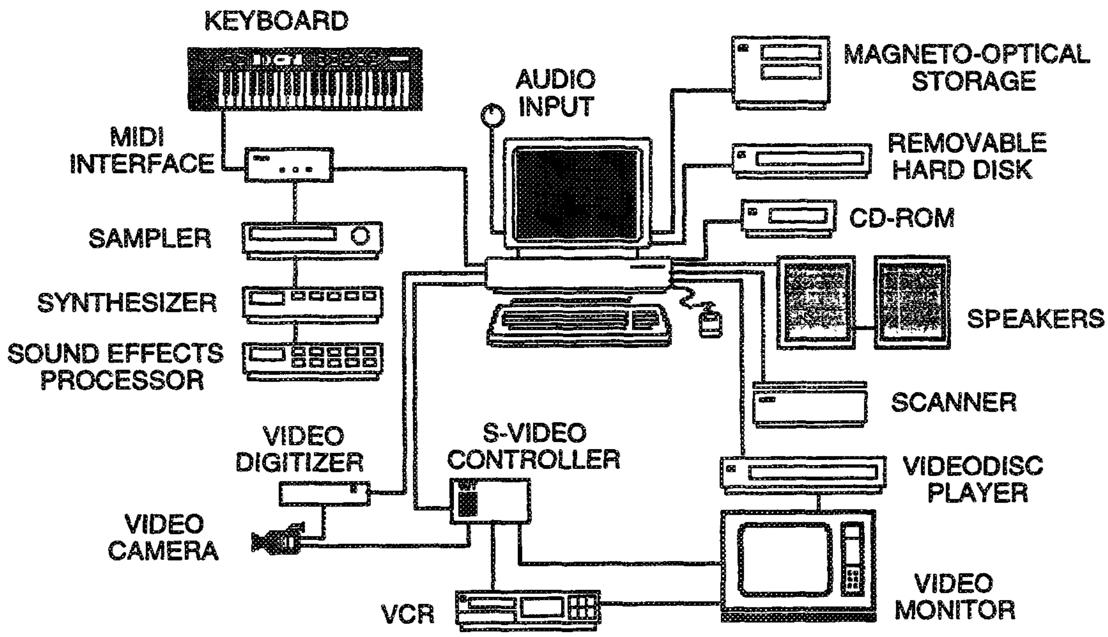
Plan: SmartMaps Multimedia Information Kiosk



Front View: SmartMaps Multimedia Information Kiosk

Authoring: Equipment Required

For the SmartMaps Multimedia Information Kiosk to work, an application for navigating within the database is needed. This application must be developed using authoring software running in more complex equipment. The computer may be high-end 486 PC or 68040 Macintosh® although Pentium® or Power PC® based computers are recommended. Special input/output devices are required: image and video scanners, S-video controller for videodisk player, VCR and video camera; voice and sound digitizer, and MIDI interface for high quality sound generated by synthesizer, sampler and sound effects processor. High capacity storage is mandatory for this equipment, as magneto-optical and removable hard disks.



Suggested equipment for Authoring a SmartMaps Multimedia Application.

Software

The computer equipment cannot work without application software. In addition to the authoring software for developing the necessary multimedia application, video digitizing and editing, image processing, sound digitizing, and editing and word processing software are required. Commercial applications for all these tasks can be found for both PC and Macintosh® environments.

Nevertheless, one special application must be developed for the main task of the SMIK, that is, the calculation of the optimal paths from one place to another, and for searching the database for bus and subway schedules. After users have stated a travel plan and modal criteria, the system will select the optimal travel plan utilizing available modes meeting the criteria. The algorithm will be full A to B through all modes including ride sharing.

EXAMPLES OF CURRENT APPLICATIONS

Although no existing applications perform all of the functions envisioned for SmartMaps, several examples illustrate certain aspects of the proposed system.

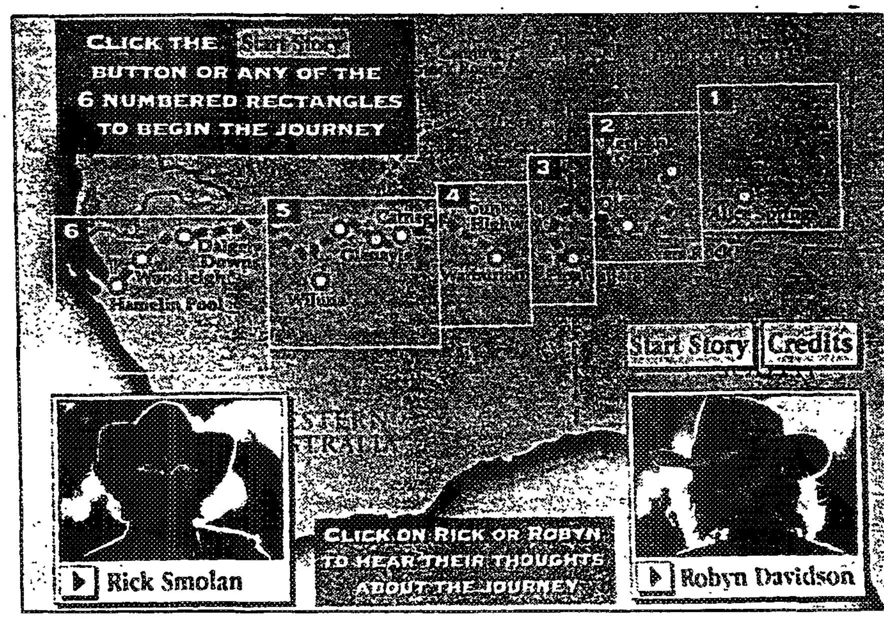
US Geological Survey Interactive Seismic Information Kiosk

This kiosk, developed for educational demonstration purposes, is a multimedia system utilizing sound, text, maps, diagrams, and photographs containing one video monitor with a touch sensitive screen. It displays information on Bay Area seismic conditions using maps, aerial photographs, charts, diagrams, and text. The user selects from a menu the geographic area and the type of information desired from a menu. The system then displays the area map. Users may take a stop-frame fly-over trip above the fault selected and may also call for various types of information relevant to that location. It provides detailed information on the 1989 Loma Prieta earthquake. Users may fly over the exact location of the Loma Prieta earthquake and see its distance below the earth's surface, as well as the series of minor earthquakes that occurred before and after the large quake are displayed. The user can select different fly-throughs to better view the epicenter. The system uses software from VistaPro, a graphic landscaping program, to show the location of the Hayward fault, as it progresses through East Bay cities. Digitized photographs, overlaid with graphic images, help interpret the fault. Digitized photographs also illustrate earthquake damage in different locations throughout the Bay Area. One can see the activity of this fault--as well as faults throughout the world--as it is updated each day through modem connections to the USGS. The touch sensitive screen and use of photographic and graphic information make this a very user-friendly system.

From Alice to Ocean, A Multi-media Interactive Walk Across the Australian Desert

After photographer Rick Smolan authored the coffee table book of Robyn Davidson's trip across the Australian desert, *From Alice to Ocean*, he decided to create a multimedia CD-ROM version. The result is a state of the art product consisting of his own photographs, video clips, computer generated graphics, and narrations, including Davidson reading from her own account of the trip, *tracks*. The interactive aspect of the program allows viewers to either sit back and look at Smolan's photographs while listening to Davidson's story or, by clicking a mouse, select a side trip, like an essay on Australian cultures or natural history or a behind the scenes view of Smolan's photographic techniques.

Multimedia productions involve many different skills, such as writing, graphics, film direction, musical arrangement and, of course, writing software to coordinate all of the different elements. However, the production of *From Alice to Ocean* was, according to Smolan, made possible by an off-the-shelf software tool called *Director*, developed by Macromedia. At present Macromedia is at the core of the nascent multimedia market, providing tools that allow individuals with no programming skills to produce sophisticated productions.



Source: *New York Times*, September 19, 1993

Telemap

Telemap is a service in Orlando, Florida offered by a joint-venture between Wayfinder and Sprint/United Telephone-Florida. The service provides driving directions electronically through pay phones. A caller inserts a credit card, calls the service, and then enters the telephone number of the desired destination. Then a computerized voice gives detailed directions including distances. Some sites are being equipped with fax machines offering printed directions.

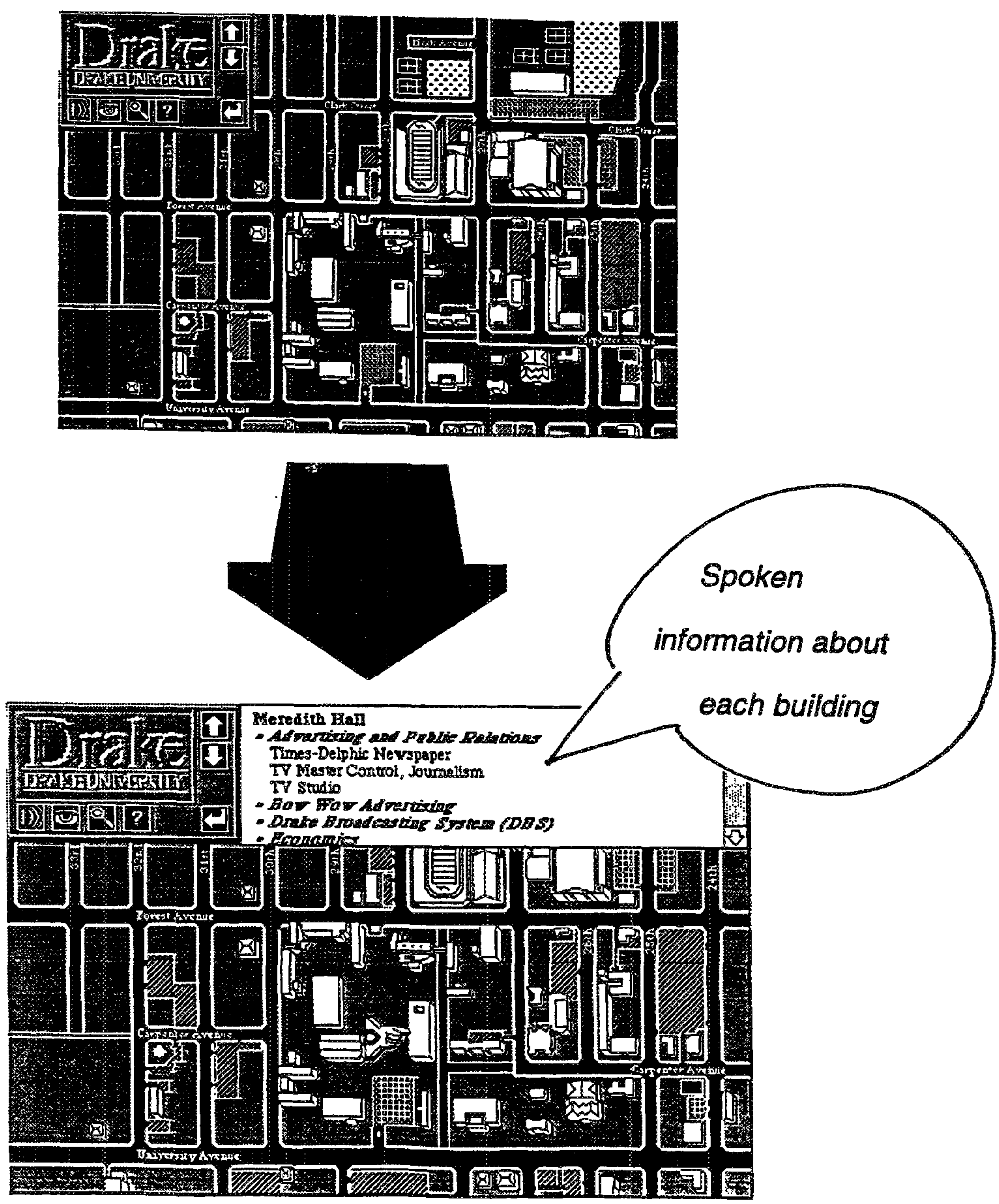
Automap

Automap Road Atlas for Windows is a route planning program available for personal computers. The database includes over 400,000 miles of freeways, highways, and state and county roads. The program will plot a color-keyed route on a map and provide printed directions. A scenic route can be planned, and parks, lakes and historic sites can be superimposed on the map to assist planning. In addition, the program calculates distances, travel times, and gas consumption.

Source: Schuon, Marshall. August 15, 1993. Sex, Maps and Videotape, *The New York Times*.

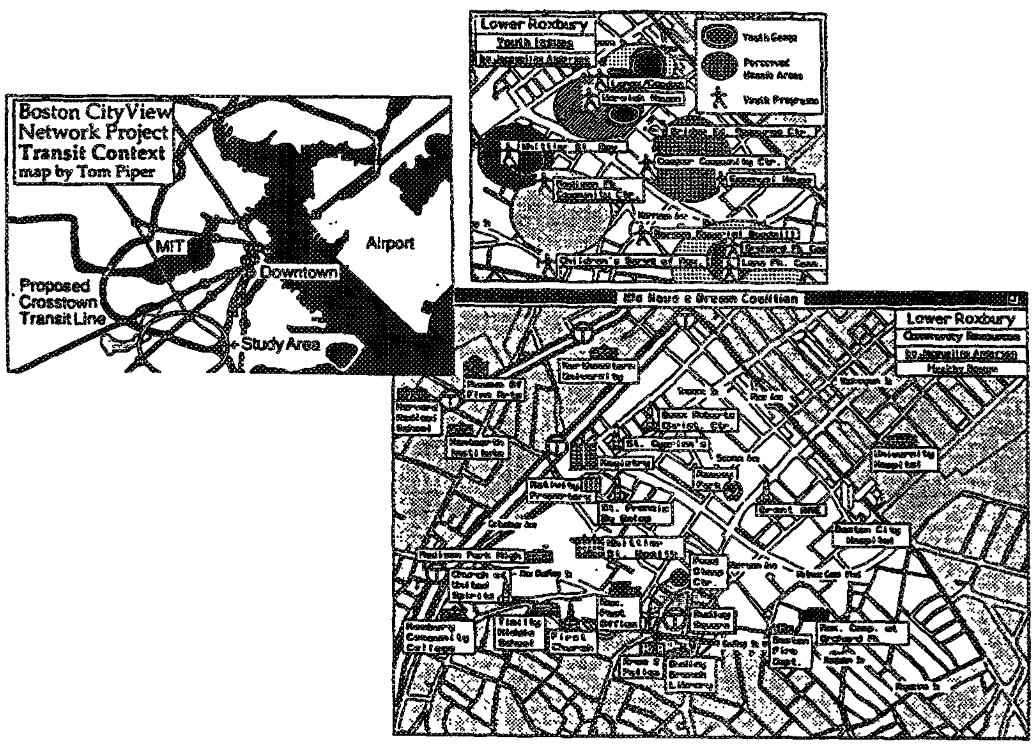
Drake University Interactive Geographic and Auditory Map

This interactive campus orientation map provides both textual and auditory information about each campus building. As the user points to buildings on the axonometric map, a text window appears describing functions in the building. At the same time a voice states the name of the building and its contents.



CityView Network

The CityView Network, sponsored by the Department of Urban Studies and Planning at MIT, attempts to use interactive computer maps and graphics as a participatory urban planning tool. The program allows "sketches" of the urban environment to be created and organized into separate overlays. "Then at the touch of a button, we are able to combine a choice of layers to study patterns and relationships." Additional information, such as photographs, charts, text, drawings, and video clips, can be called up by clicking on a particular site on the map. Those involved in the project expect that the interactive maps would facilitate citizen involvement in the planning process as well as assist planners in evaluating the citizen input.



Source: Barros, Barbara L. Spring 1994. Community Fellows Sponsor City View/Town View, *Changing Cities*, 16-17. Cambridge: Department of Urban Studies and Planning, MIT.

Smart Traveler Kiosks

As of July 17, 1994, 77 "Smart Traveler" kiosks have been installed in the greater Los Angeles area. The kiosks are multimedia touch screen operated information systems which can provide the traveler with a personalized transit route itinerary, a map which reflects the current freeway conditions within the greater Los Angeles area, and the opportunity to request an automated rideshare match. The transit and rideshare information, but not the freeway map, can be printed. The kiosks are also equipped with laser disks which can provide short videos on a variety of topics associated with Caltrans, transit, and ridesharing. All of this information is provided at no cost to the user.

These kiosks are part of a field operational test which will allow the Caltrans New Technology staff to gather information on system reliability, accuracy of information provided, user acceptance and impact on travel choices. This project is unique in that it is the first time an Advanced Traveler Information System has made available such diverse transportation information.

The field operational test evaluation is being performed by the University of Southern California. Preliminary kiosk survey data gathered by USC researchers indicates the following:

- In general, respondents find the kiosks easy to use.

- The most popular menu item is the Freeway Conditions Map, followed by transit information, the videos, and then the ride-match service.

- The majority of users would use the kiosks again. In fact, 86% of the users would encourage others to use a Smart Traveler Kiosk.

According to IBM, the deployment of the 77 kiosks makes the Smart Traveler the largest multimedia, interactive kiosk system in this country, and second only in the world to the *La Casha* system in Spain.

Smart Traveler Kiosk in a Downtown Location

LNX Systems Public Information Kiosks

LNX is a new, on-line public information system in Glendale, California. The system is accessible through colorful interactive kiosks or through personal computers with modems. The designers of the system acknowledge the widening gap between those with access to information and those without. The result is a system designed for the TV crowd rather than the computer user. The kiosks are designed to be fun and unintimidating, to encourage use by those unaccustomed to computers. Touch screens eliminate the need to be familiar with traditional computer input devices, such as keyboards and mice. They also allow direct interaction with the on-screen graphics.

LNX is more than a community bulletin board. A mix of public and commercial services are provided, with providers of commercial services paying a fee. Users can obtain information about local events and issues, public works activities, and public announcements, while being able to comment instantly. They can also conduct personal business, such as sign up for an art class, order concert tickets, or find a shoe store. By becoming registered users, individuals get their own E-mail address. In the spirit of equal access, registration is free.

Source: *LNX Systems Update*, Summer, 1993.

Shakespeare Project and Cicero

Some educators have discovered that the conventional classroom setting is inadequate for teaching particular subjects and see multimedia as a way to bring new life to learning. The Shakespeare Project and Cicero are two examples of using computer and video technology to teach the arts and humanities. The Shakespeare Project, directed by Stanford Professor Larry Friedlander, who teaches Shakespeare and acting, uses an interactive videodisk program to allow students to go beyond merely reading the text of a play. Students can view a play, study scenes in detail, create different versions of a scene, choose their own costumes, and discuss the play with the actors. As a prototype, the Shakespeare project has been considered a success and other developments are underway. Cicero is an interactive CD-ROM program developed by Professor Bernard Frischer, who teaches classics at UCLA. For students studying Roman Civilization and Intermediate Latin, the program provides a data base, including text and bibliographies, with a photo tour of a model of the City of Rome from around 200 AD. The text and other data can be linked with the model simulation, allowing students to individually explore the context of the particular item of interest. With this program students are encouraged to develop their own approaches to their assignments. The creators of these projects believe that interactive multimedia enlivens the experience of classroom learning.

Video Games

Several popular video games illustrate approaches to making spatial information understandable, accessible, and exciting for users. Relevant examples include SimCity, Hellcab, and Iron Helix. SimCity utilizes aerial axonometric views of urban environments including street and rail networks with moving trains. The user can zoom and scroll through the environment. Hellcab, a CD-ROM game, contains simulations of urban and architectural environments in New York City and allows the user to travel through them, using a stop-frame approach. The taxi driver acts as guide and speaks to the user. The user can make decisions about where to go and what to do at each location. It utilizes digitized photographic images of the attractions such as the Empire State Building or the Statue of Liberty. Animation with the digitized photos allows interactivity in each scene. Iron Helix, a CD-ROM game, simulates travel in the maze-like environment of a space ship. The user sees both a plan of the ship and eye-level walk-through views as he moves through the ship. The user navigates the ship through a set of arrow keys displayed on the screen and controlled by a mouse. The icon for the player in this map is a directional arrow that changes orientation in response to the player's commands. The view changes in accordance with the directions the player gives, zooming in and out, forward and backward, or panning left and right. Simultaneously, it displays a plan view map giving the location of the player in the ship. Sound effects intensify the experience.

The most advanced video games are those incorporating "virtual reality", such as Dactyl Nightmare and Gridbusters. These games attempt to create the experience of being in a place that exists only inside a computer. The player stands on a pod, wears a headset with speakers and video display screens placed about 4 inches from the eyes, and holds a pistol shaped control device. These attachments are connected to a relay device containing position sensors that the player wears as a belt. Cables from the belt connect the player to the computer. Within the computer there is a three dimensional model into which up to six players are transferred. The players movements and actions are simulated in the computer model in real time animation, while the computer relays to each individual, through eye level visual displays and sound effects, the results of the actions. The goal of each of the games mentioned above is to find and shoot the other players.

In spite of state of the art technology, virtual reality has serious limitations. In general, the simulation of a real world experience is hindered by sensory input often taken for granted in daily experiences. For example, the narrowness of the screen eliminates peripheral vision which plays a major role in our perception of space. In addition, the necessary equipment required for user interaction decreases the flexibility of the user. This is a severe limitation for applications such as SmartMaps, where public access and ease of operation are the goals of the project. Cumbersome and specialized equipment, such as belts and helmets, are neither practical nor desired.

A less sophisticated version of interactive, three dimensional video games, known as Battletech, has more relevance to SmartMaps. While conceptually similar to virtual reality games in that the player is transferred into a three dimensional model and interacts, i.e. finds and shoots, the other players, no attachments are worn. The player sits in a seat and controls her movement with a joystick and other controls. Eye level views of the model are displayed on a video screen in real time animation with sound effects. In addition, a small plan view similar to a radar screen shows the relative positions of other players. These games are not intuitive. The first-time user will have difficulty controlling movement within the computer space. However, the games are much more demanding than an urban information kiosk will be.

REFERENCES

Ambron, S. and Hooper, K. (Eds). 1988. *Interactive Multimedia: Visions of Multimedia for Developers, Educators & Information Providers".* Redmond, WA: Microsoft Press.

Bush, Vannevar. July 1945. As We May Think, *Atlantic Monthly Magazine*, 101-108.

Conklin, Jeff. September 1987. Hypertext: An Introduction and Survey, *Computer Magazine.*

Engelbart, Douglas. 1988. The Augmented Knowledge Workshop. in Goldberg, A. (Ed.): *A History of Personal Workstations*, 1087-1236. Reading, MA: Addison-Wesley.

Nelson, Theodore. 1980. Replacing the Printed Word: A Complete Literary System. in Lavington, S.H. (Ed.): *Procedures of the IFIP Congress 1980*, 1013-1023. Amsterdam: North-Holland Press.

5 Information Policy Issues

SmartMaps are being developed because there is a need to manage and provide the public with information. With the powerful computer networks available today we have better access to new forms of information in our jobs. In our homes, cable television and satellite communications enable us to view programming from around the world. Telephone companies and newspapers have provided their customers with dial-in recorded information systems, providing stock quotes, horoscopes and listings of local attractions.

In our journeys beyond the home or office, little has been done to facilitate our obtaining the information we require. On the streets we still rely on bus route maps. We try to plan the appropriate routes and transfers that will take us to our final destination. We dash to a telephone in search of a volume of Yellow Pages, but often we encounter in our search listings from geographical areas too vast to be of value. We telephone home to check our answering machines to determine whether a scheduled rendezvous will occur without having instant access to where the caller is located and the precise route that must be followed to arrive somewhere within an allotted time frame.

A system that would provide comprehensive information to meet our needs would simplify our tasks and allow us greater productivity. In our homes and offices, it is simply inconvenient to juggle the many tasks that must be completed to gather the information we need. When away from the home or office, a computerized transit information system might prove even more beneficial. SmartMaps is the tool to facilitate information gathering.

Not only does bringing data together in a SmartMaps system provide more information than we are accustomed to being able to access, but it also provides better information. Resources can target data to the user so she or he need not search lists, directories or maps brimming with superfluous facts. Data fed from on-line information networks can be the most up-to-date. Subtle changes in transit schedules can be registered instantly. Information from very different sources can be integrated into an accessible, compre-hensive system.

SmartMaps can improve the communication flow, providing access to the information highway with which so many people feel unconnected. Residents of communities with poor access to information will find their opportunities for knowledge improved. Efforts made by SmartMaps system designers to target low income populations allows the bridging of diverse data sources, providing access to information formerly unfamiliar not only to those individuals who rely on public transportation, but also the occasional rider. Communities that have had limited access to information due to higher illiteracy rates, coupled with an inability to afford newspaper subscriptions, televisions, or telephones, will find that vast amounts of information become accessible. By introducing practical new forms of technology to the public, tremendous educational opportunities are granted. Yet it becomes the responsibility of the system to provide information that is pertinent to the user.

With the many benefits of a SmartMaps system, questions of administrative policy and ethics are raised. This exploration of issues discusses information access, managing a SmartMaps system and ways to address system users. Hidden benefits and problems related to these issues must be considered.

INFORMATION

If the purpose of the SmartMaps information system is to provide a high-level information service, the data presented must come from many different sources. Government institutions, such as public safety departments, transit operations, and health agencies, will find SmartMaps systems a rewarding venue by which to reach the public they serve. Also, likely contributors to the databases would be nonprofit organizations, including arts and recreation institutions, social service organizations, and educational institutions. For-profit businesses would represent a significant proportion of the information available on the system.

While the SmartMaps information systems provide access for the user to many sources of information, the systems also provide agencies and businesses with access to their potential customers and clients. The combined data information systems can be of value for marketing strategies, such as mailing list development.

Developing an Information Base

To determine the types of information that might be included in a SmartMaps system, program managers might conduct surveys or focus groups of typical individuals who would use the system. Needs assessments should ascertain what information should be available and how it should be presented. Attitudes about developing a system that relies on the input of personal information should also be assessed. Large sampling populations may serve as a beneficial marketing tool.

SmartMaps administrative representatives could make presentations at community meetings to introduce the system to large numbers of people. Government officials, as well as representatives from regional agencies, business associations and advertising firms should also be consulted in the development process. Because the system must be adaptable as data sources expand, upgradable technology must be requisite in the development of SmartMaps information systems.

Public agencies and advertisers are not the only suppliers of data for the system. As an educational database, the very users who retrieve information from the system may also contribute to its resources. SmartMaps allows for the structuring of databases that incorporate user commentary about attractions, provide recommendations about events, and encourage community bulletins. Databases that allow for a directory of system users could also be available so that potential car-poolers, for example, could be matched with one another. Informational databases on special services for senior citizens, youth and certain ethnic groups might be developed by members of these communities.

Information Development and Monitoring

A balance of information is needed. Is it appropriate for sporting events to eclipse dramatic events? Are advertisers running the show? A special oversight committee might be established to ensure information balance and accuracy. Because minority groups represent very high proportions of transit riders in many cities, the inclusion of data relevant to these populations, as well as their participation on advisory boards, might be the focus of special efforts.

It may be necessary for information sources to be referenced clearly with respect to who has sponsored the information. Individuals familiar with tourists' guides often stumble over highlighted recommendations and full-page advertisements for wax museums while the city's predominant arts institutions are squeezed to a corner of a back page. It is important that SmartMaps users view the systems as more than an advertising venue. This may be difficult, however, if they are deluged with advertisements during the presentation of the information they request. Consideration should be given to providing clear distinctions between information that is considered public and that which is a privately sponsored promotion. An easily read sponsorship memo superimposed on the screen may be one method for creating an appropriate distinction.

Successive advertisements prior to the display of needed transit information may steer the potential user away. At the same time, many individuals will use the system specifically for the information provided by private advertisers. The interactive quality of the equipment allows for endorsements targeted to the user. SmartMaps is a vehicle by which the user can be made aware of products and services of likely interest.

Although advertising revenue will help support the system, the user should be comfortable that the public information presented is not biased toward particular advertisers. Transit and pedestrian routing should be composed independent of advertising databases. It would be unacceptable for a public service to intentionally direct an individual on a route that includes an advertised retail outlet unless the system user specifically requested such routing.

In addition, thought must be given to methods of incorporating options for carpooling, taxicabs and private transit services. It may be useful for the SmartMaps system always to inform users, when public transportation options are provided, that alternative transportation means exist. The user might then be presented an optional prompt for information on advertised airport limousine services. Another screen for carpool information may also be shown.

Information about users is also information about transit riders. Rarely do transit systems receive systematic data that report not only riders' destinations, but also what they will do when they get there. The SmartMaps information system allows the transit authority to learn more about the individuals it serves and where and when they are served. This information can be utilized to adjust the service provided to customers. Transit systems can learn whether their efforts to lure new riders are working, whether they have a loyal following and which of their riders are best served by the SmartMaps system. This also can assist in the development of new programs and incentives for riders of the transit system.

MANAGING SMARTMAPS

Careful oversight of the planning and operation of the SmartMaps system is necessary to ensure the integrity of the information it provides. If SmartMaps systems draw upon the resources of many different databases, a board must establish guidelines regarding the type of information that may be included and how data is to be entered and updated.

Administrative Organization

Maintaining a SmartMaps system with the capabilities described in this proposal requires computer systems experts, advertising sales representatives, security systems specialists, designers, librarians, data entry clerks and customer service specialists. SmartMaps may demand the expertise of representatives from transit agencies, chambers of commerce, local governments and community organizations. A large system also would require a team of technicians and maintenance personnel, and might necessitate occasional on-site demonstrators at certain locations to register users and provide information about the kiosks. This full range of professional backgrounds would be necessary because the scope of the interactive database takes it far beyond being an electronic map in the lobby of a subway station; a SmartMaps information system is a highly accessible tool to be used in schools, businesses and homes.

Community members should be involved in the management and development of the SmartMaps system. A commission to oversee the SmartMaps system could be organized to include business leaders, community residents, and local officials. The board might be established as a citizens' advisory panel.

Community outreach also is needed to put the system in operation successfully. SmartMaps personnel might present educational programs on the system in schools and places of work. Consideration should be given to the planning of community information forums by which interested community residents would have the opportunity for a general orientation to the system. In addition, organizations might be offered free advertising space on the system as well as opportunities for listing community events.

Public Versus Private Information

If a business cancels a clearance sale, a bus is temporarily rerouted or a museum adjusts its hours during a holiday weekend, assurances must be secured that the system will reflect these changes promptly. If changes are made on-line by individual advertisers or service providers, monitoring of such changes by information system administrators may be difficult. Businesses could call in or e-mail notices to a centralized data entry staff who would make the adjustments. It would be unfortunate to riddle the system with numerous disclaimers regarding the responsibility of inaccurate information. It is essential that a method be developed by which to monitor the system for accuracy.

Decisions also must be made about the types of advertisers that might be permitted in the system. Is it appropriate for a map of flashing taco chain restaurants to be highlighted for an individual seeking a Mexican restaurant in a particular city? Is it possible for a family-owned taqueria to afford the cost of advertising on such a system? Since monetary support from advertising is of likely concern for a SmartMaps information system, tiered sponsorship levels may be determined so organizations and businesses of different financial means would have access to the system. Unlike the Yellow Pages directory, where the size of the business is not considered in the price of placing a display advertisement, SmartMaps might consider subsidizing the cost of some small business listings. Special subsidies might be available for advertisements from minority-owned businesses, particularly those that serve minority communities where levels of public transit ridership may be significant.

Must advertising revenues be used to support SmartMaps information systems? With heavy private financing, one might argue that the system may serve less as a public resource than as a business directory. However, financing of such a system, relying only on public funds, would be difficult; it would be unlikely that the system ever would be developed and operated. Individuals who subscribe to on-line information systems are accustomed to some advertisements included in their data package. A purely public system also would not be able to provide users with information about neighborhood retailers. Some of the services that SmartMaps information systems will provide *only* could be developed with private funding. What makes the system beneficial to the user is the combination of public and private services provided.

Administrative decisions are necessary regarding the geographic scope of SmartMap advertisers. Proprietors of distant attractions may see benefits of being listed on a regional data system, even if the outlying sites are not served by public transportation. Policy should address whether areas that are not reachable by existing transit systems should be included on the SmartMaps system. It may be necessary to establish a regional boundary for participation in the system. Communities outside of the service area might be able to pay for use of SmartMaps. Additionally, businesses far from the region might advertise as out-of-town attractions. The amount of money available from non-local advertisers may play a role in dictating the policy of accepting advertising.

As the SmartMaps network grows, communities outside the immediate service area might be provided access to the system. Eventually, SmartMaps could develop into a resource that provides information both for transit users and automobile drivers. SmartMaps systems in different cities could be linked to one another, providing even greater access to more information.

MEETING USERS' NEEDS

The SmartMaps system is designed to provide its users with access to a range of information. It presents information in visual, auditory or written form -- the manner that is best understood by the user. But can the system really serve as a resource to all who require it? Are those individuals who are least likely to use a computer information system the same individuals who might benefit most from its use?

Privacy

By entering personal data into the SmartMaps system, the information network becomes an interactive one that can provide very quick premium service. Personal information facilitates the development of statistical data on system users. The type of information requested by users becomes available. Mailing lists can be developed so that users receive updated information about the system or solicited brochures from advertisers. Optional registration in the SmartMaps system may afford the user easier access to information about a range of businesses and agencies.

The amount of information required about an individual in order to operate the system effectively must be determined. Information about the user's language, education, age, income and interests will allow for an appropriate presentation of data. Additional information about the user's neighborhood or home address would enable the system to identify local users versus tourists. This may prompt information relevant only to local community residents. Even the manner in which walking directions are provided might be different for users from opposite ends of a city, with landmarks highlighted for an individual coming from the south side different from those for the commuter from the north side.

The first time users register, they might be prompted by SmartMaps: "Do you wish to have this personal information made available to advertisers?" The names of individuals who accept the release can be placed on mailing lists. Confidentiality should be assured for those who request it, although personal data still can be used for statistical analysis. (Whether using the data provides a secure level of confidentiality must also be considered.) Controls are necessary to prevent the misuse of personal information. If private facts are provided to advertisers or can be easily accessed on the database, guidelines must be established for the release of this data.

Limits might be placed on access to mailing lists. Businesses might be provided with data only about users who have requested information about their operations or users with income and education characteristics that they seek in marketing. Restrictions on mailing might also be considered. One possible method of controlling mailing lists would be to have the SmartMaps administration handle all direct marketing through personalized monthly or quarterly informational newsletters tailored directly to specific users. Selected advertisers would be provided access to their potential customers through these mailings.

In order to perform simple tasks, is it necessary for individuals to register personal information into the system? It should not be necessary to input personal data to obtain much of the information SmartMaps can provide. Maps and bus schedule information in English, Spanish, or Chinese, for example, might be available at the touch of the screen. For those fully mistrusting the capabilities of Smart Maps, this would allow them a basic level of access that might nurture curiosity about its other functions.

Because the types of information individuals request can be stored in data files, concerns might be raised about the system being capable of determining *too* much information about individuals. Can mailing lists be sold? Individuals requesting information about a particular church or services for gay travelers may not be pleased to find their name on a mailing list that associates their requests with their interests. This point reinforces the assertion that confidentiality must be assured. A citizen advisory commission might establish confidentiality guidelines. An ombudsperson might also serve as an effective monitor of confidentiality issues.

Access and Comfort

SmartMaps systems can be designed to provide information in a clear, simplified manner. The frequent transit user may sense that such a system is designed for tourists and less frequent riders, providing far more information than is needed regarding how to get from one point to another or when the next bus comes. Individuals in certain minority and immigrant communities -- those areas which often have lower incomes, higher levels of illiteracy and tend to rely on local, neighborhood-serving stores and services -- may see little benefit in registering personal information in a system that details distant athletic and cultural arts venues, unaware that useful information about local attractions or sales is available. Sensitivity is necessary in addressing expectations about immigrants using the system. Some research has suggested that immigrants from some countries fear authority. These individuals may be especially mistrusting of an information system that requests a person to register personal information.

Some evidence suggests that individuals who are not highly literate are averse to interacting with a high-tech system. Instead, they receive most of their information passively. Some individuals are unaccustomed to using computers even for very simple tasks. Others have little faith that computers can provide information as accurately as a human being would. Still other individuals see the benefits of computers, but are fearful of their own capacity for understanding how to maneuver them.

One must consider how individuals can be introduced to the system. Informational brochures and advertisements illustrating the benefits and use of SmartMaps can be developed. Marketing to potential users will make them more comfortable with the purpose of the SmartMaps information system. Having a clear understanding of the equipment's benefits may also ease concern over entering personal information into the system prior to fully benefiting from the available services.

Individuals who are not highly literate or are unfamiliar with interactive computer systems will benefit from a personalized introduction to the system. The student who is taught to use SmartMaps information systems in the classroom may introduce the technology to a parent who is uncomfortable with it. Although part of the excitement generated about such a system is its technological capability, a human introduction pushes aside the barrier of an unfamiliar machine.

Long lines at SmartMaps kiosks might discourage use of the system. Time limits imposed on users might alleviate waits, but also may lead to frustration if users have not retrieved all of the information they seek. In high-traffic areas, the installation of more than one kiosk might be considered.

It will be necessary to determine the average length of time spent on the system by users. A new user may require additional time to become familiar with the system, although a user very accustomed to the system may also spend a lot of time retrieving information. Although research has not yet been conducted, encouraging users to access SmartMaps from their homes and offices may serve to increase the number of users, advance the size of the database or reduce waiting time at a public kiosk.

A means of securing the system to prevent vandalism is in order. Studies must be conducted on the costs -- both monetary and those affecting the usefulness of the system-- of making SmartMaps vandal-proof. It also must be determined whether Smart Maps will be accessible twenty-four hours daily. A system that is inoperable at certain hours would curtail the anticipated universal user base.

Efforts should be made to alleviate fears associated with making a mistake while using the system, paying for the information service or the sharing of private information. Publicity must stress that the system is very easy to use, is free and that all information is kept confidential from other users. The art of introducing technology is one of finding how to combine the desired result of a particular technical advance with what is familiar to the user. Those elements that are unexpected, such as visual simulation or the specificity of details that can be provided, excite the user and may encourage him or her to further explore the services available with such a system. The user approaching the system for the first time seeks the comfort of knowing that she or he has the capability of understanding how to make the basic functions of the system work. At the same time, the user hopes for surprise benefits of using the system.

By making SmartMaps systems as accessible as possible to the widest range of users, will benefits remain for the most technologically sophisticated users? The many functions made available by gathering information from activity, map and advertising databases makes the system very advanced. Its benefit is that information can be provided in the most appropriate manner for the particular user. Because it is simple to operate, SmartMaps information systems can put the most adept user in touch with detailed information that might otherwise require an advanced understanding of data retrieval. At the same time, a tourist can benefit by performing a task as simple as locating a nearby attraction -- information that a map and tour book alone would not provide.

Would a simulated mapping system that allows an individual to experience traffic corridors and pedestrian areas prior to making a visit to them become a sufficient substitute for being in the actual place? Could such an experience offered by a SmartMaps system become a replacement for reality? SmartMaps promises to be an accomplished information system, but does it go too far?

Because of its capabilities, SmartMaps only can enhance the quality of the actual experience by providing the information an individual would normally seek in a vivid, unmistakable manner. SmartMaps can accommodate the user with a traveling experience of a higher caliber . With greater information, an individual is likely to feel more comfortable in her or his surroundings, allowing for the confidence to maneuver through what was previously uncertain. The user may explore new travel opportunities.

To implement a SmartMaps system will require much research and planning. But the work can be of high reward for the many experts, users and organizations involved. Specifying the precise attributes, as well as their resulting impacts on the worth of the network, will structure SmartMaps to be the most responsive of information systems. A laborious process perhaps, but the enabling technologies may be among the easiest factors to handle; the most difficult may be in making the system serve its users. It is through working with the many communities to be served by the system that the interest of the users can be stirred. The group of individuals who use the system is the most valuable piece of its operation.

6 Future Directions and Research Needs

Continued research and testing should be ongoing components of the Smart Maps project. Additional theoretical and experimental research is necessary for the development of prototypes. This research would permit project teams to tighten the user matrix, refine the design criteria, and identify additional policy concerns. Once developed, the prototypes must be field tested and then redesigned until a satisfactory system can be implemented. The rapid pace of development in the electronics industry also warrants a continued examination of prospective technologies and emerging applications even after the system is on-line. In addition, policy issues and user feedback will continue to require improvements throughout the life of the system.

The research on environmental cognition has generally been directed toward developing a better understanding of the processes involved in various environment-related tasks, including wayfinding and spatial representation. It is usually intended to develop theoretical models and serves as a valuable background for the actual development of the kind of electronic urban information systems envisioned in SmartMaps. With the project goals in mind, it is now possible to identify gaps in the existing literature and propose an experimental research agenda as part of the future development of this project.

As evident in the Matrix of Social Factors in Chapter 2, there are many gaps in the theoretical research related to this project. It is not necessary that every issue be investigated before a SmartMaps system can be implemented. However, some research will be important to the effective operation of these systems. For example, in most large cities in the United States, the population is becoming more culturally diverse. Yet, there is virtually no research available regarding cultural differences in environmental cognition, wayfinding, and map reading skills. Other issues that have not been sufficiently addressed include the effectiveness of different map styles, learning form tactile maps, and communicating effectively with the illiterate or semi-literate that make up a large proportion of the transit dependent population. There has also been little research in the area of computer/user interfacing. Taken together, these issues demonstrate the multidisciplinary nature of the development of SmartMaps, requiring input from psychologists, sociologists, urban designers, computer scientists, and geographers. Given the diversity of issues related to the design of SmartMaps, the project team will have to determine which areas of the research they can feasibly conduct, while keeping informed of continuing research in other areas. It is possible that the published findings by the project team and the development of prototypes will encourage others to investigate outstanding issues related to the subject.

Four overlapping aspects of environmental cognition are necessary for the development of advanced electronic mapping systems, and each of these has been insufficiently explored.

- The first involves differences in social, cultural and educational backgrounds in relation to perception and use of transit information systems.

- Second, there needs to be more direct and focused research on the effectiveness of various ways of presenting transit information to the user: diagrammatic map, pictorial map, model, place images, text, the spoken word.

- Third, possibilities of presenting information through a combination of visual and auditory methods should be considered.

- The fourth aspect is human-computer interaction: what modes of presentation and interaction will be most effective?

Previous research has suggested different types of information that are effective in wayfinding and spatial understanding. For example, it has been shown that a combination of sequential ground level views and some form of overall representation is an effective method of familiarization. In the sequential representations it has been suggested that landmark and transition points be clearly identified, while in the overall views spatial relationships and connections should be emphasized. Other findings indicate that multiple sensory input, such as simultaneous visual and auditory information, reinforces learning and recall. These findings need to be evaluated in the context of the SmartMaps project. Future experimental research should address these issues and others in environmental representation as related to the specific project goals, design criteria, and conceptual designs specified in this report. The proposed SmartMaps system should be evaluated in focus groups of sample users and participants selected to represent a diversity of potential user needs, interests, abilities, and orientations. Possible evaluative instruments include questionnaires, interviews, and qualitative evaluations based on ethnographic methods, in addition to laboratory and field experiments to test specific project components. Some examples of the experiments include:

A comparison of different degrees of detail in graphic presentation. Excessive detail in graphic representation increases cost by requiring more rendering time initially, and ultimately more time to make modifications as the environment changes. It also has been shown that, in some cases, more detail is actually a hindrance to comprehension of graphic representations, such as sequential and overview representations.

Example of a comparison:
Conventional street maps should be compared with digitized street maps in wayfinding tasks. The level of detail can range from photo-realistic images to simple graphic representations. The kinds of comparisons would include specific route maps vs. pictorial maps vs. three dimensional computer models.

A comparison between still images and animated sequences. Current computer technology is capable of providing sophisticated video representations. However, the use of these techniques is expensive in terms of time and money and is not very flexible. If still images can achieve the same effect, reliance on costly animated sequences is unnecessary.

Example of a comparison:
Photographic slides could be compared with moving video clips of the same route. Different edited versions of the video could be tested to determine the best segments of a route to present as a wayfinding aid.

A comparison between different combinations of auditory and visual information. The inclusion of auditory information with graphic presentation has been shown to be an effective method. However, some combinations become interference rather than assistance. This research should build on previous work and research currently in progress to adapt the basic theories to the specific requirements of the SmartMaps system.

The importance of continued research and development cannot be over emphasized. Likewise, the multidisciplinary approach to the research should be stressed. Two different approaches to the development of SmartMaps are possible. Today much of the development is being driven by technology. Systems are being designed based on the capabilities of current technology, which is changing almost daily.

The other approach is from the standpoint of the users. "What can we do with the latest technology?" must be revised to "What do we need the latest technology to do?" Answers to this question are also changing rapidly since this area of research is new and complex. SmartMaps project teams should focus on user needs issues while at the same time exploring technological solutions to meet these needs.

7 Mapping Techniques Relevant to Transit Users

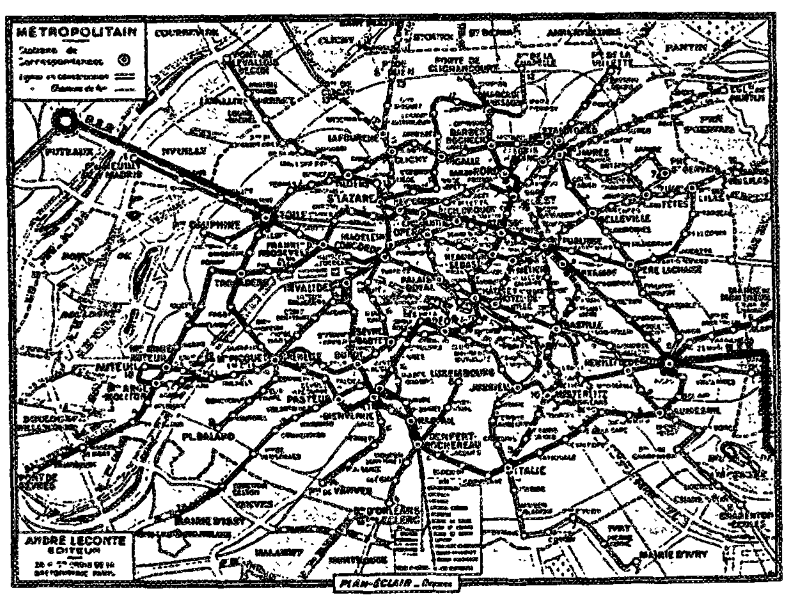
The following maps illustrate various approaches to presentation of environmental information relevant to the creation of a SmartMaps transit information system. Although most of the examples are non-electronic, they illustrate approaches to communicating geographic and transit information that can be applied to SmartMaps. These include techniques for:

- Presenting route information
- Maps for the blind
- Maps for children
- Combining textual and geographic information
- Presenting different geographic scales simultaneously
- Use of symbols and diagrams
- Representing the appearance of places and communicating the sense of place.
- Interactive simulation maps

Source: Southworth, Michael and Susan. 1982. *Maps: A Visual Survey and Design Guide.* Boston: New York Graphic Society.

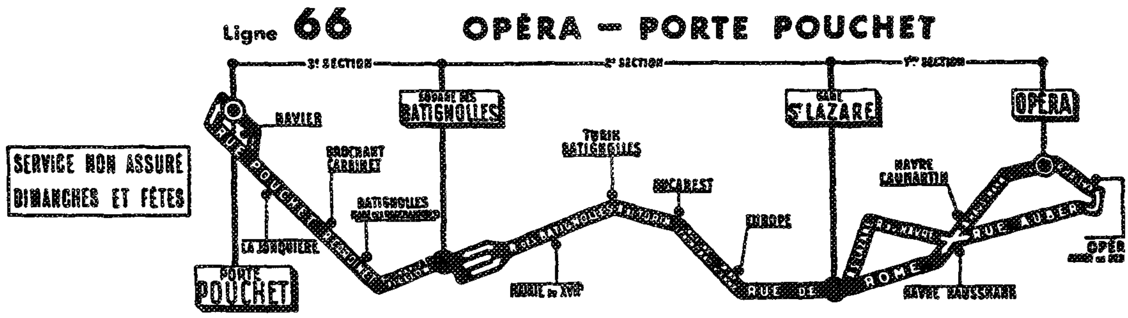
Paris Métro Light-up Route Map

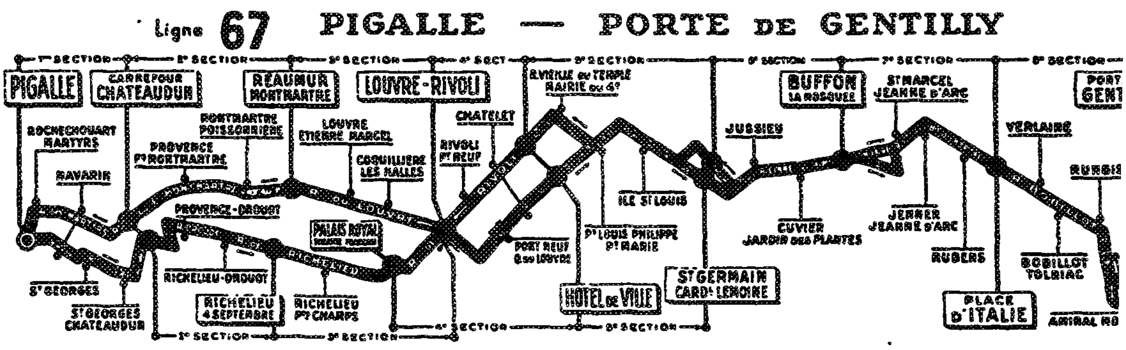
For the Paris Métro system, the most extensive subway system in the world, with a complex spiderweb of routes, the light-up electric map is a very useful device. Most destinations in the system can be reached by at least two routes from any given starting point; several transfers are often necessary. Finding the most efficient route could be a time-consuming effort. Using the electric map, a rider simply pushes the button for his destination on the panel below the map. The destination and the most efficient route to it then light up. An electric map is applicable to any transportation system: bus, airplane, train, highway, as well as subway. It is also useful in complex office buildings, art museums, or college campuses. Computer technology can make electronic routing maps very sophisticated by allowing route selection using criteria other than efficiency—for example, a scenic route, the safest route, the least crowded route. Personalized itineraries and route maps may also be printed out by such computer terminals. *In Richard Saul Wurman,* Design Quarterly 80, Making the City Observable *(Walker Art Center and MIT Press; copyright 1971 by Walker Art Center).*

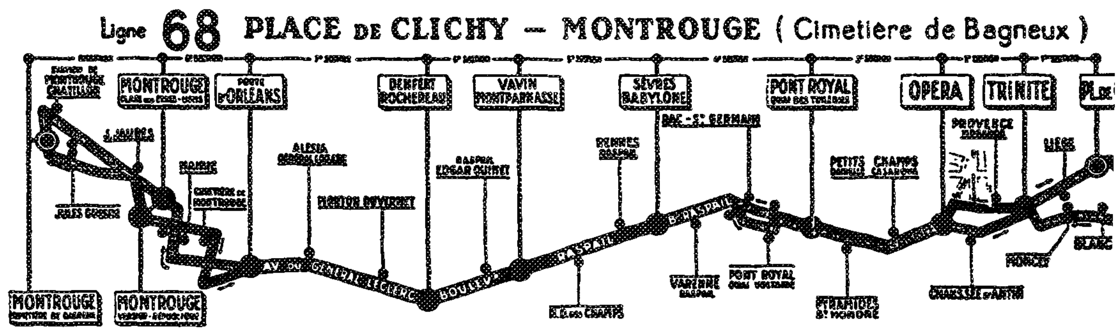


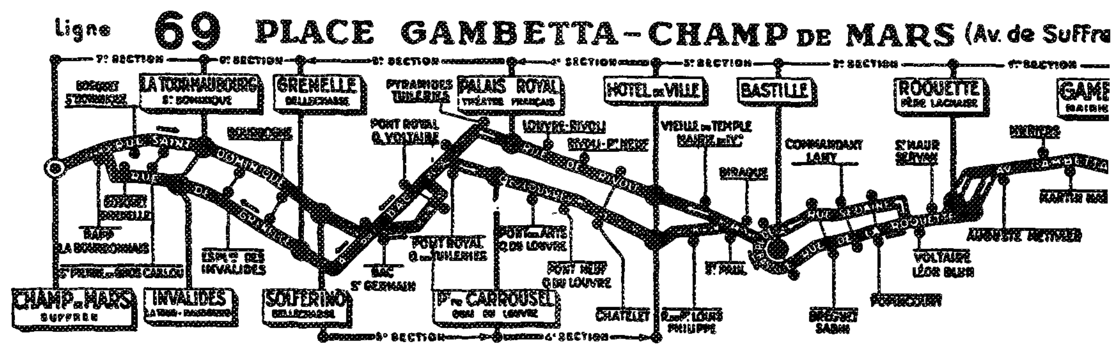
Strip Maps: Paris Buses
These bus route maps provide the names of major stops and Métro connections, as well as fare divisions for Paris bus lines. The routing directions, turns, and so on are approximately correct, but the user must know where he is going in terms of the major stop names in order to use the maps. No information about specific sites, intersecting streets, or notable buildings is included except indirectly, as in the use of the "Hotel de Ville" Métro station as a major stop.

Presenting the bus lines individually, as this collection does, makes them easier to follow than a single mapping of complex, interwoven bus lines, which requires difficult untangling. It is easy to comprehend the skeletal information, but one is left without much sense of the surroundings since the lines are shown virtually in a vacuum (compare 4.39). *Raymond Denaès,* Guide Général de Paris *(Paris, Éditions L'indispensable).*



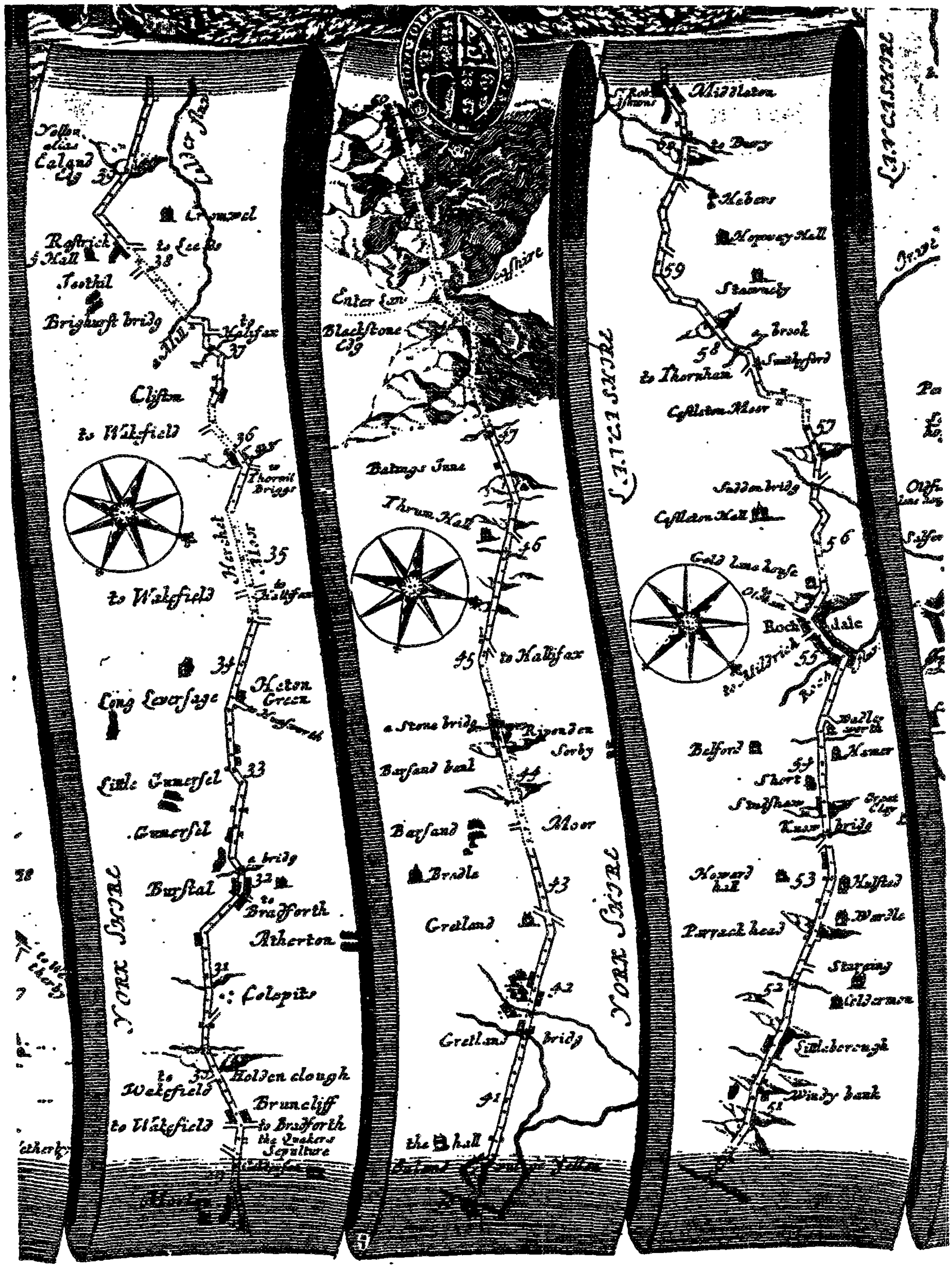


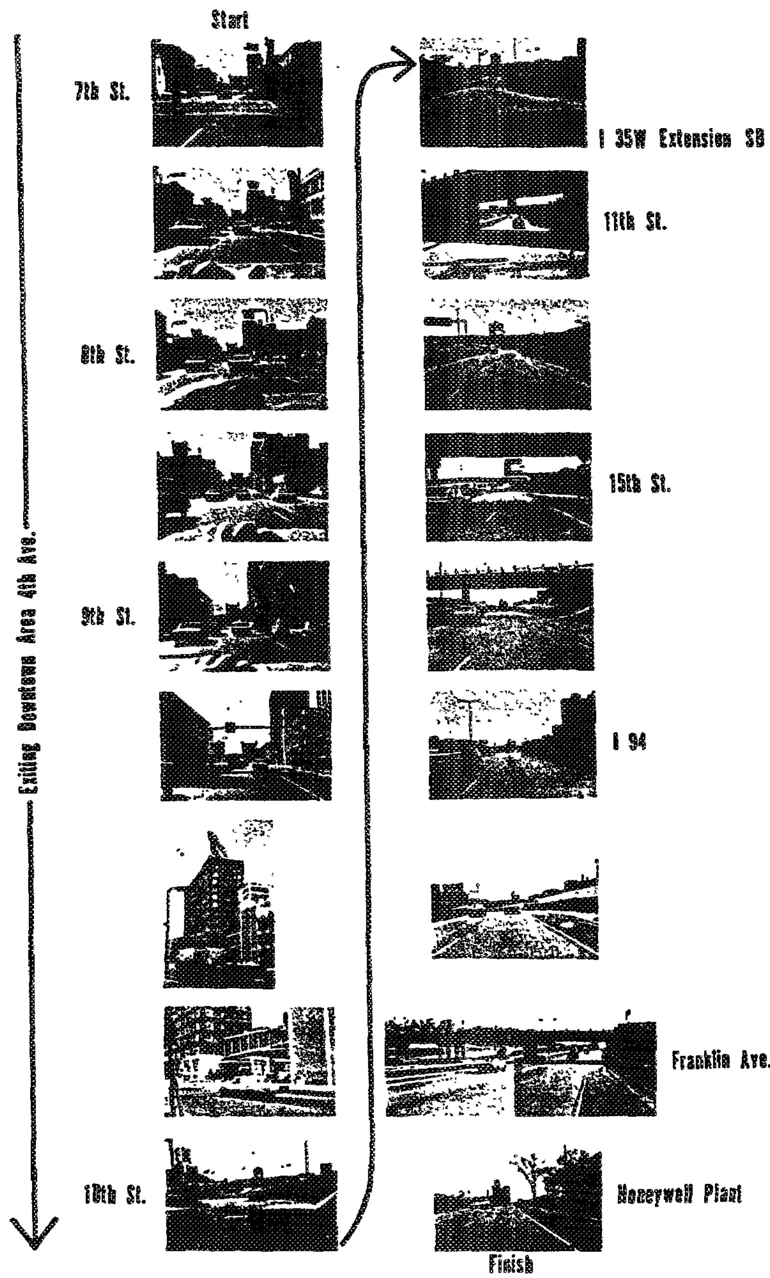




trip Map: York to West hester

ılike the diagrammatic strip ap (5.27), this rendition at- mpts to show slight changes direction as well as some ndmarks along the way. One ıust recognize, of course, that ıe road system was far simpler ıd without complex inter- ıanges when this map was ıade; it appeared in John)gilby's *Britannia* in 1675. The raphic device of showing the ɔad on a continuous ribbonlike trip is appealing; one reads the ıap from bottom to top, and rom left to right. *Edward ynam,* The Mapmaker's Art: *ssays on the History of Maps London: Batchworth Press, 1953).*



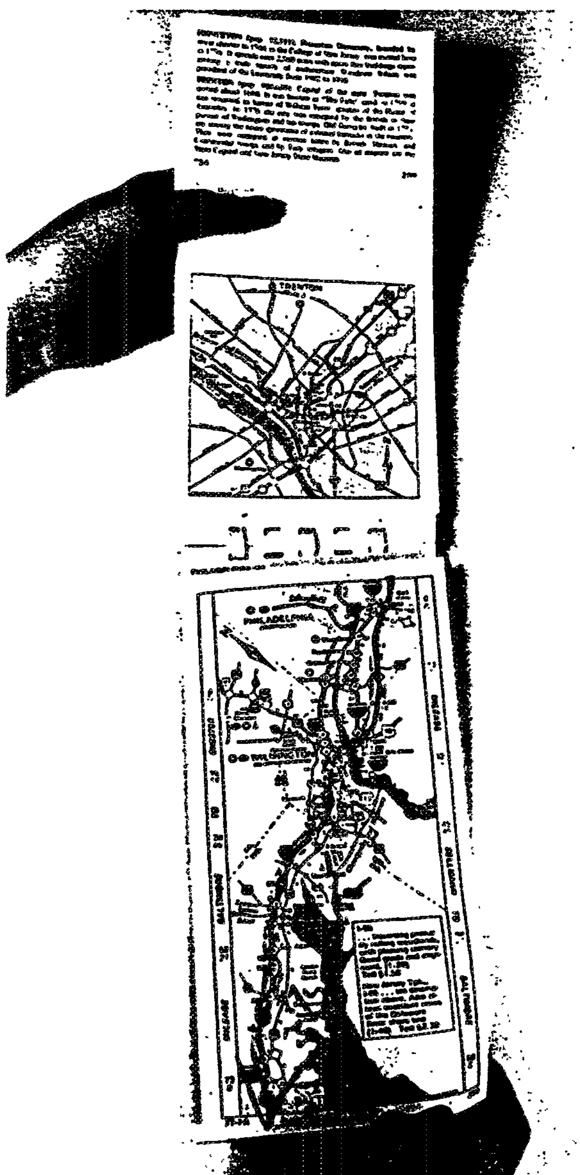


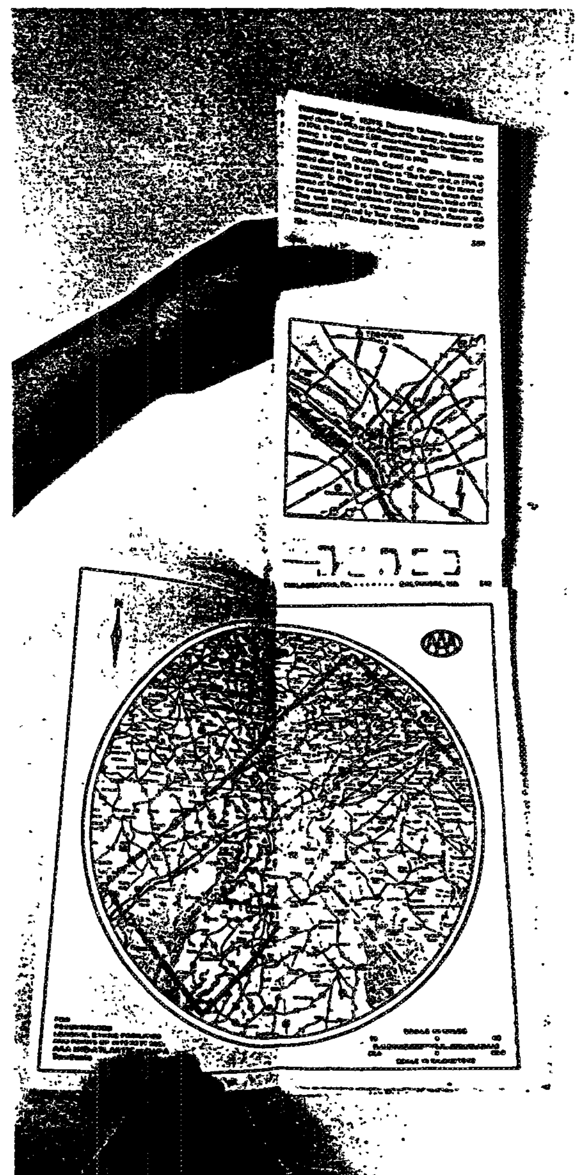
Photographic Route Sequence: Exiting Downtown Area via Fourth Avenue, Minneapolis

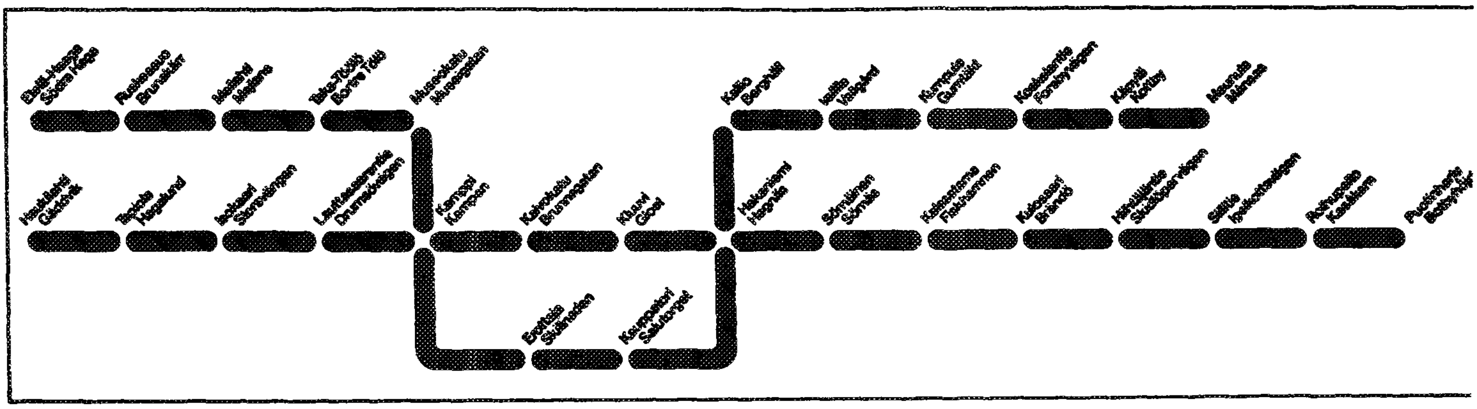
Route sequences of still photos or film are useful in environmental analysis and design and can also be effective in route learning. In still-photograph sequences it is important that each photograph contain a repetition of some identifiable element from the previous photograph so there is no confusion about the relations between them. The ninth photograph down on the left indicates that one is going to turn a corner. Although photographic sequences provide good route information, there is no sense of what is outside the picture frames. In addition they normally have to be annotated with such information as street names and addresses, which are not usually dominant enough in a photograph. *Department of Planning & Development, City of Minneapolis, 1969.*

riptik

ïptiks are personalized route aps prepared by the American utomobile Association. Given ıy origin and destination in orth America, the AAA uses andardized maps of route segıents to prepare a strip map of ıe entire itinerary. The recomıended route is marked in felt ıarker; the route proceeds equentially from front to back f the booklet. Detailed maps ıd verbal descriptions of metıpolitan areas are included for ach segment of the route. The ystem is valuable for the moırist and could be adapted to ther forms of transportation. *opyright © AAA. Reproduced y permission.*

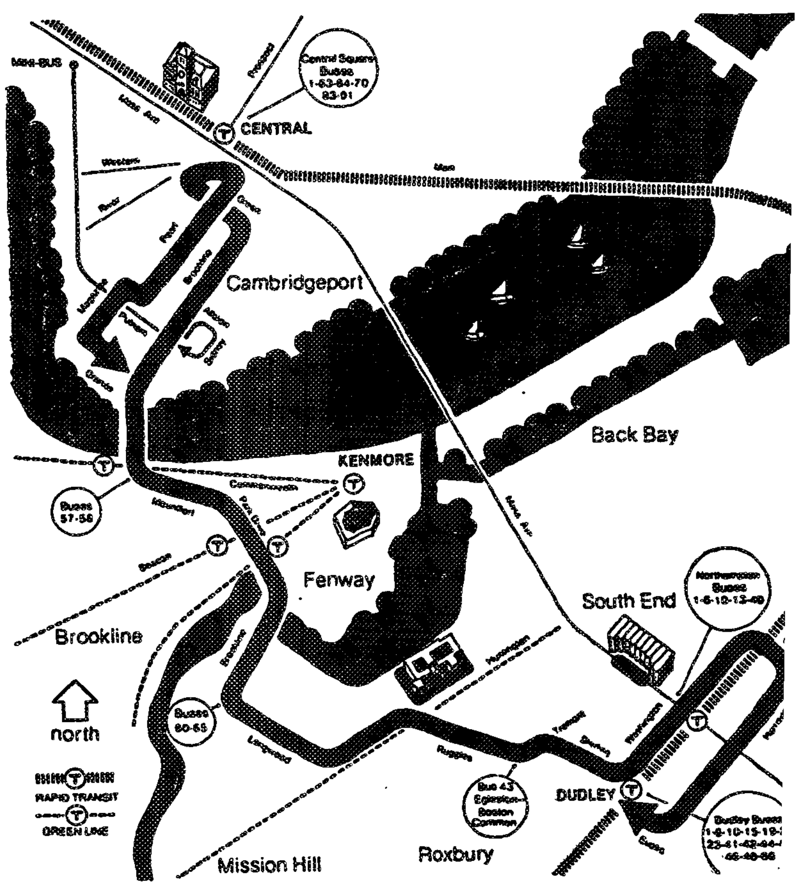






Line Diagram for Helsinki Subway
A graphic alternative to the London Underground approach (5.13), the Helsinki subway system looks like a string of sausages. Stations are emphasized by breaks in the route. Although graphically elegant, indicating stations as breaks rather than enclosed spaces or masses may confuse some users. *Ola Laiho, Esko Miettinen of G4, Designers, Helsinki; courtesy GRAPHIS Press Corp., Zurich, Switzerland.*

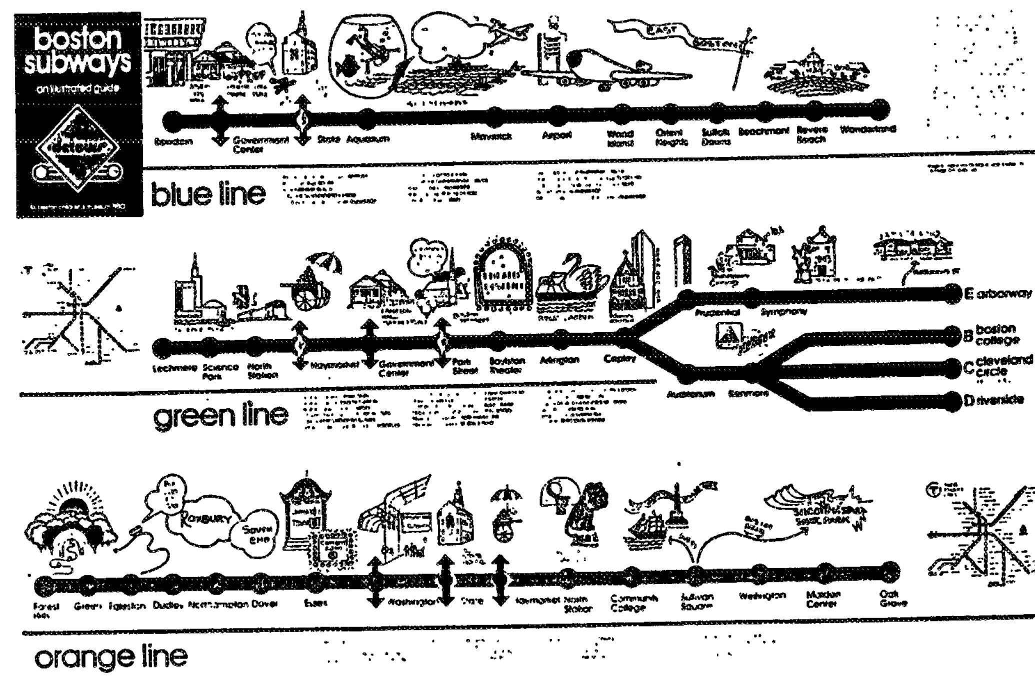
Pictorial Bus Route
Communicating route information without confusion is a problem because so much is available. This map eliminates all but the essential information. The route itself is given visual dominance by increasing its width and printing it in color. Intersecting bus and subway lines are indicated to aid trip planning. Bus schedules are printed on the reverse side of the folder. Major recognizable landmarks on or near the route are shown in pictorial terms. The pictorial technique was used to make the maps readily usable by the general public. More than 150 of Boston's bus routes have been mapped in this way (compare 5.1, 5.18). *By Michael & Susan Southworth, City Design & Architecture; copyright 1980 Massachusetts Bay Transportation Authority, Boston, MA.*

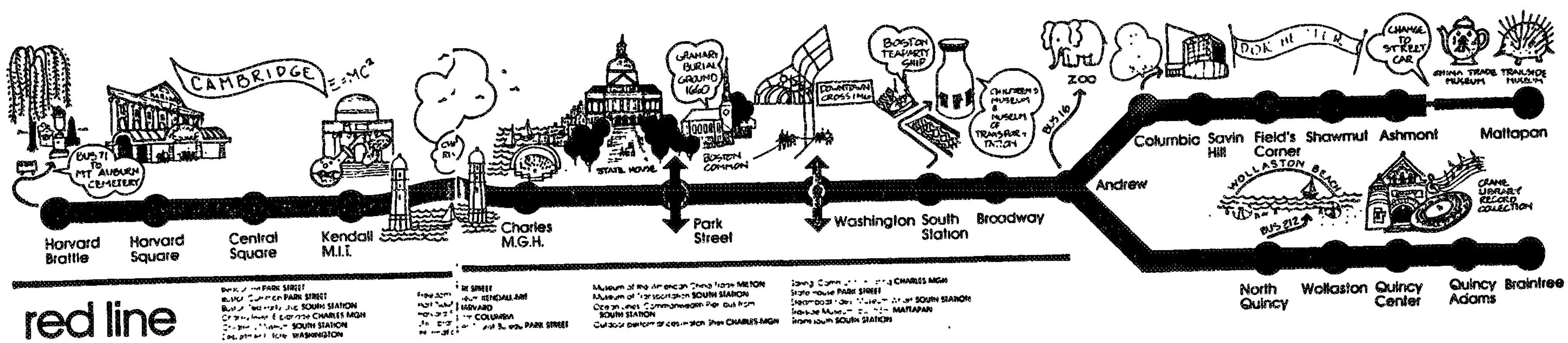


Pictorial Subway Guide for Children

The Boston subway system is represented pictorially to meet the special needs of children. Destinations of particular interest are shown in sketches colored to match the lines on which they occur. Boston has four color-coded lines—the Blue Line, Red Line, Orange Line, and Green Line. Each subway line is shown as a separate strip map to focus on its individual character and to simplify use. Pictures are stylized typical views or symbols associated with locations, such as a diver and fish for the Aquarium, an elephant for the Zoo, a swan boat for the Public Garden. Relations between lines are indicated by intersecting arrows in the appropriate color for each line, as well as by small "spider" diagrams that show the overall system with station names and line colors.

Such pictorial representations of prominent destinations enable users to form a quick image of the character of each subway line and to recall the stations. The designers felt this approach would help children to discover the city. A child can travel through the pictures, select a place that is appealing, note the name of the station and its relation to other stations on the line, and then figure out how to get there. The map stands in sharp contrast to the common "spider" diagram transportation maps, which intentionally exclude all contextual character for the sake of diagrammatic simplicity. It was considered important to reduce the amount of sophistication and knowledge children must possess to use this map. *Copyright © Boston Children's Museum 1980. Jim Zien, DETOURS Project Director; map graphics by Michael and Susan Southworth. Supported in part by a Youth Project Grant from the National Endowment for the Humanities.*





Verbal Route Guide: Up the Coast to Malibu

Verbal maps, in addition to being understandable by those who have problems with conventional maps, can provide more information and a stronger environmental sense. This bicyclists' guide from Santa Monica to Malibu evokes in a few words strong pictures of the landscapes, people, and activities one can expect to find along this section of the Pacific Coast Highway. Each route begins with an abbreviated assessment in terms of length, terrain, traffic, and recommended season or time. Then comes a paragraph describing the whole experience in general terms. Next, points of interest are described with special attention to comforts and interests of the cyclist. These are keyed to a skeletal reference map. *Gershon Weltman and Elisha Dubin,* Bicycle Touring in Los Angeles *(Los Angeles: Ward Ritchie Press, copyright 1972 by the authors).*

IO UP THE COAST TO MALIBU

LENGTH: *26 miles round trip*
TERRAIN: *Mainly flat*
TRAFFIC: *Medium to heavy*
BEST RIDDEN: *Any time of the year*

The ride from Santa Monica to Malibu on Pacific Coast Highway has a great sense of distance and place, despite its reasonable length. You leave the big city behind, pedal steadily on through vast, scenic spaces, and finally arrive at a quaint village with beautiful and distinctive inhabitants. It is sort of cross-country touring in miniature, a foreign experience in your own backyard. Pacific Coast Highway is a fast road, with a goodly amount of car and truck traffic, particularly in summer. But there are marked shoulder lanes on both sides, so that the cyclist is removed somewhat from the main stream. In addition, motorists are more used to seeing bicycle riders on this stretch of open road than elsewhere, and tend to give them wide berth. En route, we have plenty of time to take in the various features of the seaside environment: the eroded palisades, the mountain canyons running into the ocean, the shifting sands, the offshore reefs, and the way the coastline is formed into numerous small bays. The breeze usually blows directly offshore, cleaning the air without really slowing our progress in either direction. Each season has its own pleasures on the beach, from the refreshing swims of summer to the envigorating air and churning seas of winter. Having sampled one, the cyclist will want to explore them all.

65

Along the Way

1. Our sea ride begins on the Pacific Coast Highway at the mouth of Santa Monica Canyon, where Chautauqua Boulevard meets West Channel Road. Will Rogers Beach has ample parking; but on summer weekends, the lots fill up early, so an early start is best then. The cozy eateries and drinkeries in the Canyon offer a stirrup cup of various kinds to the dauntless rider.

2. Will Rogers Beach State Park stretches for over three miles of coastline to Castle Rock at the city limits. The large and good-looking apartments that have been built against the palisades are probably the wave of the future — a compromise between those who want to live at the beach and those who want to use it.

3. Around Topanga Canyon Boulevard we encounter the older type of oceanfront development: rows of shoulder-to-shoulder homes, cottages, apartments, and clubs, which barricade the beach quite effectively against the public. Access ways have now been opened by the County at several points, and cyclists will be pleased that the days of such completely selfserving land use are probably over.

4. The scalloped beaches just west of Topanga have close-in reefs which attract many fish, as well as the favorite game of skin divers — the California Spiny Lobster. We may meet some of the wet-suited hunters on shore, or see their red and white flag bobbing on the waves.

5. We approach Malibu along a continuous line of dwellings, punctuated by quick food stands, shops, gas stations, and whatall, most with giant overhead signs. Not a great deal of respect has been shown here to our splendid Riviera.

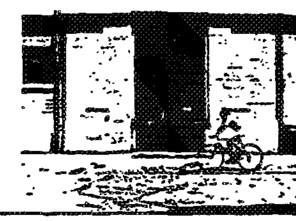
66

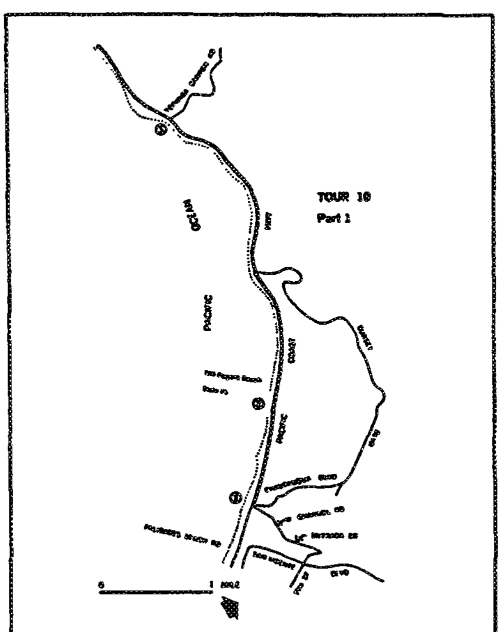
6. Malibu Pier is a properly salty collection of seafood restaurants and fishing supply shops. Locals drop their lines from pierside, while others take the sports fishing boats which leave from pier's end for cruises up the coast. A good place to relax for a while over a soft drink, a beer, or a hot cup of coffee, depending on you and the season.

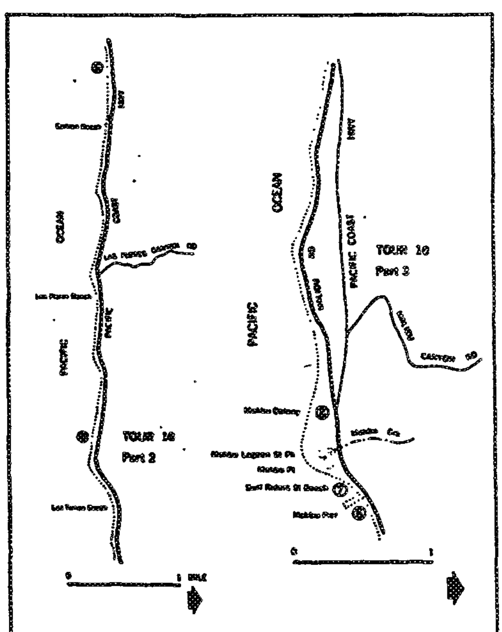
7. Gidget is alive and well at Surf Riders State Beach, just west of the Malibu Pier. This portion of surf line has been reserved for the hot-doggers and hang-tenners, and one can see them hard at it whatever the weather or time of day.

8. We bear left onto Malibu Road, which carries us two-and-a-half miles further along the shoreline, beside some of Malibu Colony's finest and most interesting beach houses. Spare and simple Hunt house, at 24514 Malibu Road, has received special commendation: it was designed in 1955 by Craig Ellwood. The road runs into the Coast Highway near Solstice Beach, and here we turn around to retrace our route back to Santa Monica Canyon. Don't worry, the ocean views are never the same twice, and the way back proves just as intriguing as the way out.

Bike riding in the city—new wonders to see each block, plus exercise.





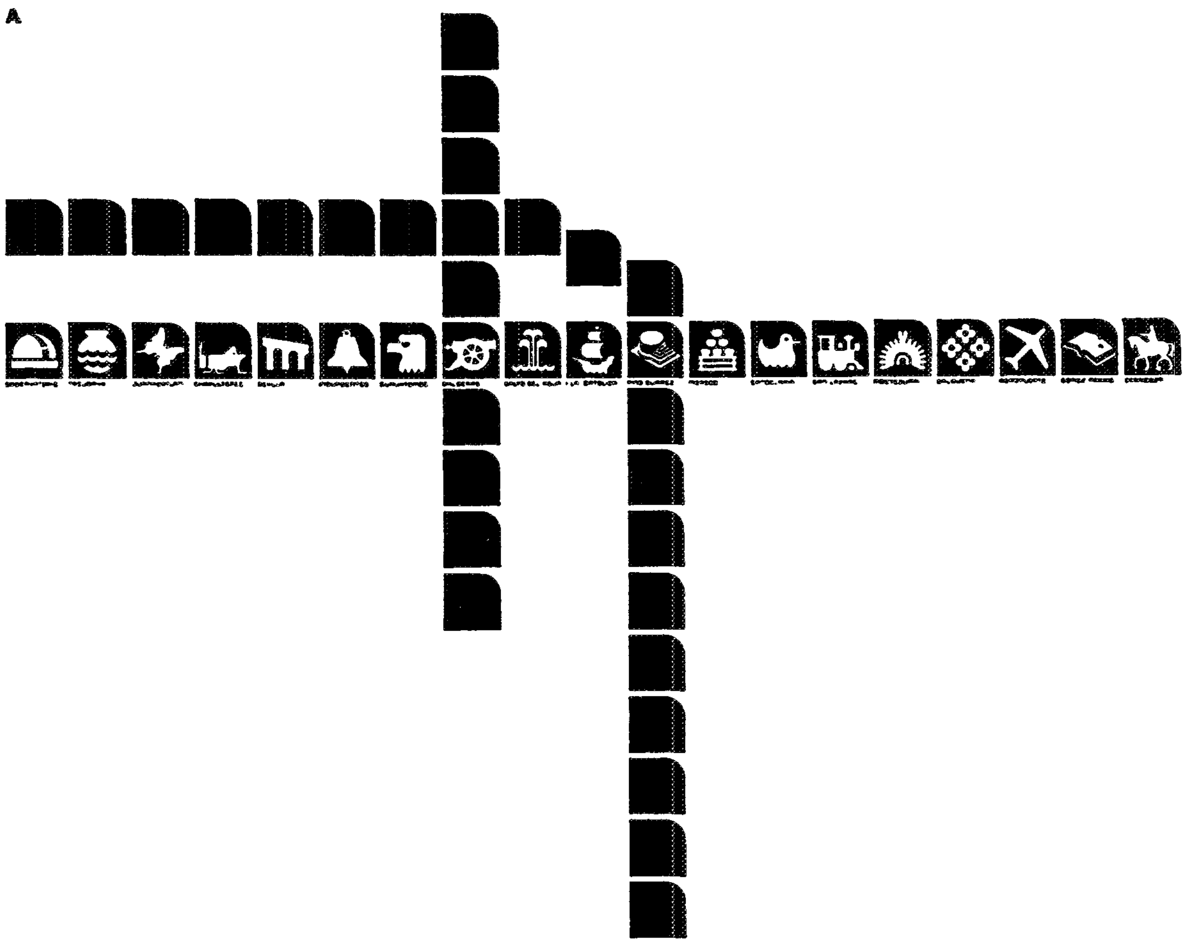


Pictographic Maps: Mexico City Metro and National Zoo

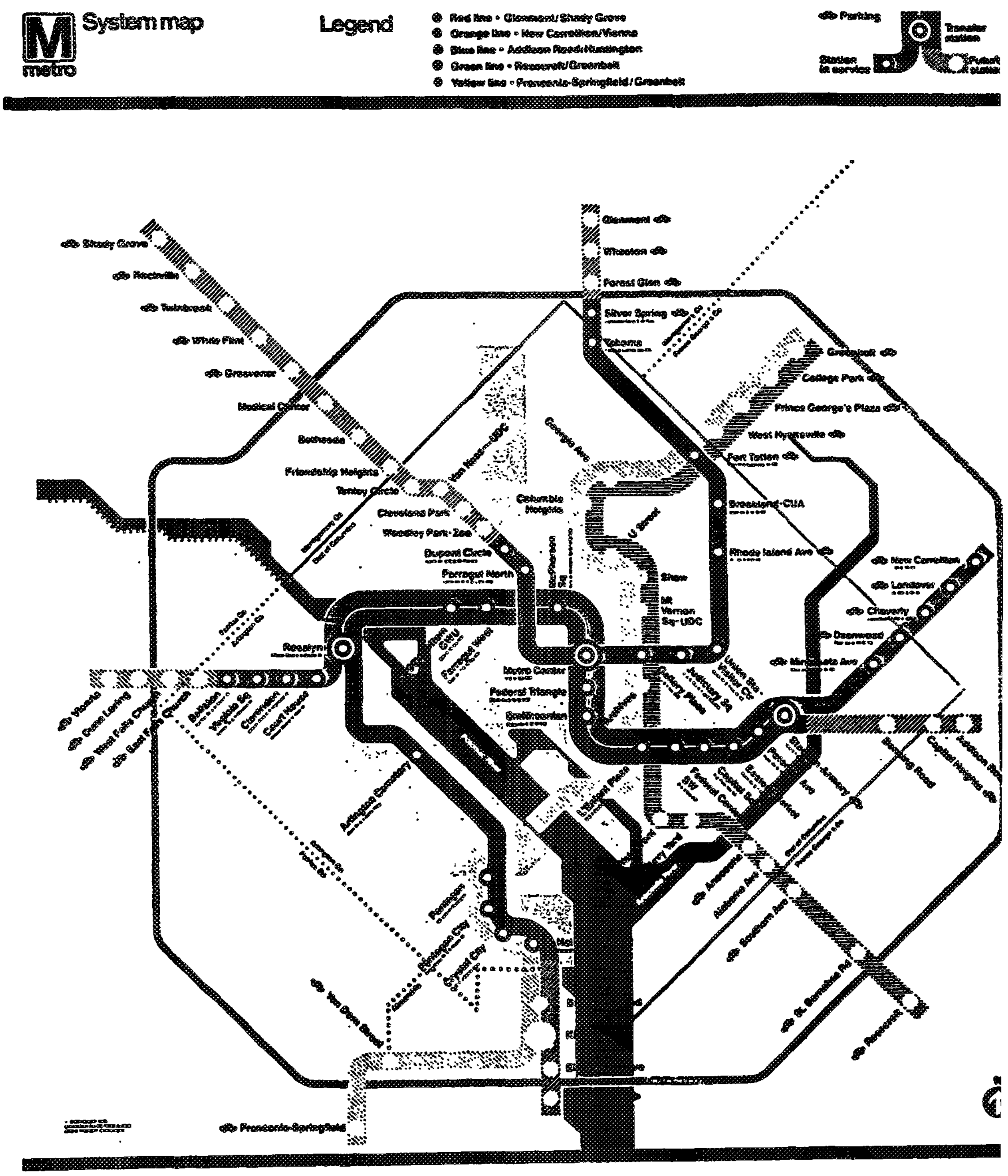
Pictographs can be very useful in guiding large crowds of people efficiently around a city. The Mexico City system was particularly appropriate for the 1968 Olympics visitors since it is equally comprehensible to foreigners. Pictographs were developed to symbolize landmarks located near each station of the Mexico City Metro system. They have been arranged to represent the order of stations and the overall pattern (**A**).

Sources for several pictographs are illustrated in **B**. As long as the pictographs suggest the correct destinations to most users, the graphic system is easy and direct to use. In this system, the airplane and train are more likely to be understood by strangers than some of the other pictographs. *Mexico City Metro graphic design and photography by Lance Wyman.*

A



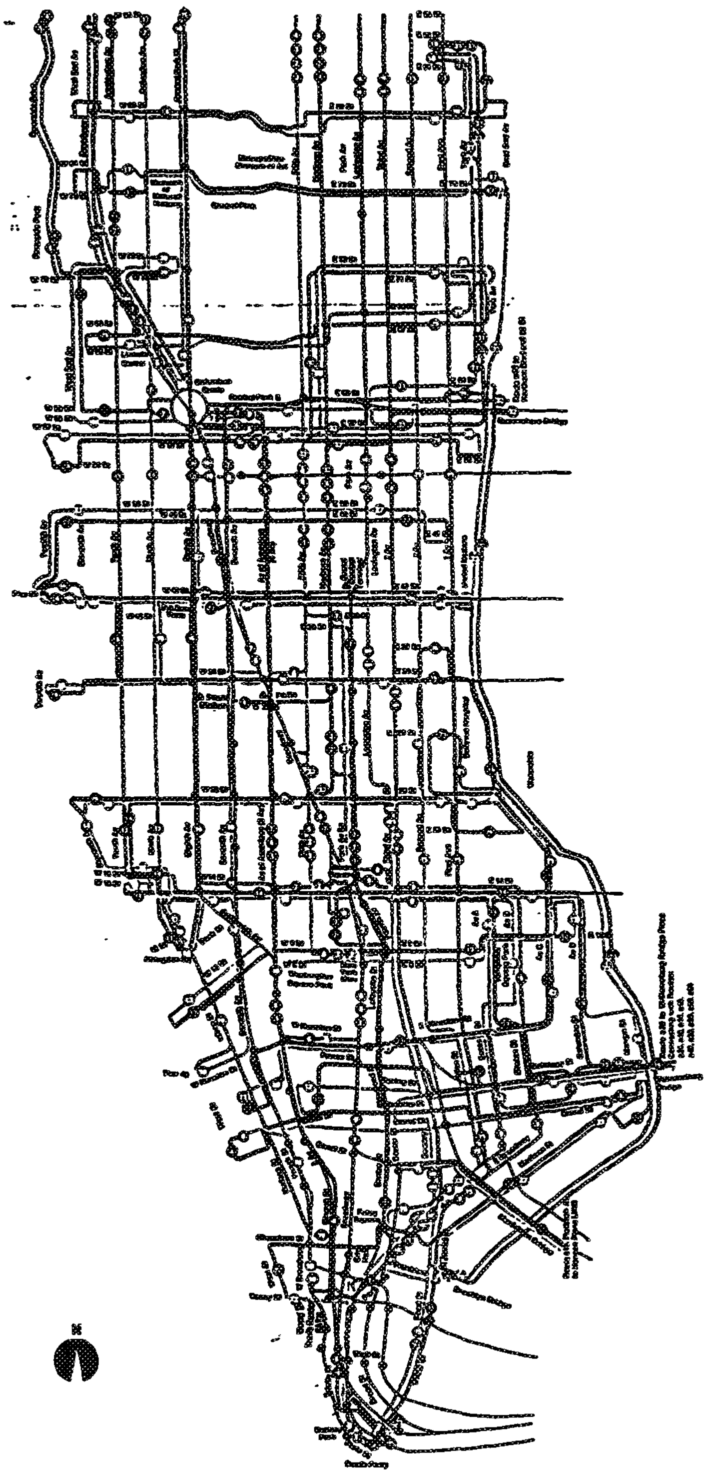
System Diagram with Landmarks: Washington, DC, Metro
The Washington, DC, Metro diagram is a variation on the subway "spider" diagrams of other major city subway systems and attempts to relate a rather abstract diagram to the real city by using common references. Several geographic landmarks are included—the Potomac and Anacostia rivers are in pale blue, district and county boundaries are in gray, and public lands are in light green, with several of the most prominent building facades in simplified form in white. Within the fat, colorful lines are two sizes of white dots for the stations and circled dots that represent stations serving as transfer points between lines. Whenever possible, the station names have been located in the horizontal position for ease of reading even when the lines are not vertical (compare 5.13). *Graphic design by Bill Cannan and Co., New York City, for Washington Metropolitan Area Transit Authority.*

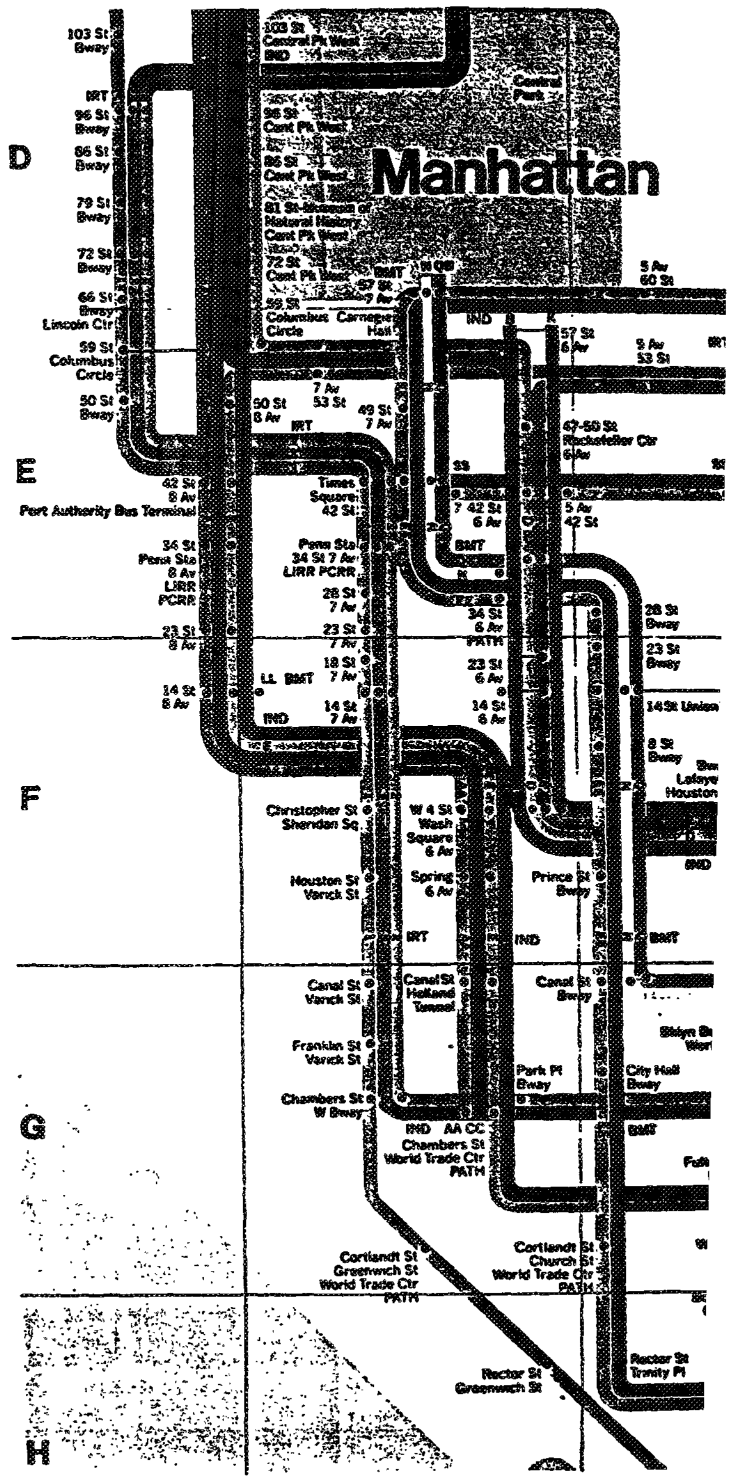


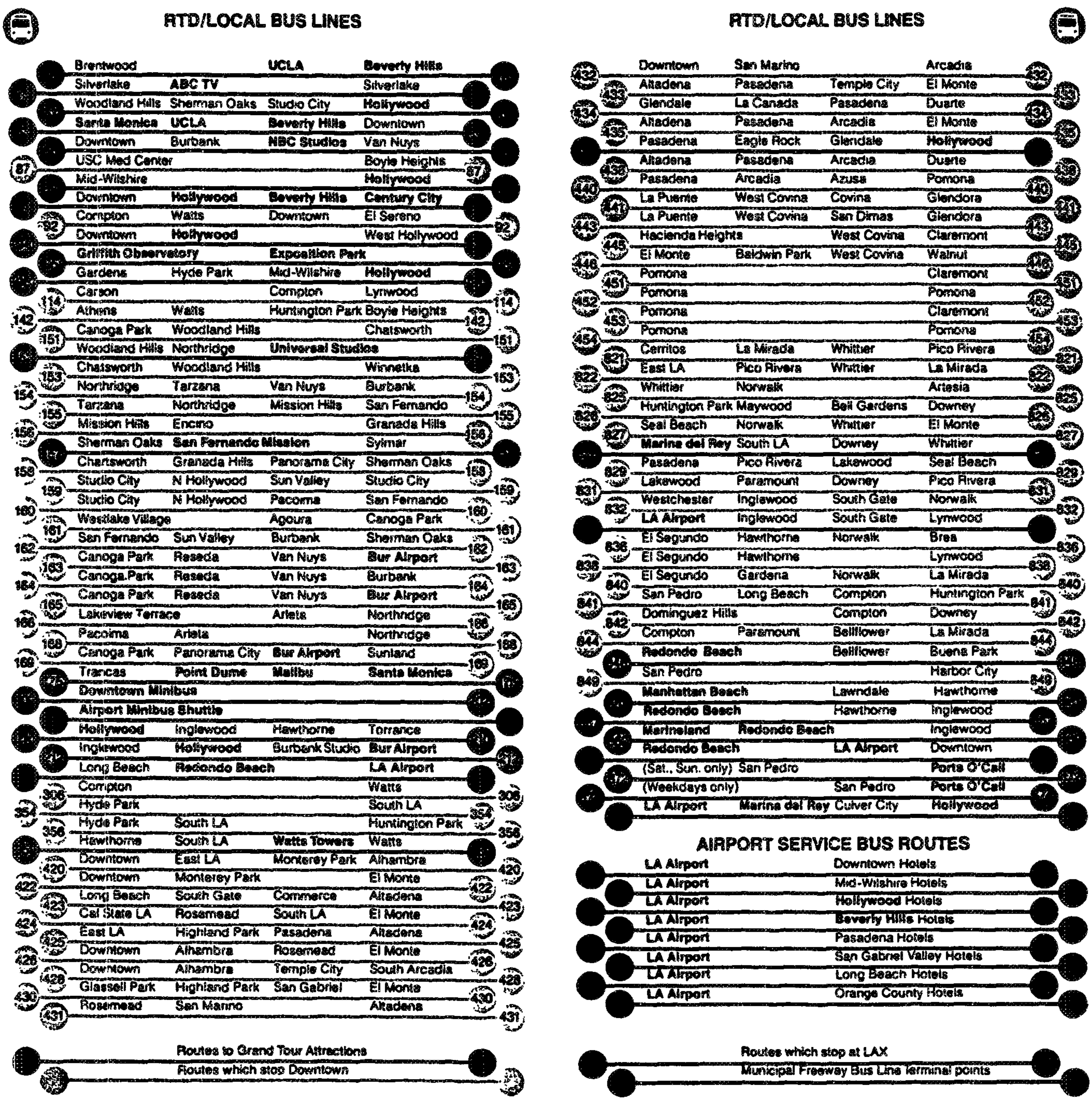
ew York Subway Map
iis map attempts to solve any of the functional probms of earlier New York subay maps. Care has been taken give many geographic refernces, including streets, street ames, and several landmarks ıd points of interest. The Manattan street pattern has been storted, however, to accomodate the complexity of the ıbway network. Instead of usg the color-coding and rigid eometry of the elegant Vignelli ıap (5.22), only one color—red—is used for all subway lines; different lines are identified by numbers or letters at stations and along routes. This facilitates reproduction of the map in a variety of media and color formats and eliminates the need for color discrimination. The map was tested extensively before final delineation. Such testing is essential to the success of a complex public map. *New York City Transit Authority.*

lanhattan Bus Guide
his rather successful bus map ses four colors—red, orange, lue, and green—to distinguish orthbound, southbound, westound, and eastbound buses. uses are identified by numers inside circles along routes. he light gray street pattern ıelps make the map intelligible, but only streets traversed by buses are named. As with the New York subway guide (5.22), inclusion of district names and more landmarks would make the map more useful. *New York City Transit Authority; copyright 1974.*

lew York Subway Guide
he complex New York subway system, a maze of intersecting ınd overlapping routes, is simlified in a handsome diagram f color-coded route lines in the manner of the London Underground map (5.13). Distances ıre distorted for the sake of larifying the diagram. Streets ınd some landmarks are named o provide orientation, but more rientation cues, such as district names, would be helpful. Color-coding is useful when no more than a handful of readily distinguished colors is necessary. Testing has shown that color discrimination of the general public is not reliable for coding of more than five or six variables. *Massimo Vignelli, designer; New York City Transit Authority, copyright 1974.*



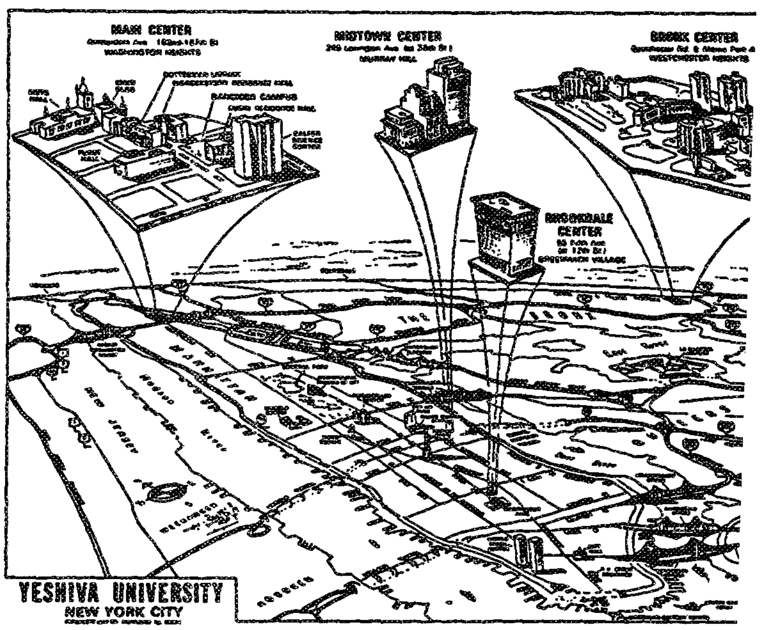

Manhattan
D
E
F
G
H
103 St Bway
IRT
96 St Bway
86 St Bway
79 St Bway
72 St Bway
66 St Bway Lincoln Ctr
59 St Columbus Circle
50 St Bway
42 St 8 Av
Port Authority Bus Terminal
34 St Penn Sta 8 Av LIRR PCRR
23 St 8 Av
14 St 8 Av
Central Park
5 Av 60 St
57 St 6 Av
9 Av 53 St
47-50 St Rockefeller Ctr 6 Av
50 St 8 Av
7 Av 53 St
49 St 7 Av
Times Square 42 St
7 42 St 6 Av
5 Av 42 St
Penn Sta 34 St 7 Av LIRR PCRR
28 St 7 Av
23 St 7 Av
18 St 7 Av
14 St 7 Av
LL BMT
IND
34 St 6 Av PATH
23 St 6 Av
14 St 6 Av
28 St Bway
23 St Bway
Christopher St Sheridan Sq
W 4 St Wash Square 6 Av
Houston St Varick St
Spring 6 Av
Prince St Bway
Canal St Varick St
Canal St Holland Tunnel
Canal St Bway
Franklin St Varick St
Park Pl Bway
City Hall Bway
Chambers St W Bway
IND AA CC Chambers St World Trade Ctr PATH
Cortlandt St Greenwich St World Trade Ctr PATH
Cortlandt St Church St World Trade Ctr PATH
Rector St Greenwich St
Rector St Trinity Pl



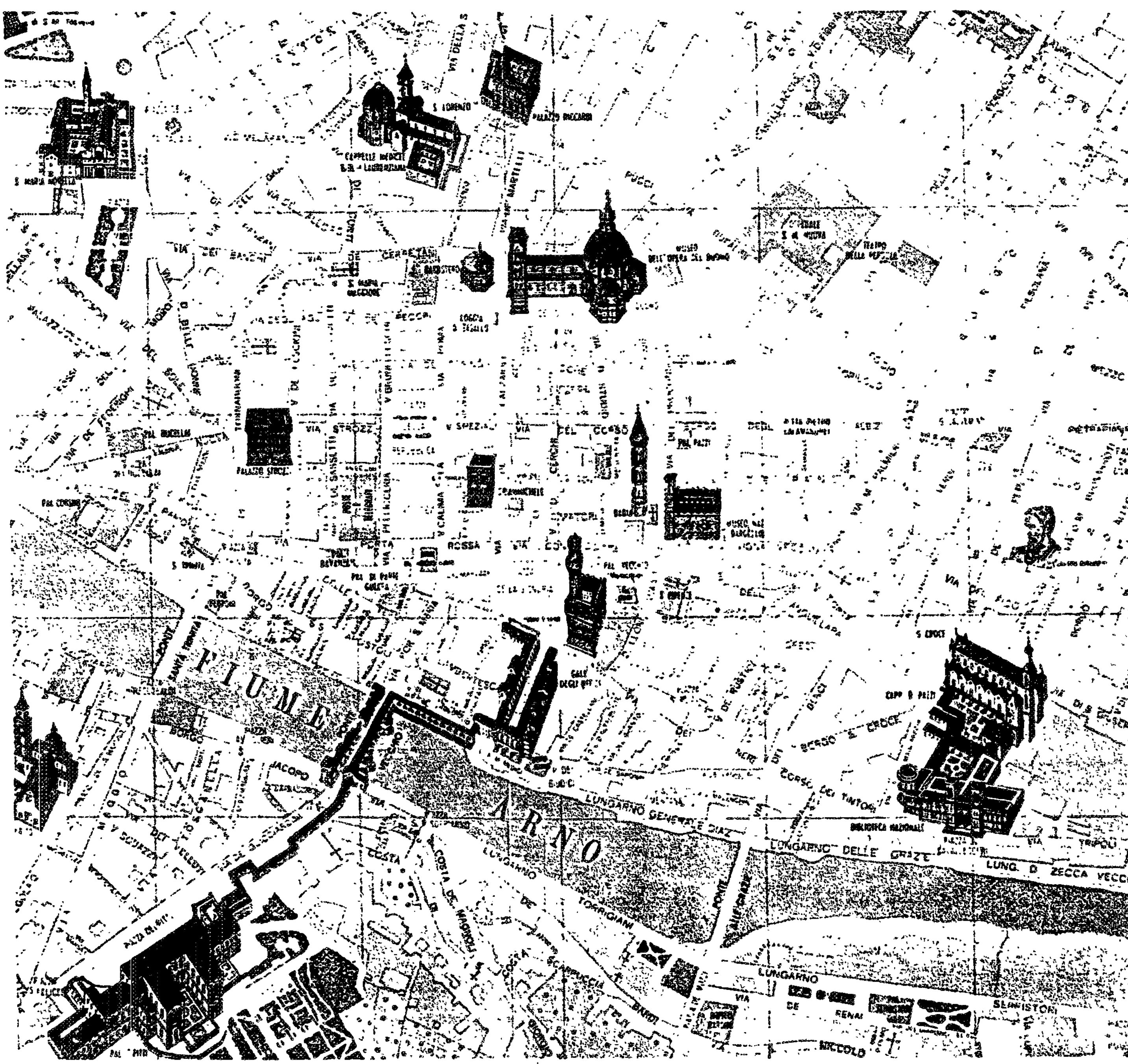
Bus Chart: Los Angeles
This chart is actually a series of diagrammatic strip maps of bus routes. Routes are listed in numerical order with end points and primary destinations listed verbally. The chart is attractive and easy to read, but no information is given about interconnecting bus routes or travel time. Route colors differentiate various types of buses: red lines go to major tourist attractions, orange lines begin or end downtown, green lines stop at the airport, and blue lines are part of the municipal freeway bus system. *Richard Saul Wurman and Michael Everitt, in Richard Saul Wurman, LA/Access (Los Angeles: Access Press, Inc., © 1980).*

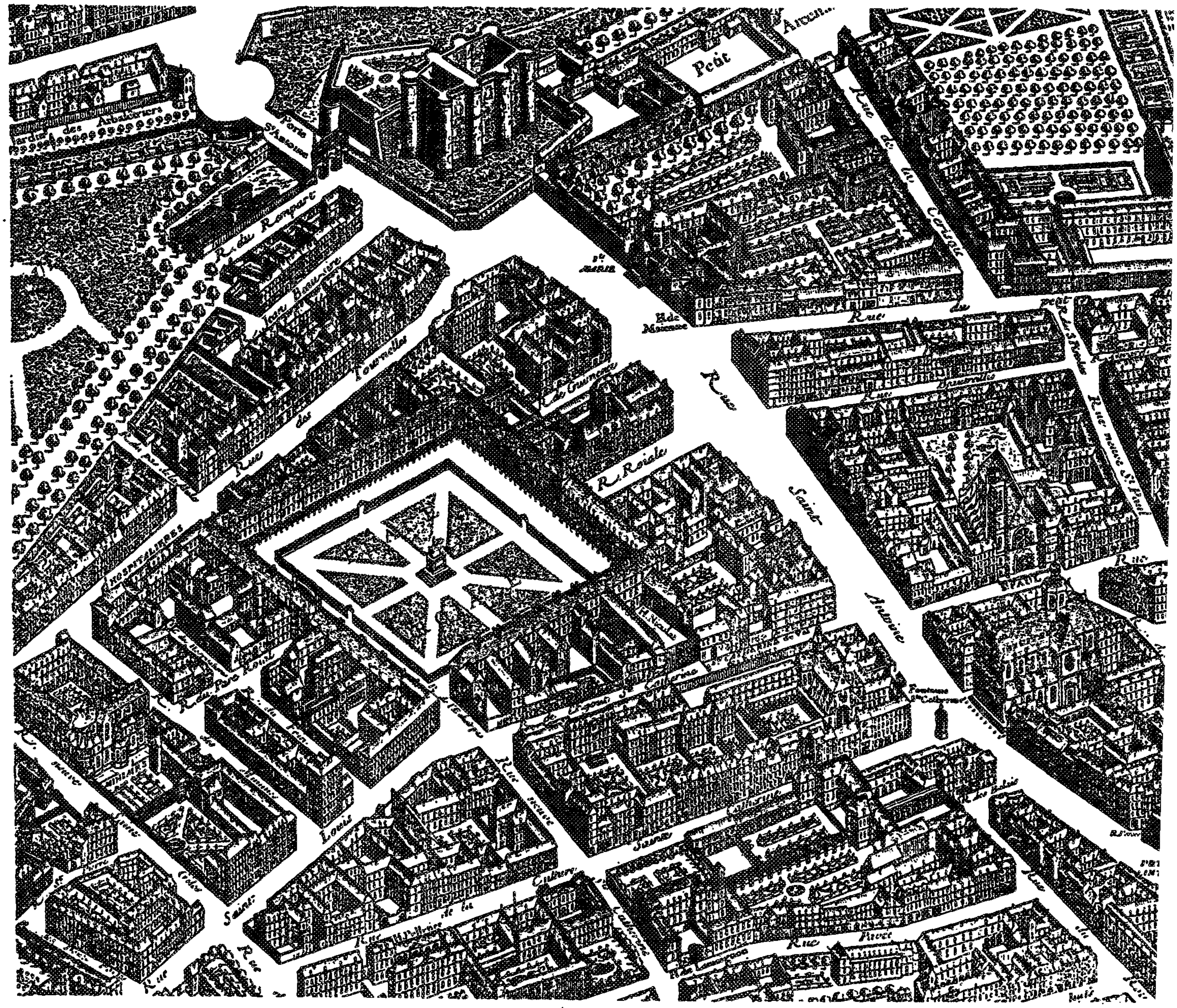
Historic Mantorville, Minnesota
A simple street map is made more imageable by surrounding it with sketches of several landmarks that are keyed back into the map. Although this technique requires the user to jump back and forth between the map and the sketches, the map is kept free of distracting information and is easy to use. For large areas with numerous sites, however, the technique becomes impractical. *By Ron Hunt for Mantorville Restoration Association, Mantorville, MN.*

Zoom Map: Yeshiva University
A school with a regionally dispersed campus had the difficult problem of showing the location and transportation connections between the several campuses, as well as the appearance and layout of each campus. This was accomplished on one map by means of an unusual zoom technique. The pieces of land seem to pop out of the distance and float like magic carpets close to our view. *Copyright © Perspecto Map Co., Inc., Richmond, IL 60071. Map artist, Eugene Derdeyn.*



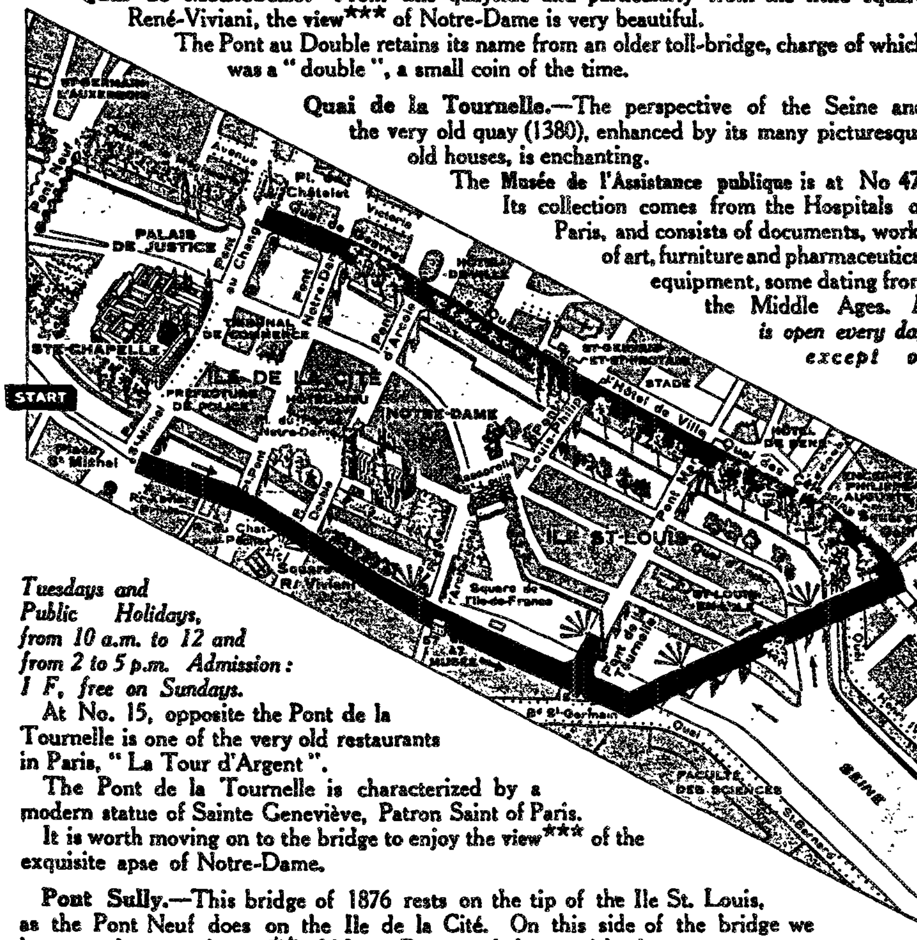
Florence: Plan of the City
Major landmarks are carefully delineated in three dimensions with correct orientation and scale against the background of a simple but correct street map (compare 4.1). Because only a few buildings were chosen for illustration there was no need for other distortions, such as widening of the streets (compare 4.20). Blocks are shaded, leaving the streets white and more legible. The map is attractive and easy for strangers to use. *Reproduced from the plan of Florence by Litografia Artistica Cartografica, Florence, Italy.*





Paris: Plan Turgot, 1734
Elegance and detail are the outstanding qualities of this eighteenth-century engraved map. Buildings are shown in axonometric projections, with correct detail and orientation. Streets, however, are widened so that they don't disappear behind buildings. The map allows study and armchair travel in depth, but it could also be used for real travel. Because of its detail, this technique is eminently well suited to the foot traveler. *From* Paris au XVIII Siècle; Plan de Paris en 20 Planches; Dessiné et gravé sous les ordres de Michel Étienne TURGOT, Prévôt des marchands; Commencé en 1734—Achevé de graver en 1739; Levé et dessiné par Louis Bretez *(Paris: A. Taride, 1908). Photo courtesy of Harvard College Library.*

Route Map: Place St. Michel to the Pont Sully, Paris
This map suggests a sight-seeing route (shown in red on the original) and indicates major landmarks in pictorial terms. Major vantage points are indicated by the fanlike symbol. The accompanying text provides a running verbal description of the sites in sequential order. *Michelin,* Paris and Principal Sights Near By *(Michelin copyright 1968, English ed.)*



Quai de Montebello.—From this quayside and particularly from the little square René-Viviani, the view*** of Notre-Dame is very beautiful.

The Pont au Double retains its name from an older toll-bridge, charge of which was a " double ", a small coin of the time.

Quai de la Tournelle.—The perspective of the Seine and the very old quay (1380), enhanced by its many picturesque old houses, is enchanting.

The **Musée de l'Assistance publique** is at No 47. Its collection comes from the Hospitals of Paris, and consists of documents, works of art, furniture and pharmaceutical equipment, some dating from the Middle Ages. *It is open every day except on Tuesdays and Public Holidays, from 10 a.m. to 12 and from 2 to 5 p.m. Admission: 1 F, free on Sundays.*

At No. 15, opposite the Pont de la Tournelle is one of the very old restaurants in Paris, " La Tour d'Argent ".

The Pont de la Tournelle is characterized by a modern statue of Sainte Geneviève, Patron Saint of Paris.

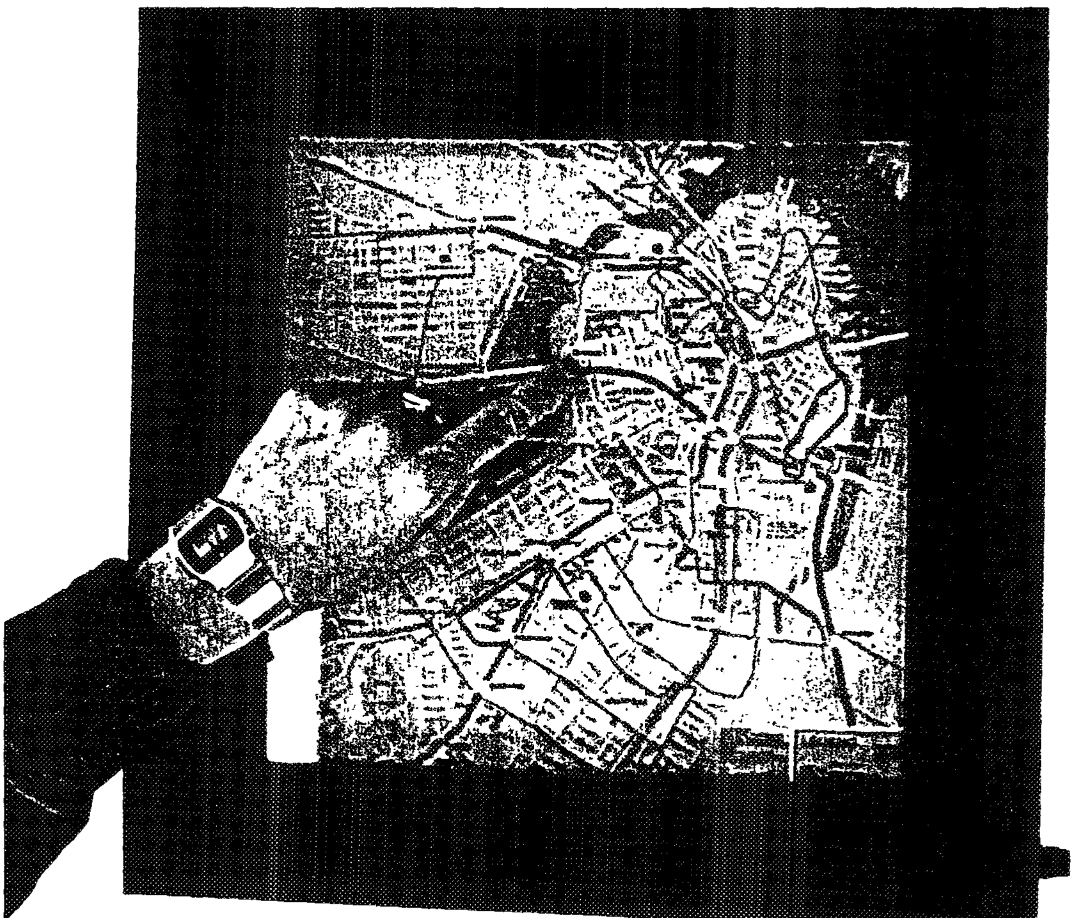
It is worth moving on to the bridge to enjoy the view*** of the exquisite apse of Notre-Dame.

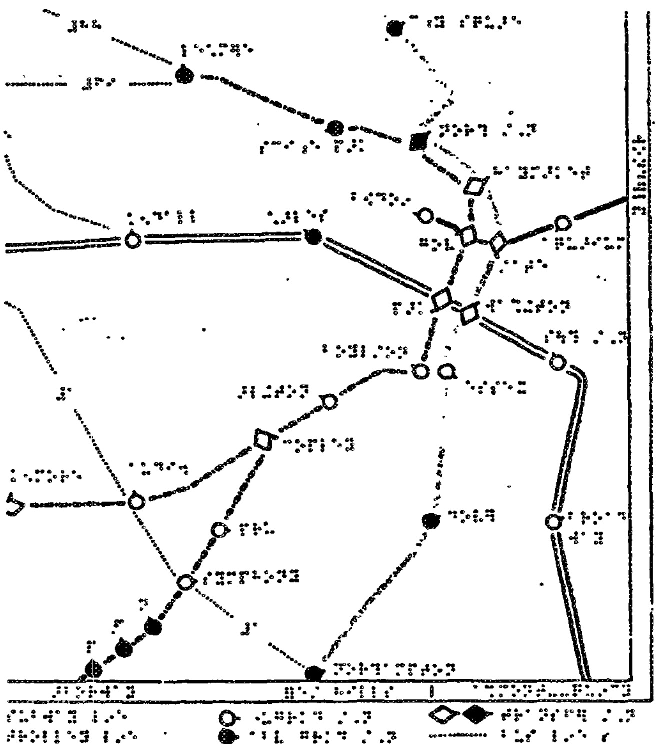
Pont Sully.—This bridge of 1876 rests on the tip of the Ile St. Louis, as the Pont Neuf does on the Ile de la Cité. On this side of the bridge we have another superb view** of Notre Dame and the two islands.

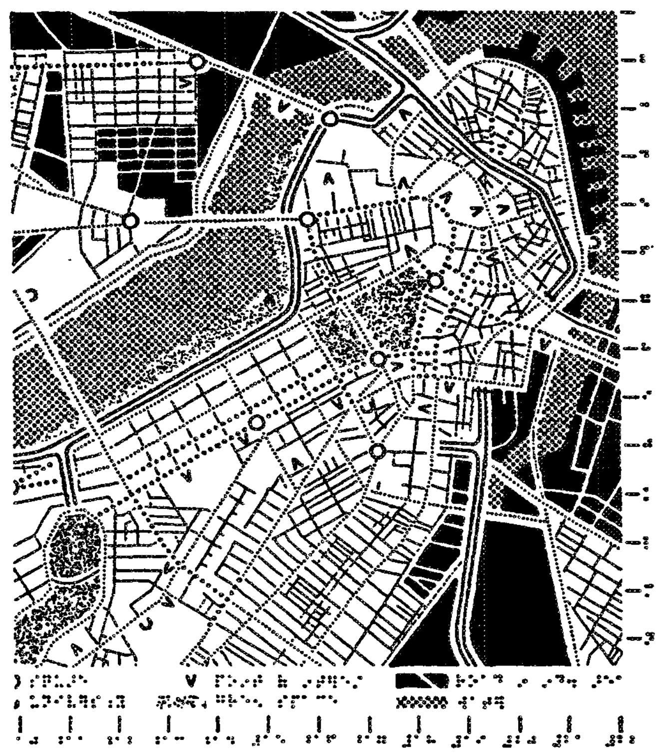
The garden of the island, crossed by the bridge, is charmingly wooded and a favourite haunt of children. From the other side of the island, the sight** is in a different key, more intimate and perhaps more delightful.

Touch-Sensitive Auditory Map

By touching any point on the map, the user hears a description of the place he is touching. Sonars (piezo ceramic transducers) located on two sides of the frame locate the coordinates where the user's finger is pointing. The corresponding data set is then retrieved from the disk where auditory data is stored digitally. A map such as this would be particularly valuable to the sight-impaired, nonreaders, or children. *Architecture Machine Group, MIT.*

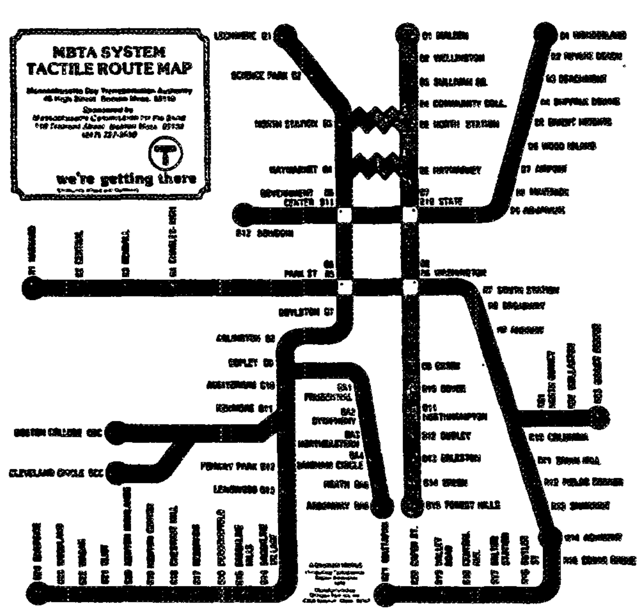




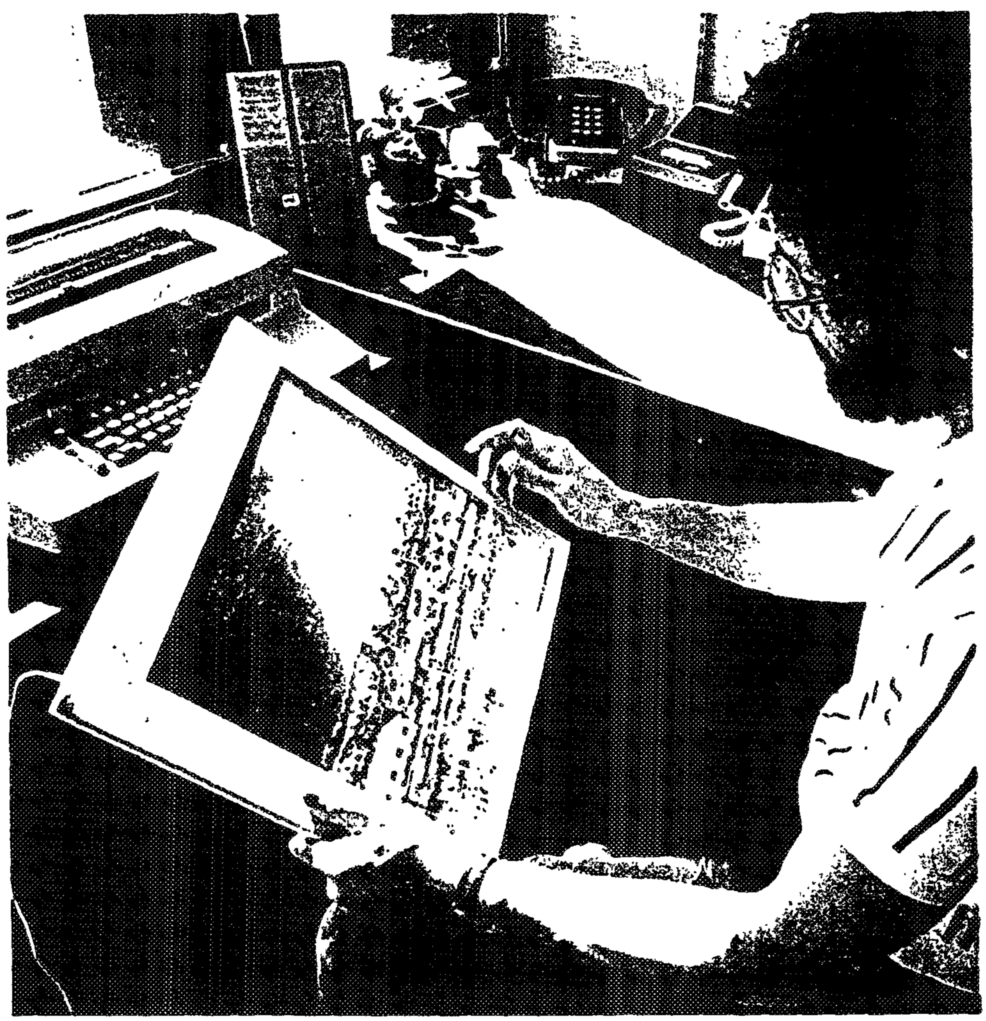


Braille-Tactile Map: Boston and Cambridge
Maps for the blind, a fascinating branch of cartography, also have implications for the sighted. Buildings and pathways are embossed in low relief, creating a map that is in many ways more concrete and intelligible than most printed maps. For the blind, special attention is given to navigation aids and problems; for example, curbs and other barriers or hazards are tactually emphasized, as are guidance cues such as paving texture, fences, or walls. Place names are usually embossed on the maps in Braille. (For more information see Ann Middleton Kidwell and Peter Swartz Greer, *Sites, Perception, and the Non-Visual Experience*, American Foundation for the Blind, 1973.) *Prepared by MIT Planning Office, manufactured by Ithamai Kutai, distributed by Howe Press of the Perkins School for the Blind, Watertown, MA; copyright 1973 by the Massachusetts Institute of Technology.*

Braille Map: MBTA System Tactile Route Map
The Braille map of the Boston subway system presents the route diagram with raised ridges defining the lines, station names in Braille, and a raised dot on the line for each station location. The routes are also printed in color and station names are printed in letters, allowing for interaction with the sighted. Additiona: .nformation, including instructions and information about each station, is keyed into the map from several attached sheets in Braille. Relative distances between stations are distorted in the diagram, which may present planning problems for the blind just as it would for the sighted. *Robert Amendola and Gilligan Tactiles, Inc., for Massachusetts Commission for the Blind and Massachusetts Bay Transportation Authority, Boston, MA; copyright 1974.*



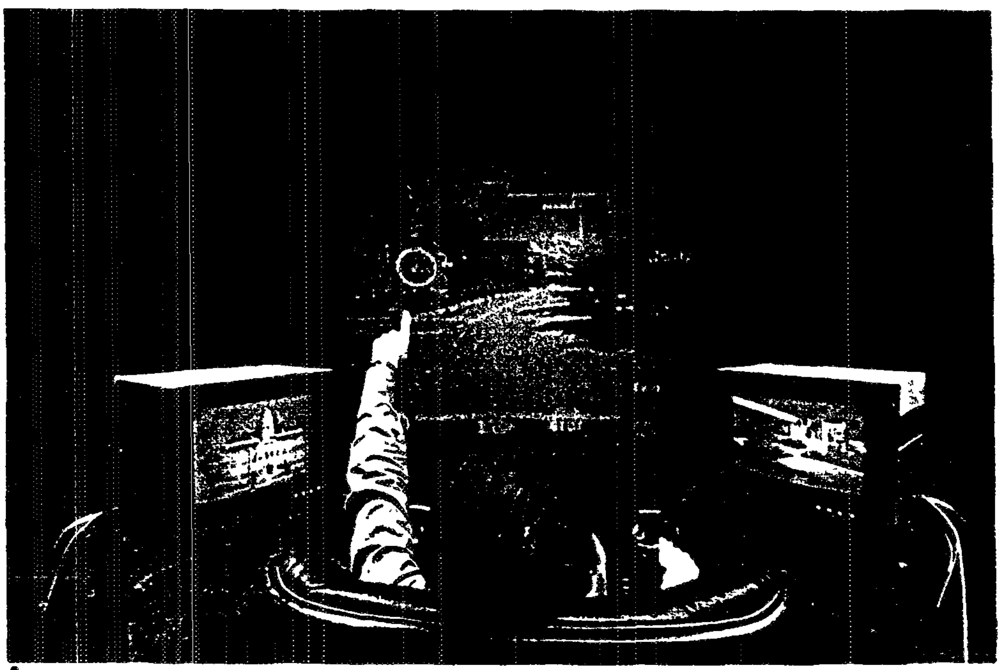
Participatory Simulation Map: Mapping by Yourself
A hand-held 12-by-12-inch mapping "window" is capable of presenting computer-stored images of an environment from multiple vantage points. In effect, the user can travel through the modeled environment, controlling path, speed, angle of approach, and scale. Touch-sensitive layers on the panel allow the user to input requests and to manipulate information displayed by using the fingers. Other aspects of the "Mapping by Yourself" project include amplifying maps with sound, representing uncertain information, and making surfaces such as the ground penetrable, "transparent." *Architecture Machine Group, MIT.*

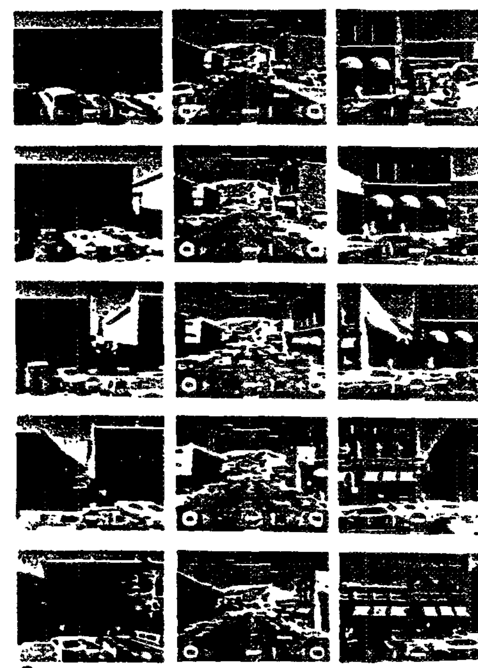


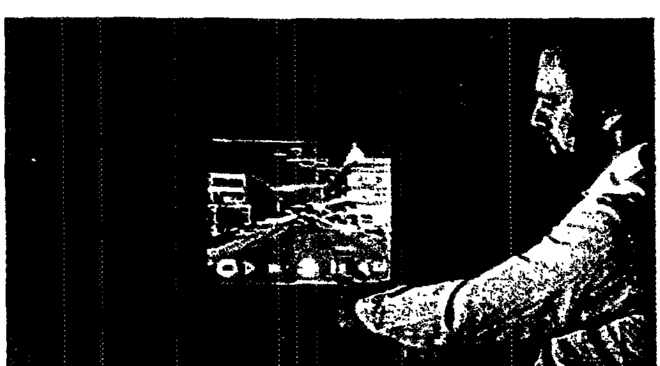
Interactive Movie Map: Aspen

This experimental mapping system attempts to simluate "being there" and gives the user the ability to "drive" through the environment, selecting his own route and speed. The viewer "drives" by means of a joystick or a touch-sensitive video screen that has a control area at the bottom for forward, reverse, top, left and right turns, slow and fast (**A**, **B**, **C**). The user may also enter many buildings and explore them or obtain more information. For example, one may stop at a restaurant and look at its menu, or at a hotel and view its rooms (**D**). Buildings and streets may be seen at different seasons or at different points in their history (**E**). Self-documentation is another aspect of the system; users may annotate views with notes or sketches, thus creating personalized maps. The technique is useful in familiarizing people with an environment before they actually visit it and has obvious entertainment value for the armchair traveler. The entire photographic base was digitized to eliminate distractions and to enable users to simulate aerial travel and make changes in architectural form (**F**).

Optical video-disk technology, which allows storage and random access to 54,000 television frames, is used to store views of all streets. In this case, Aspen was photographed from a truck with a camera mounted eleven feet above the road (**G**). Photographs were taken every ten feet and in four directions—left, right, ahead, and behind. An audio track provides street names, compass directions, confirmation of turns and other commands, information about landmarks, and distance information. The same streets were also photographed using an anamorphic lens, which records a 360-degree doughnut-shaped panorama that can be projected on cylindrical walls surrounding the user, enhancing the sense of reality. *Architecture Machine Group, MIT.*


A


C


B