THE ARCHITECT'S ROLE

IN

PARTICIPATORY PLANNING PROCESSES

A Case Study of the
Boston Transportation Planning Review

by

WILLIAM DAVID MARTIN
B.Arch., University of Southern California
(1964)

Submitted in Partial Fulfillment
of the Requirements for the Degree of

MASTER OF CITY PLANNING

and for the Degree of

MASTER OF ARCHITECTURE IN ADVANCED STUDIES

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
September 1976

Signature of Author..
Department of Urban Studies and Planning
September 12, 1976

Certified by..
Thesis Supervisor, Department of Urban Studies and Planning

....
Thesis Supervisor, Department of Architecture

Accepted by..
Chairman, Departmental Committee on Graduate Students
Department of Urban Studies and Planning

....
Chairman, Departmental Committee on Graduate Students
Department of Architecture

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A Case Study of the Boston Transportation Planning Review

William David Martin

Submitted to the Department of Urban Studies and Planning and of Architecture on September 13, 1976, in partial fulfillment of the requirements for the degrees of Master in City Planning and Master of Architecture in Advanced Studies.

The objective of this thesis is to understand design problem solving behavior in a participatory planning context. The context is the Boston Transportation Planning Review, an eighteen-month multidisciplinary study of several controversial interstate highway projects proposed for the Boston metropolitan core. An analysis is made of the architect/author's problem solving process in developing alternatives for Interstate 95 Relocated and the third Harbor Crossing.

The study is divided into three parts.

The first part, METHODOLOGY, traces the origin and development of the thesis and presents the basic concepts used in the analysis. Concepts are organized by two themes: those which explain the architect's choice of information, including factors of the task environment and individual attributes of the architect; and concepts which explain the use or processing of information, including divergent and convergent thinking processes, selective attention, sketching, pattern acquisition and conceptual framework development.

The second part presents an analysis of problem solving behavior in two contrasting episodes. The first episode, I-95 RELOCATED, illustrates the operation of the concepts identified in the METHODOLOGY. A detailed description of the task environment and the learning process the architect experienced in the project start-up phase is followed by a description of the initial conceptualization and design development of alternatives. The second episode, HARBOR CROSSING, illustrates some of the problems encountered in applying a design strategy that worked well in the first episode to a different task environment.

The third part of the thesis presents CONCLUDING OBSERVATIONS suggested by the analysis. The fundamental conclusions are (1) that an holistic approach to the study of design behavior yields insights not possible with an analytic approach; (2) that much more is knowable about the nature of design and designing than the author had heretofore been taught/exposed to; (3) that an introspective approach to design analysis can be a powerful tool for self-directed growth and "real" (first-hand) knowledge; (4) that the functioning of an information processing model of design developed by this thesis corroborates much of the basic research of Newell and Simon, de Bono, Arnheim, Bruner and Lynch, among others; (5) that designing transportation alternatives shares many essential details of designing in other contexts; and (6) that personal values play a crucial role in design behavior, exerting a powerful influence on the design process and the products of that process.

Insights and extensions derived from these conclusions include the postulation of a developmental explanation of the "rational" model and the "inspirational" model of design, the need for a reorientation of design education and several recommendations for the design of future planning/design processes.

Thesis Supervisors:	Ralph A. Gakenheimer	Tunny F. Lee
Titles:	Associate professor Department of Urban Studies and Planning	Associate Professor of Urban Design Department of Architecture

Many minds, hearts and hands have supported this effort through its various stages of evolution. I would especially like to thank:

Professors Ralph Gakenheimer and Tunney Lee for their patient guidance and insights through many drafts and discussions.

Dean William Porter and Professor Kevin Lynch for their inspiration, example and timely suggestions at critical junctures throughout my graduate experience at MIT.

Peter Hopkinson, David Smith and Charles Steinman, colleagues at Skidmore, Owings and Merrill, for their continuing support of my professional growth and their helpful comments on many drafts.

Guy Weinzapfel and Adel Foz for the sharing of many ideas and insights that are central to the thesis as well as for their thoughtful reviews of my drafts.

Numerous others at MIT, SOM and the BTPR, whose support of my professional and academic development during this period have contributed to the preparation of this thesis.

My family and many friends who provided moral support along the way.

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This thesis is about design behavior; the interrelationship between human problem solving faculties and the design environment which sets these faculties in motion.

For all that has been written and said, the individual architect understands little about the inner workings of the processes by which he is known as a "professional". Architectural education still falls back on a collection of myths to explain the "mystery" of the creative process. Insights into the true nature of design are invariably partial; disembodied from the social and spatial contexts which give them meaning they conform to mechanistic models which give the illusion that design may be understood as a collection of separate bits and pieces, things, events, causes and effects.

The rationale for the analysis of separate parts should be grounded in a recognition of their essential inseparability. This thesis attempts to present an analysis of design behavior in parts that may be perceived as a whole; it respects the inherent mutuality of process and context, tasks and task environments, facts and values.

The analysis is based on my experiences as an architect/urban designer/planner on the staff of the Boston Transportation Planning Review (BTPR), an eighteen-month multidisciplinary study of metropolitan expressway and transit facilities. The commencement of the BTPR coincided with the completion of my first two years of the joint degree program at MIT. I was exploring ideas for a thesis topic when I learned that Skidmore, Owings and Merrill, one of the design consultants, would be hiring architects in Boston to work on the project. I decided to take a leave-of-absence from MIT to participate in the BTPR and then write my thesis on some aspect of my experience.

The BTPR was a precedent-setting transportation planning process; yet there may never be another process like it. This is because the context which spawned the BTPR is unique to a particular juncture in Boston's evolution, a juncture characterized by (1) the eclipse of the automobile as the dominant transportation solution to urban (re)development; (2) the political awakening of core area communities to the excesses of continued expressway construction in the inner city; (3) the failure of technocratic planning models to deal with problems and processes which include extensive social consequences; and (4) the termination of the federal interstate highway program which, with its guarantee of 90 percent federal funding, had for many years distorted the evaluation of alternatives to the automobile for urban mobility.

The increasing awareness of the need for radical change in transportation planning was widespread. Yet the inertia provided by previous highway proposals and vested interest groups of land speculators, highway builders, and the auto/oil industries (as well as many professionals and public officials) was a formidable obstacle to be overcome by Governor Francis Sargent's call for a "balanced transportation plan" for the Boston metropolitan core.

The BTPR staff thus found itself on the front lines in a battle between conflicting values and priorities that marked an historic turning point in Boston's spatial and socio-political development. It was an exciting place to be! For a few veteran community leaders it was apparently a foregone conclusion that once the highway proposals were subjected to a participatory process they would not be constructed. As one who found himself on the front lines for eighteen months, I did not share this perception of political inevitability; the conflict was real and the exposure of critical issues and choices for public debate required a total commitment of skills and energies.

The thesis explores the origins and inner workings of my problem solving process through an analysis of the development of alternatives for the third Harbor Crossing and a segment of Interstate 95 through the Boston regional core. The analysis is concerned with design as a total system of behavior rather than as products or isolated processes. The focus is thus on the interrelationships between my professional skills and personal values on the one hand, and the demands of the BTPR problem context on the other. A basic methodological assumption is that the understanding of behavior requires a concurrent analysis of both the task and the task environment, that the two, in fact, arise mutually or imply one another. Thus, the thesis describes the essential elements of the BTPR task environment and analyzes my "symbiotic" relationship to that environment in the development of alternatives.

The exploration of the relationship of the BTPR task environment to my problem solving behavior has been one of the major objectives in writing the thesis. A second objective has been to identify and understand the principal features and mechanisms of my design process as it evolved during the BTPR. In accomplishing this objective, I believe I have "demythified" many misconceptions about the nature of design and designing. A third objective has been to document this process of self-discovery and integration of ideas. A fourth and final objective has been to use the thesis to explore my ideas regarding design education, the design of planning processes and the identification of normative roles for the architect in future processes.

The thesis is structured to accomplish these four objectives. Chapter I, METHODOLOGY, begins by describing the evolution of the thesis and the selection of two complementary "themes": the choice and the use of information in the development of alternatives. Next, it describes the basic concepts used in the analysis of the use of information during BTPR design episodes. Concepts relating divergent thinking, selective attention, sketching, pattern acquisition and conceptual framework development are used to adapt Newell and Simon's (1972) information processing model to fit my design process. Finally, the factors influencing my choice of information -- contextual factors and individual attributes -- are identified and the notion of orientation is introduced to explain the operation of my personal values and motivations.

The second and third chapters present two contrasting episodes from the BTPR to illustrate my problem solving behavior. EPISODE ONE: I-95 RELOCATED describes the development of six alternative Program Packages for Interstate 95 Relocated (I-95R) in Boston's Inner North Shore. The first two sections of this episode describe in some detail the BTPR/I-95R task environment and my initial perceptions and preparation for designing in this environment. The following two sections describe the process of conceptualization -- the initial translation of problem statement into form solutions -- and the development of a set of Basic Choices into six final Program Packages for community review and decisions.

EPISODE TWO: HARBOR CROSSING illustrates the behavioral adaptation required by the application of the problem solving strategies learned in the first episode to a different task environment. It begins by comparing the task environments of the two episodes and then analyzes the implications of these differences in the development of three radically different alternatives for the Harbor Crossing study area. Two complementary factors are seen as the key to understanding the problem solving sequence for this episode: the role of the East Boston community and my orientation toward the participatory process.

The fourth chapter, CONCLUSIONS AND EXTENSIONS, presents major conclusions based on the analysis of the episodes and some of the implications of these conclusions for design education, the design of participatory processes and normative roles for the architect in future processes.

The reader interested primarily in problem solving and design methods will be most interested in the last three sections of the METHODOLOGY, the "Genesis of the Problem Space" and "Summary" sections from EPISODE ONE and the first part of the CONCLUDING OBSERVATIONS. The reader interested primarily in the BTPR context and the design of planning processes will want to read the Study Design summary in the APPENDIX, "The Task Environment" and "Phase I" and "Phase II" from EPISODE ONE, all of EPISODE TWO and the section in the CONCLUDING OBSERVATIONS dealing with the design of future processes. And for the reader interested in design as behavior -- as the interplay between "choice" and "use", facts and values, tasks and task environments -- he may have to read the entire thesis, perhaps beginning with the CONCLUDING OBSERVATIONS to get a sense of the whole.

It should be noted that the term "architect" as used in this thesis refers to the author and other BTPR staff members with architectural education backgrounds. The term is intended to differentiate these individuals from the engineers, economists, transportation analysts and other BTPR disciplines. Most of the BTPR architects had had previous experience with large-scale design projects. It would perhaps have been more correct to use the term "urban designer"; clearly, the grasp of issues, relationships and processes was beyond that normally associated with architectural projects.

A final caveat for the reader: this thesis is written from the point of view of one architect in the BTPR: the author. From this vantage, the reader who is unfamiliar with the BTPR is likely to view the process in the same manner he perceives the sun to be rising in the morning instead of the earth turning. (There are several recent references on the BTPR which provide a more "balanced" view.[1]) The architect played an important role in the development of alternatives, to be sure, but the final products of the BTPR were decisions, not alternatives, and the architect was by no means at the center of the BTPR decision-making process. The architects represented less than one-tenth of the total BTPR technical staff. Moreover, the staff itself was only a small part in the constellation of participants which included numerous political leaders, federal and state agency representatives, public and private interest groups, community groups and organizations, and innumerable private citizens -- each of whom had a special point of view to express and some personal stake in the eventual outcome of the study. The products which finally emerged (i.e., the Governor's decisions) were the results of a process which managed to take account of the inputs and concerns of the full spectrum of participants.

There was a young man who said, "Though
It seems that I know that I know
  What I would like to see
  Is the 'I' that knows 'me'
When I <u>know</u> that I know that I know."

The construction of a valid methodology by which to rationalize what must be a relatively unusual thesis approach, i.e., an analysis of my own design process, was problematic. Many investigators have made important contributions to research by analyzing their own behaviors, but these have invariably been done under carefully controlled laboratory conditions, the results of which could easily be replicated by others. This thesis has neither the objectivity of a rigorous "scientific" analysis of someone else's work nor the test of sufficiency resulting from a carefully controlled analysis of my own behavior. The analysis was done after the "experiment" (my involvement in the BTPR) was completed; it is (necessarily) subjective, a Rashomon perspective. The perceptions of my role have evolved as much during the writing of the thesis as they did during the process itself. Finding an appropriate thesis methodology under these conditions was a lot like chasing a phantom: the methodology changed almost as fast as my perceptions. (Thus the syllogism on the last page of the POSTSCRIPT.) As a consequence, the methodology is, to a considerable extent, a summary of how the thesis evolved to its present state.

The focus of the thesis is clearly on the individual, on myself. Yet the analysis is empirical rather than experimental: there is no experimental design and no control group, as might be expected in a traditional psychological study. Rather, through detailed analysis there is an attempt to understand both the specific mechanisms of my problem solving behavior and the relationship of that behavior to the highly complex task environment of the BTPR. Although my process was well documented in terms of keeping all of my meeting notes, memoranda, sketches, work programs, etc., participant observation theory was of little help in developing the methodology since I had no systematic plan of analysis during the BTPR by which to "objectively" assess my experiences.

Newell and Simon (1972) have noted that the study of problem solving when applied to psychology leads naturally to constructing systems that model the behavior of a single individual in a single task situation. "Full particularity is the rule not the exception."[2] In terms of psychological theory, then, the methodological objective has been to deal with the uniqueness of my own behavior (idiographic) as distinguished from an experimental approach which deals with the individual as an intersection of statistically defined populations (nomothetic).

Most studies of complex environments follow one of two basic approaches (or some combination of the two): analytic or holistic.[3] The analytic approach generally begins with concept formation, hypothesis development and testing. It then describes possible interrelations among concepts, developing various levels of assertion about reality, from empirical generalizations based on precise measurements to general laws and tested theory. The ultimate objective of the analytic approach is to develop a set of general laws which are independent of the situation, such that any given similar situation could be understood by reference to them. Logical justifications for the analytical approach are well developed. It has been identified for some time with scientific method (which makes the holistic approach "unscientific" by definition). The precise measurements required by the analytic approach suggests the use of survey techniques or comparative analyses.

The holistic approach, by contrast, seeks to understand organization. The careful study of a single case, while lacking the generalizability of the survey, is a more promising strategy for understanding how various elements are organized and operate as a system. The implicit assumption is that the knowledge gained is applicable to a class of similar, complex situations. The density of detail makes the case study ideal for the development and testing of complex models of the organization of the case elements.

This thesis follows the holistic rather than the analytic approach; my process of introspection and self-discovery did not lend itself to <u>a</u>

priori determination. Instead the structure began to emerge only very slowly as I got further into the analysis. I endeavored to find a patterning in the analysis of my problem solving process which differentiated between the invariants of problem solving behavior on the one hand and the variables of the task environment and individual attributes which shaped that behavior on the other. The BTPR case thus serves partly as an argument for the model of problem solving which is developed by the analysis, and partly as an illustration of its application.

A brief description of how an holistic approach to an analysis of my BTPR experience evolved into a thesis with two major themes may be helpful in providing a background by which to understand the resultant thesis format and the function of the models described subsequently.

Escalation and Regression

Determining what aspects of an incredibly rich professional experience I would focus on was difficult. I began with the posing of a series of questions about the architect's role in the BTPR such as "Why did the architect (versus some other discipline) control the technical and participatory processes in every corridor?" and "How much influence did the architect have on the ultimate decisions made?" and "What were the major factors defining the architect's role?" I first wrote down my own ideas, my hunches about what the key factors were. I identified particular aspects of the Study Design -- its openness, its multi-valued orientation, the separation of technical and decision-making responsibilities, etc. -- plus a variety of individual attributes, features of the study process and management, and factors relating to the Boston context, etc., all creating what I perceived as a "neutral" role for the architect.

This approach was clearly too broad to be dealt with in a rigorous manner. It eventually narrowed to an analysis of the architect's role in the technical process and finally to his role in the design of alternatives. This seemed to be a manageable thesis topic or so it seemed at first. Hindsight shows, however, that it was at this point that I fell victim to two tendencies of research that illustrate the hierarchical nature of complexity, namely "escalation" and "regression".[4] I credit my succumbing to these tendencies to my professional training wherein I was invariably admonished at the outset of each design problem to explore the next larger as well as the next smaller scale for relevant inputs to the problem context and to insure "good fit". In any event, my writing took me in these two (opposite) directions. The architect's role in the design of alternatives escalated well beyond its starting point, via the intuitively logical justification that the design of alternatives could not be understood out of the context of the BTPR technical process as a whole. The technical process, of course, was intimately tied to the BTPR participatory and decision-making processes which evolved from a complex history of Boston's urbanization and the evolution of transportation, as well as political and social processes. By the time one grapples with issues of community values, the legitimization of the BTPR process, and normative roles for the architect, one is half-way to dealing with the ultimate questions of philosophy.

At the same time, my analysis began an infinite regression to understand the molecules and atoms of problem solving behavior which had produced the final BTPR alternatives. Initially, this regression produced a highly detailed chronology of the development of alternatives compiled from extensive notes taken during the BTPR. This chronology dutifully noted the effect of each input from each source on the evolving design. But it was largely a descriptive history with few insights into how the architect actually used information.

It was at this point that my thesis advisors suggested that I refocus my approach to emphasize the development of my own problem solving process, rather than the development of the alternatives. I began to look more carefully at why and how I used information. The thesis became the vehicle for a period of intensive introspection and intellectual growth. I read extensively to find answers to the many questions that surfaced. It was during this period that I first came across Newell and Simon's work Human Problem Solving. Their model, based on an information processing theory of problem solving, provided the elements of a basic framework which I sensed could be extended to account for many of the essential elements of my design behavior during the BTPR.

Two Themes

Refocusing on an information processing analysis led me to slice through the materials collected during both the expansion and regression directions producing two complementary themes: one describing the factors which influenced my choice of information and the other describing how I used that information in the development of alternatives. While reducing the amount of relevant data to manageable proportions these two themes also provided a structure which would accomplish the four main purposes of the thesis outlined in the PREFACE.

Although the two themes -- choice of information and use of information -- are seldom (consciously) differentiated during design problem solving, they have implications which justify their separation for purposes of analysis. The use of information, as suggested by Newell and Simon, can be described by a set of characteristics which are essentially invariant across problem solvers in a given task environment. By contrast, the choice of what information will be used in problem solving, particularly in a complex task environment like the BTPR, is a function of many factors which are highly individualized like the values, attitudes and orientations held by each problem solver. Thus, one theme of the thesis attempts to develop a model incorporating the commonalities among BTPR architects while the other theme tries to identify factors which differentiate between them.[5] The following three subsections describe the principal models and concepts which structure the analysis of each theme.

The holistic approach to my thesis led to a search for patterns and conceptual organizations by which to describe my problem solving behavior in the BTPR. The thesis became a vehicle for a very exciting and intensive period of personal growth. Everything I read seemed to have special implications for my search, offering many valuable insights. As a consequence, the ideas of many authors are employed throughout the analyses, whenever and wherever they were helpful in clarifying elements of my problem solving behavior. Since most of these ideas have meaning only in the particular context in which they are used, they are referred to in the text or in footnotes at that point. A few, however, are important enough to the thesis as a whole to be summarized here.

The following subsections describe first, the major elements of the BTPR Study Design which provided the principal model for the task environment and technical process; next, models which are used in the description of how information was processed, with emphasis on the Newell and Simon IPS model; and finally, a summary of the factors influencing the choice of information used.

A passing note may be appropriate here with respect to a comprehensive model, one which might encompass all aspects of my experience with the BTPR: I never found one. The BTPR could, of course, be characterized by a general model of the design process -- e.g., define goals, collect data, analyze, design, evaluate, select[6] -- but such models are not very helpful in explaining the intricacies of individual behavior which is the principal focus of this thesis. Several authors have argued that a general model for the environmental sciences is not even possible. Fleisher (1970), for example, argues that such a model would probably need to include not only a description of the process required to develop alternatives but also their feasibility of implementation. Since the latter is a function of the nature of the problem and its specific context, it is not a matter for models and a priori processing.[7]

BTPR Study Design

The BTPR Study Design was the product of a special Task Force convened by the Governor following his declaration of a moratorium on all new highway construction in the metropolitan region within Route 128. The Task Force, composed of community representatives, professional consultants and state and federal agency representatives, was charged with developing a process which would result in a "balanced" transportation plan for the Boston metropolitan region. The product of their efforts had a pervasive influence on all aspects of the architect's role in the BTPR. The "Study Design for a Balanced Transportation Program for the Boston Metropolitan Region" set forth in considerable detail the background leading up to the BTPR, the objectives of the study and the goals and major features of the BTPR task environment. A key element of the Study Design was the definition of and relationship between various technical, participatory and decision-making aspects of the study process.

The Study Design identified three broad preliminary alternatives which were well spaced in terms of the emphasis given to the mix of elements from different transportation philosophies. A three-phase iterative design process was outlined which was intended to "increase the effectiveness of participation by permitting many alternatives to be examined in sketch plan form, decreasing the time required for each plan-making cycle, and permitting feedback from participants to shape reformulation of plans and designs in later phases." The analysis of episodes will show that the Study Design requirement for the use of sketch planning and sketch design techniques in Phase I was a major factor in the architect (those with architectural education backgrounds) assuming the role of technical synthesizer and initiator of alternatives.

The Study Design also defined the study products or "program packages" on which decisions would be based. Each program package would include "a wide range of transportation elements (e.g., expressways, rapid transit, arterial improvements, parking policy, local circulation and feeder transit), and also a wide range of complementary elements designed to alleviate negative impacts and exploit opportunities to improve the quality of life in impacted communities (e.g., economic development, replacement housing, improved community facilities)." Over seventy criteria were identified by the Study Design for use in the design and evaluation of program package alternatives. These included social, economic and aesthetic criteria requiring the application of qualitative assessment techniques as well as the traditional quantitative cost/benefit measures of capital costs, time savings, accident reductions, etc. The authors of the Study Design clearly intended this document to be an instrument of change, a means of integrating community values into the transportation planning and design process.

The Study Design was thus the principal "model" structuring the BTPR process and guiding both the choice and use of information by the architect in his development of alternatives. It defined a process which implied a set of values heretofore neglected in transportation planning. The analysis of design episodes frequently refers to various sections of this document. Many of these references are included in the twenty-five page summary of the Study Design which is appended to this thesis.

One of the two principal themes of the thesis, as described earlier, deals with the use of information in design problem solving -- what actually happens in the architect's mind and how design behavior is externalized in the translation of problem statements and informational inputs into form/design outputs.

Most models of the functioning of the human mind deal (implicitly at least) with one of two modes of thinking, both of which are essential to design problem solving in the BTPR context: 1) convergent thinking, during which cognitive subprocesses are directed toward acquiring a solution or closure to a problem for which a known or generally acceptable answer may be found; and 2) divergent thinking in which cognitive subprocesses seek a new (at least to the thinker) or not generally accepted solution.[8] Each of these modes implies a different way of processing information: convergent thinking is what one normally thinks of in problem solving, i.e., finding "the answer" using reasoning, logic, or critical thinking: it is the "selective" thinking mode. Divergent thinking is associated with creativity, with imaginative or original thinking; it is the "generative" thinking mode.

The two modes are entirely complementary in design problem solving but since they serve very different functions, the distinction between the two is essential to understanding the use of information.

Design employs informational symbols encoded in visual patterns. The analysis of design episodes explores how these patterns are formed and manipulated in the development of transportation alternatives during the

BTPR. Essentially, we will see that convergent thinking uses patterns stored in memory from previous experience to select a solution appropriate to the problem. Divergent thinking is employed when a solution is not apparent or when a solution (answer) is not being sought. Divergent thinking uses information provocatively to restructure existing patterns and/or acquire new ones which may then be used by convergent thinking subprocesses to develop a solution. Herein lies the essential complementarity of the two modes: in order to be able to use the provocative qualities of divergent thinking the designer must be able to follow up with the selective qualities of convergent thinking. In this thesis, the models and concepts selected to describe how information is processed during pattern acquisition and problem solving usually deal with subprocesses in one or the other of these two modes of thinking. The Newell and Simon IPS model, for example, illustrates the use of convergent thinking processes.

Newell and Simon's IPS Model

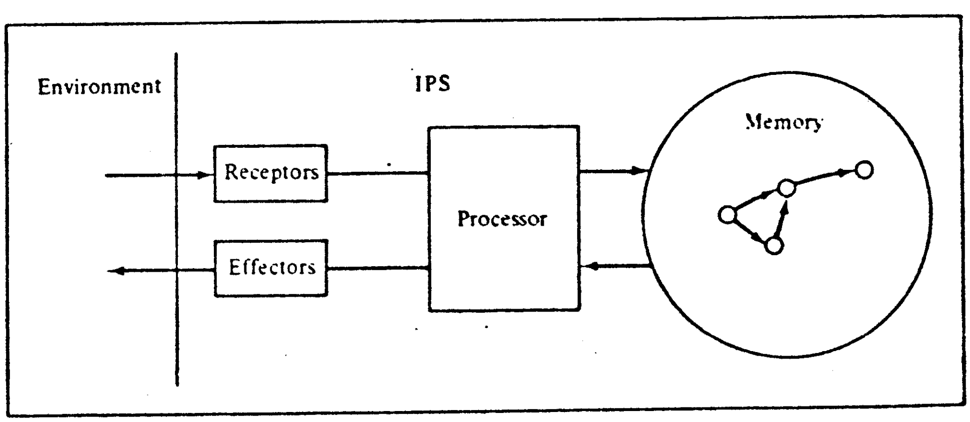
Using the computer as their basic metaphor, Newell and Simon (1972) have developed an information processing system (IPS) model of problem solving based on the self-maximizing properties of the mind when it is employing the selective or convergent thinking mode. The theory supporting the Newell-Simon model draws upon the concepts and terminology of cybernetics and artificial intelligence to describe the organization and behavior of the human mind in closed-system problem solving tasks in a laboratory setting.

The core of the Newell-Simon IPS model is defined by three basic memory structures:

1. Long-term memory (LTM) -- the principal internal library or storage area, largely preconscious, where information from previous experience is encoded in symbols and patterns;
2. Short-term memory (STM) -- the conscious area of the mind, capable of handling a limited number of symbols or patterns at any one time, which mediates between LTM and symbol inputs and outputs from and to the external environment; and
3. External memory (EM) -- external symbol and pattern storage sources such as books, manuals, sketches, photographs, or the (perceivable) external environment itself.

The interaction of LTM and STM with the task environment and EM sources is mediated by sensory receptors, principally the eyes, and by motor effectors, principally the arm and hand (as for example, in sketching). In their diagram of the general structure of an information processing system, shown below, Newell and Simon include the STM as an element of the "processor"

Figure 1: General Structure of an Information Processing System



which also includes a fixed set of elementary information processes and an "interpreter" that determines the sequence of processes to be executed.

Problem solving activities take place in a problem space which contains not only the actual solution but possible solutions that the problem solver might consider. The problem space is evoked by, and is an internal representation of, the task environment or problem solving context. The problem space contains, in addition to possible solutions, the problem solver's understanding of the problem, the total information available to him from his various memories, and a set of symbol structures and operators which enable the information to be processed. Processing or search takes place according to a discrete set of methods known to the problem solver (e.g., working forward, means-ends analysis, etc.). The application of methods and their sequence are realized by a selected production system, an organized program of elementary processes performed by the IPS on the information available.

The important (invariant) characteristics of the human IPS that influence its programs for handling problem solving tasks are summarized by Newell and Simon:[9]

1. It is a serial system consisting of an active processor, input (sensory) and output (motor) systems, an internal LTM and STM and an EM.

2. Its LTM has unlimited capacity and is organized associatively, its contents being symbols and structures of symbols. Any stimulus configuration that becomes a recognizable configuration (chunk) is designated in LTM by a symbol. Writing a new symbol structure that contains K familiar symbols takes about 5K to 10K seconds of processing time. Accessing and reading a symbol out of LTM takes a few hundred milliseconds.

3. Its STM holds about five to seven symbols, but only about two can be retained for one task while another unrelated task is performed. All the symbols in STM are available to the processes (i.e., there is no accessing or search of STM).

4. Its STM and LTM are homogeneous, in that sensory patterns in all sensory modalities, processes, and motor patterns are symbolized and handled identically in STM and LTM.

5. Its elementary processes take times of the order of fifty milliseconds but the overall rate of processing is fundamentally limited by read rates from LTM and EM.

6. EM (the immediate available visual field) has access times of the order of a hundred milliseconds (the saccade) and read times to STM of the order of fifty milliseconds. Write times are of the order of a second per symbol for overlearned external symbols.

7. Its program is structured as a production system, the conditions for evocation of a production being the presence of appropriate symbols in the STM augmented by the foveal EM.

8. It possesses a class of symbol structures, the goal structures, that are used to organize problem solving.

Seeing/understanding the implications of these characteristics for my own problem solving behavior provided the greatest source of insights gained in writing this thesis. The concepts summarized by these eight characteristics are used throughout the analysis of design episodes and are particularly important to the CONCLUDING OBSERVATIONS section which deals with the use of information.

Although exposure to the Newell and Simon model came after I was well into thesis writing, its methodological approach was similar to mine in at least one important respect: the step-by-step problem solving chronology which I had already derived from voluminous notes and drawings very closely approximated the verbal protocols which Newell and Simon used to verify their theory. As a consequence, their model was easily adapted to provide the major structuring of the analysis of how information was processed in the development of BTPR alternatives. The chronologic aspect of the thesis is important to understanding both the problem solver as an information processing system (IPS) and the task environment as an organizing system. As Newell and Simon point out, "An information processing theory is dynamic. . .in the sense of describing the change in a system through time. Such a theory describes the time course of behavior, characterizing each new act as a function of the immediately preceding state of the organism and of its environment."[10]

Limits of the Newell-Simon Model

One of the beauties of the Newell-Simon model is that it invites extensions and modifications; the authors themselves touch on many areas where additional research is needed. With respect to design problem solving, several features must be added to their model to account for behavior which I found important to problem solving in the BTPR context. Among the more important extensions are those having to do with (1) non-goal-directed behavior, particularly divergent thinking processes and pattern reorganization, (2) the role of sketching and selective perception, and (3) the development and use of conceptual frameworks. A fourth area concerning the role of values and individual orientations in problem solving is discussed in the section entitled "Factors of Choice".

Divergent Thinking Processes

In terms of information processing, the Newell-Simon model as noted earlier is selective rather than generative. It uses the metaphor of the computer to develop a theory that emphasizes a convergent structuring of problem solving methods and programs. A generative model based on a divergent thinking mode (also called intuitive, creative, or lateral thinking), is just as essential to understanding design problem solving. Divergent thinking breaks the hierarchically-ordered serial nature of the IPS model by employing strategies which are not goal (answer) oriented in the sense used by Newell-Simon and which utilize patterns and symbols not residing in the Newell-Simon problem space.[11] Divergent thinking employs provocative attributes as opposed to self-maximizing attributes of the mind.

The three principal task environments studied by Newell and Simon in a carefully controlled laboratory setting were chess, logic and cript-arithmetic. The task environments for each closed-system task included a statement of the problem and (if required) directions for finding a solution. Thus, the problem solver was confronted with tasks very much like those encountered in taking tests in schools, tasks solved using well-developed convergent problem solving skills. But most design contexts (and certainly the BTPR) are very different from this; designing is open-system problem solving in which the problem itself must be defined and then a solution conceived in the absence of any single or 'correct' answer.[12]

The limited repetoire of methods suggested by the Newell-Simon model does not provide a satisfactory explanation for creative explorations of the problem space such as is required in the conceptual or parti stage of design. De Bono (1970) suggests several characteristics of convergent models which limit their effectiveness in creative tasks such as design:[13]

1. Once established, new patterns and pattern categories become permanent.

2. New information is altered so that it fits an established category (result: distortion of information).

3. At no point is it essential to create new categories; one can get by with very few categories.

4. The fewer the categories the greater the degree of distortion of incoming information.

De Bono argues that such systems function to create, store and recognize patterns which, through repetitive use, become more and more established and resistant to change. The system contains no adequate mechanism for changing patterns and restructuring the contents of LTM. This he suggests is the principal function of divergent thinking.

Rather than providing an alternative to the Newell-Simon model, de Bono's ideas tend instead to extend and build upon their model. De Bono sees convergent and divergent thinking (or "vertical" and "lateral" as he calls them) as being entirely complementary in designing and other creative endeavors: "Lateral thinking is useful for generating ideas and vertical thinking is useful for solving them. Lateral thinking enhances the effectiveness of vertical thinking by offering it more to select from. Vertical thinking multiplies the effectiveness of lateral thinking by making good use of the ideas generated."[13]

De Bono identifies three types of problems:

1. A problem (whose solution, by definition, is not immediately apparent) which requires for its solution the application of convergent information processing techniques to information which may be gleaned from the task

environment. The tasks studied by Newell and Simon fall into this category.

2. A problem whose solution requires a rearrangement of information already available, i.e., an "insight restructuring" of the patterns and information accessible by STM (from either LTM or EM). This type of problem requires divergent thinking (the application of convergent processes have, in fact, already "failed" to develop a solution). The Study Design defined the BTPR task environment in almost exactly these terms. The study team inherited solutions/proposals in every corridor. The principal task was to utilize existing information to develop alternatives to these proposals.

3. The problem of no problem. The problem solver is blocked by the adequacy of the present arrangement (i.e., it meets the conditions for solution of the first problem type) from moving to a much better one. The problem is to realize that there is a problem, to realize that improvements can be made and to define this realization as a problem. This type of problem also requires divergent thinking. The Harbor Crossing episode provides an excellent illustration of this type of problem.

The second and third problem types both require the generation of new patterns or the restructuring of existing patterns through the application of divergent thinking techniques. This must occur before the selective powers of convergent thinking represented by the first problem type can be applied. In other words, divergent thinking occurs at an earlier stage than convergent thinking. Most of the time one might be using convergent thinking during problem solving, but apparently when one needs to use divergent thinking no amount of excellence in convergent thinking will do instead.

De Bono argues that divergent thinking is a skill which has atrophied under our current educational system, which places a higher premium on correct answers than correct (problem solving) behavior. The need for divergent thinking skills in design education will be discussed further in the CONCLUDING OBSERVATIONS.

Selective Perception

Newell and Simon's basic IPS model includes sensory receptors, principally the eyes and ears, which acquire different kinds of information about the external environment. However, the problem solving behavior of the tasks they studied apparently did not depend on functions of the sensory systems: ". . .details of the visual sensory system, including the system for visual pattern recognition, become irrelevant by reason of the nature of the problem materials."[14] This certainly cannot be said of design problem solving!

Visual perception plays a vital role in all phases of design. The thesis analysis draws on the ideas of many authors to explain much of the phenomena relating to perception, particularly in the I-95 Relocated episode. Selective attention during reconnaissance, for example, plays a crucial role in the development of a vocabulary of form-related patterns in LTM which are later used by the architect in developing alternatives through the visual imagining of a proposed alternative in its physical environment. But the most extensive use of visual perception occurs during episodes of sketch designing. It is the critical link in what Lockard (1974) has described as the "eyemindhand network" to emphasize that the functions of the eye and the hand are inseparable from the functions of the brain during design problem solving. Arnheim (1969) provides a theoretical basis for this notion, arguing that thinking originates in the perceptual sphere and that "much of the truly creative exertion of the mind in any field or discipline and at any level consists in perceptual operations."[15] Far from being the mere passive recording of stimulus material, perception is an active concern of the mind and the sense of sight exhibits highly selective problem solving behavior.

In its preoccupation with information processing concepts based on words and numbers, models such as Newell and Simon's relegate perception (along with our other senses) to a mere ancillary role to intellect with no important consequences for problem solving behavior.

Arnheim's fundamental thesis is that productive thinking (i.e., thinking involved in discovery, invention, design, etc.) consists in the shaping of visual patterns (images) as opposed to verbal or mathematic-based symbol manipulation. He argues further that there is no imageless thought, although the image may not be objectively related to the symbol evoking it. The image may not be recognizable because it may not fit the observer's definition of an image. Such images being nonmimetic appear as "nonsensuous content" to the observer.[16] Thus Arnheim believes that the split between sense (perception) and thought is not only arbitrary but has compartmentalized thought and prevented us from understanding fundamental relationships between the arts and the sciences. His thesis is easily confirmed by design behavior, particularly during the parti or sketch design phase when patterns and images are evoked and manipulated rapidly by the "eyemindhand". It is worth speculating on the notion that additional study of design problem solving, straddling as it does the domains of both art and science, can be a key to the understanding of relationships between the two. In any event, Arnheim's ideas are used extensively in the analysis to explain many of the phenomena dealing with perception and the development of patterns in LTM.

Sketching

Sketching and design drawing are also fundamental to design problem solving. They provide the means for exploring the problem space. They engage the concurrent interaction of perception, cognitive processing and graphic motor skills in such a way as to make Lockard's "eyemindhand" image a very compelling one. Newell and Simon include drawings as simply another EM source, but as Lockard correctly points out, drawings which are self-made are very special kinds of EM sources.

> "EM displays drawn by the eyemindhand are direct pointouts . . .from the LTM network. They can carry much more information than we can hold in our STM attention space, and even much more information than we can hold and recall accurately in. . .the LTM network. This. . .explains why drawn designs seem at some point to "take over" the design synthesis. They simply can represent more information more accurately than either our unaided STM attention space or our LTM network."[17]

The importance of drawings are clearly supported by Newell and Simon's findings. They suggest that from a functional point of view that the portion of a drawing within focal view should be considered as an integral part of available STM, since it serves to increase short-term capacity and enhances the stability of memory considerably. In addition, the importance of interactive drawing or sketching is attested to by the efficiencies resulting from such activity with respect to elementary IPS processing. Patterns used in design can be stored either in the mind (LTM) or in drawings (EM). The time it takes STM to read from either LTM or an EM within foveal view is the same, i.e., a few hundred milliseconds.[18] But the time required to record a new pattern in EM during sketch design (about one second per symbol) tends to be much shorter than the time required to record new structures in LTM (five to ten seconds per symbol).[19] The difference between the two times becomes even greater with increased skill in sketching, i.e., in developing easily recorded external symbols to represent each internal symbol.[20]

Sketches and other self-made EM drawings (maps, diagrams, charts, etc.) also play a key role in the development of conceptual frameworks. This is described in the following subsection.

Conceptual Frameworks

Another area of BTPR design problem solving for which Newell and Simon's work offers little elucidation is in the development and use of conceptual frameworks. The formation of concepts or categories of information/patterns is a common everyday functional mode of the mind. Yet presumably because such activity involves the interposition of values in the organizing of patterns, it is no longer subject to verifiable quantitative measurement upon which traditional scientific inquiry relies. As a consequence, it has been avoided by much of the serious research done on thinking and problem solving.[21]

Bruner defines a concept as a network of inferences that are or may be set into play by an act of categorization.[22] Concept formation then takes place whenever new patterns or symbols are connected or linked to other patterns of a particular class or category already held in LTM. Conceptual frameworks, as used in this thesis, are families of patterns held in LTM and connected by various combinations of relational attributes. Conceptual frameworks function to sort informational inputs from the task environment into functional categories which conform to the problem solver's understanding (image) of the task environment, i.e., his problem space. Conversely, informational inputs may serve to evoke a conceptual framework -- i.e., a particular family of patterns -- for use during design problem solving. Each conceptual framework is a different internal representation of the task environment; thus, each provides a different problem space within which the problem solver may explore solutions.

Conceptual frameworks come in all sizes. The family or set of patterns and associative linking programs may be comprehensive enough to constitute a "theory". An example, used in the BTPR analysis, is the Lynch-Rodwin (1959) schema which classifies all urban elements as belonging to one of two major categories: <u>flow systems</u> or <u>adapted space</u>.[23] By contrast, conceptual frameworks may be used to differentiate subtle differences between relatively finite pattern sets. An illustration of this, also from the analysis, is provided by the opposing patterns and inferences which comprise the view of the road versus those which comprise the view from the road.

Some of the conceptual frameworks I used during the BTPR were drawn from past experience -- particularly my just-completed two years at MIT -- and were adapted to the BTPR task environment. Others were developed in response to specific demands of the task environment. In either case the patterns and pattern-linking programs included in each conceptual framework were based on my current perception of the problem and the criteria to be used in the design and evaluation of alternatives. In contrast to the automatic and largely subconscious processes of the mind such as selective attention, the functioning of conceptual frameworks often operated at a preconscious or even conscious level during the development of alternatives. They might have been introduced with "What would happen if we look at the problem this way. . .?" They weren't usually given a label -- e.g., view from the road -- as I have done for purposes of identification in the thesis, but I usually knew when they were operating.

One of the most challenging aspects of the BTPR was the integration of information at several scales. The goal was to produce program package alternatives which were a synthesis of the transportation needs and development/conservation opportunities present at each scale. The following subparagraphs summarize the dominant conceptual frameworks which served to organize patterns and information at each of three scales:

1. Regional scale: spatial organizations of the task environment

at this scale were composed of regional desire lines, major destination points/generators and principal existint flow system elements, i.e., interstate highways and major arterials plus the regional rapid transit and commuter rail networks. In addition, mental mapping at this scale encompassed gross land use and topographic features such as ponds, rivers, natural/developed open space networks, and high and low density adapted space areas.

2. Town/community scale: conceptual frameworks operant at this scale consisted of mental and EM mappings of adapted space using standard land use classifications (commercial, industrial, residential, open space, etc.), and flow systems by type and size (e.g., highways by interstate, arterial, collector, local street, etc.). The dominant spatial organization of the community utilized Lynch's (1960) schema of districts and neighborhoods held together by a matrix of paths (auto, pedestrian, transit and train) and defined by physical and/or social edges, nodes and landmarks.[24]
3. Local neighborhood: the conceptual frameworks operating at this scale had to deal with the geometrics of highway and transit design, and the spatial and activity relationships between a specific flow system segment and the adjacent adapted space. The design criteria outlined by the Study Design[25] tended to divide into two

groups at this scale, one group dealing with the concerns of the potential driver/user of the highway/transit link, and the other group treating concerns of the community residents who would either be displaced by the proposed facility or would be living/working near it. I used these two groups of criteria to develop conceptual frameworks which I call view from the road and view of the road.[26]

The shifting of conceptual frameworks at different scales seems to be a common phenomenon not only for architects and city planners but for the urban resident as well. Lynch noted this in his studies of the way residents image their urban environments, "The image of a given physical reality may occasionally shift its type with different circumstances of viewing. Thus an expressway may be a path for the driver, an edge for the pedestrian. Or a central area may be a district when a city is organized (conceptualized) on a medium scale, and a node when the entire metropolitan area is considered."[27]

With respect to design problem solving in the BTPR context, it was important to have more than one conceptual framework or problem space. Each one provided a different way of organizing (often the same) patterns and information, thereby allowing different strategies for exploration of the problem space. Conceptual frameworks are not mutually exclusive. They may overlap considerably and often vie with each other for dominance, e.g., the view of versus the view from the road. Insofar as a conceptual framework may circumscribe a limited set of possible solutions as a function of its network of LTM patterns and programs, the ability to develop and use several frameworks at different scales (or within the same scale) may be a requisite skill for designers in complex task environments. It is probably equally important that conceptual frameworks be open to change and adaptation. There is of course nothing to guarantee that a particular arrangement of patterns and information is the best possible one for a specific task; it probably isn't. Moreover, it may hinder effective problem solving in a new or changed task environment. These notions are explored further in the episodes and CONCLUDING OBSERVATIONS.

In the BTPR, most of the patterns which characterized various conceptual frameworks were "stored" in numerous EM maps and diagrams, the more important of which were included in various BTPR reports. At the smallest scale, the local neighborhood/corridor, diagrams and maps were supplemented with sketches, photo collage and sections to illustrate the view of versus the view from the road. Several examples are included with the episodes.

There is one important aspect of conceptual frameworks which differentiates them from previously discussed extensions of the Newell-Simon model (divergent thinking, selective attention and sketching); namely, that they are, to a large degree, personal constructs of the individual problem solver. It is highly unlikely, for example, that any of the other BTPR staff architects would identify precisely the same conceptual frameworks which I have outlined in this subsection. Particular patterns which make up conceptual frameworks may be very similar among problem solvers; but the particular pattern combinations and pattern-linking programs which describe a particular conceptual framework are likely to be unique to the individual. The reasons for this lie in the factors which differentiate behavior among problem solvers. These are described in the following section, "Factors of Choice."

The processes and concepts identified in the preceding subsections are common to virtually all instances of BTPR design problem solving. The invariant features of Newell and Simon's IPS model, plus the use of divergent thinking, selective attention and sketching in the development and use of LTM patterns and conceptual frameworks are seen as common to all designers and design tasks.

In comparing my problem solving behavior with other BTPR architects and staff members, I discovered that the key differences were not so much in how we manipulated information as in the choices of information and criteria to be used and the relative priorities which we gave them. In attempting to identify patterns in the tendencies of individuals to make particular choices, it seemed that each individual was guided by his own perceptions or image of the task environment and objectives. I had a strong hunch that these images and tendencies were rooted in personally-held values and attitudes.

The influence of values on the choice of information was readily apparent; the difficulty came in trying to operationalize the functioning of values to analyze problem solving behavior. The specific factors and processes involved in choice are much more elusive than those which describe how information is processed once those choices are made.

The content and sequence of use of information during problem solving have a pervasive effect on the resultant form/solutions developed. Further, my BTPR experience suggests that patterns of choice are relatively consistent for each problem solver. Yet I have found no models which explain choice as the "interaction of invariant cognitive subprocesses" in a manner which would complement the Newell-Simon model. The Newell-Simon model itself offers little assistance in describing the mechanisms involved in the screening and selection of information to be used as inputs to the problem solving process. While it does an excellent job of identifying and rationalizing the invariant aspects of human problem solving, it tends largely to discount the variables which account for the vicissitudes of human behavior.[28]

In any event, it is clear from the analysis presented in the episodes that each step in the development of alternatives was characterized by the exercise of particular choices: whom I listened to, what information I sought, what sources I used, and what value and priority I gave to each input to my problem solving process. I eventually identified two sets of factors which seemed to have the greatest influence on choices made at critical decision points: external factors of the task environment and and internal factors of my individual attributes.

Task Environment "Givens"

This set of factors comprise all of the "givens" of the task environment: the Boston metropolitan spatial and socio-political context, the history of the existing transportation network and pre-BTPR proposals, the BTPR technical, participatory and decision-making processes and other factors outlined in the Study Design and described in some detail in the first section of EPISODE ONE. At any given point in problem solving there can be identified a combination of task environment givens which tend to structure the range of choices available to the problem solver. Since all

BTPR staff members were subject to the same conditions and constraints of the task environment, this area of influence on choice provides a source of commonality among problem solvers. Thus it is within the second set of factors -- individual attributes -- that the behavior-differentiating factors are to be found.

Individual Attributes

This set of factors includes all of the attributes which in aggregate account for the uniqueness of each individual, i.e., his problem solving "personality". Included in this category are educational background and professional experience; technical, management and interpersonal skills; and personal attitudes, values and orientations.

In general, common educational backgrounds and professional training were sufficient to distinguish the problem solving behavior of architects as a group from other BTPR staff; the characteristic use of sketch design techniques and spatially-organized conceptual frameworks were hallmarks of no other BTPR discipline. Nevertheless, differences in experience levels between individual architects accounted for rather dramatic differences in their problem solving behavior, particularly during the early stages of the BTPR. These are described toward the end of the second section of the I-95R episode, "Genesis of the Problem Space".

Varying levels of skill attainment among staff members also accounted for differences in choices. Those individuals with well integrated interpersonal skills, for example, tended to seek information from a wider range of individuals than those with less developed communications skills. Similarly, those with good management skills made better use of technical staff and organizational procedures to get information; those with good drawing and graphic skills relied more on sketch designing and other graphic techniques to synthesize information and make decisions/choices. These differences were fairly obvious: they were easily recognized features of each individual's problem solving "style".

A much more subtle -- but also more pervasive -- source of differences in choice were the personal values, attitudes and opinions of each BTPR staff member. These factors influenced all aspects of the individual's problem solving behavior: how he perceived the goals and objectives of the BTPR process, his interactions with the technical staff and participant groups, how he developed and used conceptual frameworks, and his perceptions of his own role in the overall process.

In summary, choice may be seen as the interaction of a variety of (external) task environment givens and (internal) individual attributes. These factors combine to define both the problem solver's current task objectives and the range of relevant choices available to him. In the analysis of a specific instance of choice these factors might be operationalized as (1) my current task objectives as defined by the demands of the task environment and (2) the semantic content of these objectives as defined by my current perceptions or image of the task environment.

The task environment per se does not make demands on the problem solver; rather, they are made by the particular task objectives via the problem solver's commitment to attain them. The features of the task environment that give rise to these demands constitute the relevant structure of the task environment. Thus the opening sections of the I-95R design episode presented in the next chapter first describe the major features of the BTPR and I-95R task environments and, next, my initial images and perceptions of those features.

Each problem solver, it seems, infers task objectives from perceptions of overall goals and his current image of the task environment. It is my image of the task environment -- i.e., my problem space -- that defines the semantic content of task objectives and governs my behavior. This image is composed of subjective knowledge of the task environment; it is built up as a result of all my past experiences; and it is subject to the structuring of personally-held values, attitudes and opinions.

Thus, the problem space or image of the task environment is unique to the individual problem solver. For simple or closed-system tasks, such as those studied by Newell and Simon, differences in problem spaces between individuals (according to the authors) tend to be insignificant.[29] But for complex task environments such as the BTPR, even relatively small differences in problem spaces may be manifested by dramatic differences in problem solving behavior. The comparison of experienced versus inexperienced architects presented in the next chapter illustrates this point.

Orientations

The search for a construct which would describe the process of choice in the BTPR context was similar to the effort to identify conceptual frameworks (described in the preceding subsection) by which I organized form-related patterns for use in designing. I eventually identified four patterns of tendencies or orientations which predisposed the architect and other BTPR staff members to make particular choices and decisions at particular stages in the development of BTPR alternatives. These orientations may be characterized/caricatured as follows:

- Orientation toward the technical process: an individual maintaining this orientation strives for technical competency in the design and evaluation of alternatives; he is a strong advocate of the technocratic planning model; he is comfortable recommending a "best" solution (to problems with social consequences) to decision-makers based on technical evaluations; he generally values "progress" in the sense implied by a decision to build more highways and transit;
- Orientation toward the locus of power: this individual's main concern is what does the (ultimate) decision-maker need to know and what is the best way to present the choices; he is more concerned with the evaluation of alternatives and their relative costs and benefits than he is with the generation of alternatives; he is as concerned with political feasibility as he is with technical feasibility;
- Orientation toward the participatory process: this individual views the technical process as a means of assisting the community to define and come to grips with their own goals and values with respect to the issues under study; he views his own role as a "neutral" technical facilitator in this process; he spends a lot of time preparing for and maintaining dialogue with various community groups and

individuals; and

- Orientation toward personal advancement: this individual is concerned with the enhancement of his own growth/status as a professional; he assumes responsibility for high-visibility tasks from which he can learn the most and/or which are most valued by the management hierarchy; he is concerned about personal competency and invests much time and energy in the tasks he undertakes.

Orientations mediate between task environment givens and individual attributes. They structure the problem solver's image of the task environment by (1) predisposing him to choose particular data, criteria and sources of information; and (2) by screening all informational inputs to his problem solving process for conformity to personally held values and attitudes. Orientations thus serve to define the semantic and value-laden content of the problem solver's current task objectives. In this manner they guide his problem solving behavior.

Differences in orientations between problem solvers -- or indeed different orientations held at different times by the same individual -- do not necessarily imply differences in basic technical goals, e.g. (to use a previous example), determining whether the pre-BTPR proposals should be constructed. Rather, orientations are seen as affecting the subgoals and particular task objectives which make up specific problem solving episodes or streams of behavior. Orientations are "approval selective": the orientation that was being employed at any particular stage in the BTPR was made by determining the answers to "Who is the (perceived) client? Whose inputs are most valued? Who am I trying to please?"

I see elements of all four orientations influencing my behavior during various stages in the development of BTPR alternatives. In the earlier stages I was very concerned about developing technical competence. I was also anxious to please my new employer and to assume responsibility for tasks I felt I was capable of performing and for those from which I could learn the most. And as the time came for decisions at the end of each phase, I concentrated on devising better ways to summarize and illustrate the key issues and trade-offs to be evaluated by the decision-makers. But I believe my basic orientation during the BTPR was toward the participatory process. This orientation had a continuing influence on the sources and content of information I chose to use in developing alternatives. It favored the use of patterns and criteria associated with "community quality" and the conceptual framework I have called the "view _of_ the road" (from the perspective of the adjacent community). It also motivated me to develop the interactional skills required to maintain productive dialogue with community groups and to use my design and graphic skills to devise presentation techniques capable of communicating complex issues to lay participants. An appreciation of the pervasive influence of this orientation is helpful in understanding much of the problem solving behavior described in the episodes which follow.

The development of the notion of orientations was very important to the analysis of my design behavior in the BTPR. It is perhaps unfortunate that the thesis does not provide a comparison of behavior between individuals in order to make better use of this construct.

In summary, we have seen that choice is a complex part of problem solving behavior. Part of choosing is rational and logical, reflecting the demands of the task environment and behaving according to the selective invariants of the Newell-Simon IPS model. But part of choosing is also intuitive, based on subjective knowledge and the influence of personally held values and attitudes as expressed through basic orientations. In the final analysis, choice is a human responsibility outside the logic of the task environment. This is because the criteria and standards upon which such choices are made must rest ultimately on the value systems of the individual problem solver/architect and in a larger sense on the community and society in which they operate.

In the episodes which follow there is no separation between choice and use of information; the two arise together, they are part of the same process. Yet it is through their very separation in this chapter that I understand their inseparability.

Like the Gestaltists' figure-ground theory of perception, I can describe/focus on only one way of looking at a situation at a time. Thus, various models are used to describe aspects of the choice and use of information during design. Yet, the "outline" of the aspects I describe are also the "inline" of those I ignore. The trick is to present an analysis of the parts and have the reader understand the whole. What I have discovered is that this trick is easier (by a quantum) to accomplish through drawings than through the written word.

This episode provides a case study of my problem solving process in the development of alternatives for Interstate 95 Relocated (I-95R) through the community of Revere on Boston's North Shore.

The purpose of this analysis is to understand my design behavior in the BTPR context. To accomplish this purpose it is necessary to explore the interrelationships between my problem solving/design skills and personal values/orientation on the one hand and the I-95R task environment on the other. The meeting ground for the interaction between the two is, of course, in my mind, ie. in my problem space.

At the outset of the BTPR I was "inexperienced" with respect to both transportation planning and participatory processes. This episode thus provides an opportunity to analyze in some detail how my problem space -- my interpretation of the BTPR/I-95R task environments and my role in them -- evolved to enable me to develop alternatives (solve problems) successfully.

The episode is divided into four sections.

The first section, THE TASK ENVIRONMENT, describes the principal elements of the BTPR/I-95R context which provided the overall framework and parameters for problem solving. Included in this section are brief sketches of the physical and socio-political contexts, the principal task objectives, the organization of the BTPR technical staff and participatory process, and a summary description of the major products which assisted decision-making.

The second section, GENESIS OF THE PROBLEM SPACE, looks at my perceptions of the BTPR task environment and my role in it and attempts to trace the learning process that took place as these perceptions developed. An analysis is made of several aspects of an "orientation" period that are seen as key to later (successful) problem solving behavior. These aspects include the acquisition of appropriate form-related patterns, the role of selective perception and sketching in pattern formation and the genesis of conceptual frameworks which organized these patterns for use in the design of BTPR/I-95R alternatives.

The third section describes the CONCEPTUALIZATION of basic alternatives and choices for I-95R and the other North Shore highway and transit facilities. My design approach during this four-month Phase I of the BTPR is presented and includes an analysis of transportation problems and resources, the definition of problems at regional, subarea, and local community scales and the use of sketch planning techniques to generate alternatives. The section concludes with a description of the basic conceptual choices from which the Governor established the priorities for Phase II design development.

The fourth section describes the DESIGN DEVELOPMENT of Phase I basic choices, focusing on the use of sketch design techniques and various conceptual frameworks to develop a final set of six alternatives for I-95R. The choice of information and the judgments and decisions made at various stages are analyzed through my interactions with technical staff and community participants.

The final section, SUMMARY, reviews the major elements of my problem solving process in the I-95R case and sets the stage for the Harbor Crossing episode presented in the following chapter.

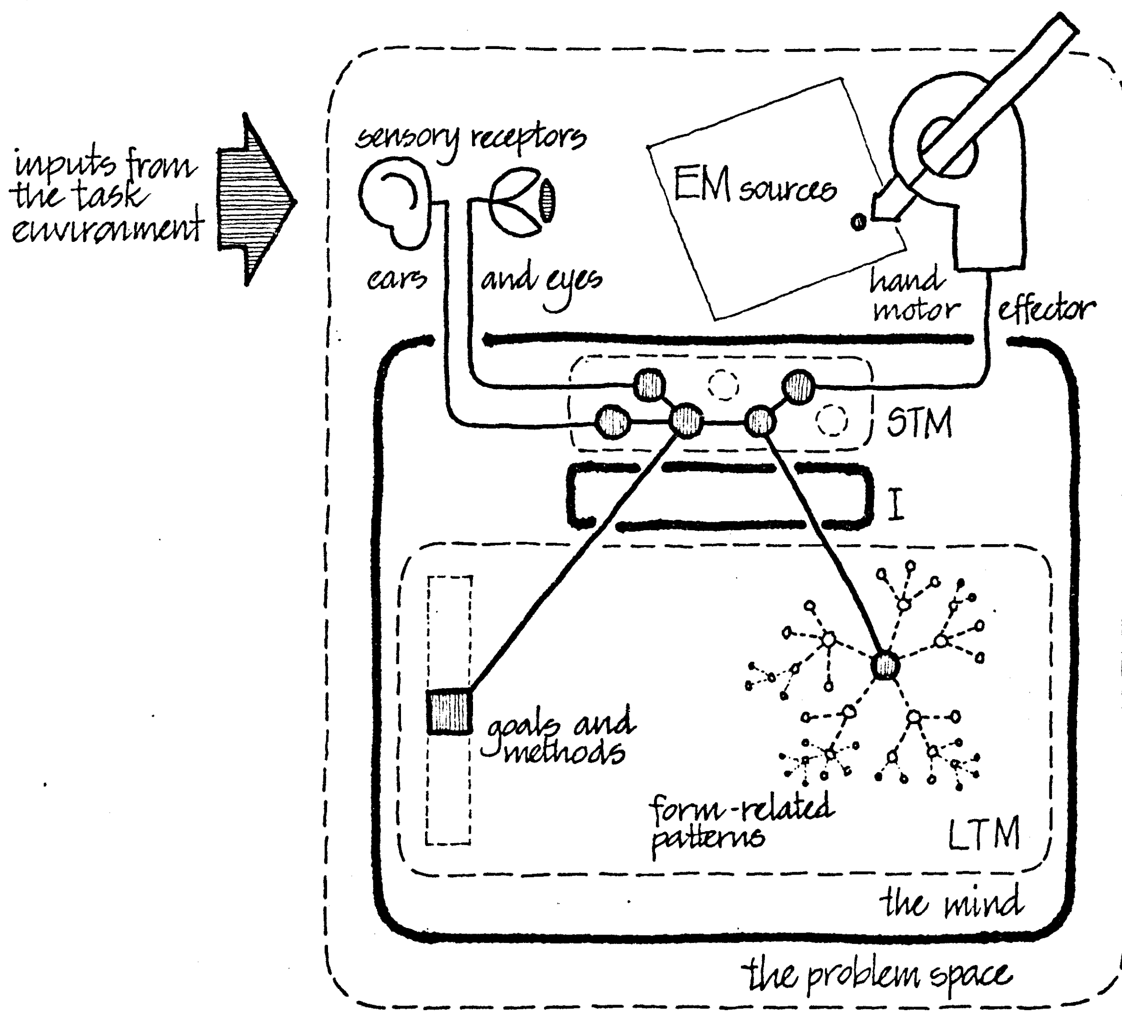
The architect's role in this episode is seen as the key role in the development of alternatives. As technical synthesizer, I not only initiated the generation of alternatives but also developed work programs and schedules, coordinated the interchange of technical information, defined the critical issues for analysis and directed the production of study products and reports. I was also the principal technical spokesman in the dialogue with community participants as well as with study management, advisory and decision-making groups.

The major elements of my problem solving process emerge from the analysis of my role as technical synthesizer. A model of problem solving adapted from an information processing system (IPS) model developed by Newell and Simon (1972) is used to explore my approach to the development of alternatives. Essentially, design problem solving is seen as an iterative process using (sensory) perception and (motor) sketching to explore the form implications and potential solutions of (a limited set of) selected objectives. The objectives are derived from my perceptions of the problem and the demands of the problem context or <u>task environment</u>. These perceptions or images -- along with a set of symbol structures or patterns and pattern-linking programs, plus the total information available to me -- make up my <u>problem space</u>. Information is available from three basic memory structures: long-term memory or <u>LTM</u> which encodes information from previous experiences in symbols and patterns in the mind; short-term memory or <u>STM</u>, the conscious area of the mind which holds the current task objective and mediates between patterns and programs held in LTM, and the external task environment; and external memory or <u>EM</u>

which includes sketches, books, maps, and other external information sources. The basic organization of these elements for design problem solving is illustrated in Figure 2. (See pp. 30-31 of METHODOLOGY).

The interpreter designated as "I" in Figure 2 mediates communication between STM and LTM. The interpreter evaluates and selects goals and methods based on my personal values and attitudes plus my current understanding of information available from the task environment and within the problem space. In addition, it serves to screen all incoming data,

Figure 2: Schematic Organization of Design Problem Solving



filtering out those inputs which conflict with current goals/task objective and prioritizing the remaining information in accordance with my basic task orientation.

A summary description of my design problem solving process in the development of alternatives for I-95R could be summarized as follows: current task objective(s) held in STM are used to direct selective perception of the task environment and available EM sources and to retrieve/recollect appropriate patterns, programs and problem solving methods from LTM. These patterns are manipulated (STM processing) by using sketch design techniques and various problem solving strategies until the pattern combinations satisfy the task objectives. Perceived incongruities or misfits between objectives and evolving pattern combinations are used as new information inputs to stimulate the recollection of other more appropriate patterns from LTM or EM. Proceeding in this iterative manner of pattern recall, STM processing and testing eventually generated one or more sketch plans which satisfied the requirements of the selected task objectives.

The four sections which make up this episode explore the origins and the application of this model in the development of alternatives for I-95 Relocated.

An overview of the BTPR task environment is essential to understanding my problem solving behavior due to the fact that my perceptions of the problem, current task objectives and state of information were constantly changing and evolving in the highly interactive BTPR process. Problem solving was characterized by virtually continuous interaction with the existing physical and socio-political context and by constant input and feedback from the BTPR technical staff, public agency representatives and various community and special interest groups.

The relevant features of the task environment, for purposes of this analysis, are those external factors which constrain my design behavior (i.e., my choices) via my commitment to attain the objectives defined by the particular task or problem. Many of these features -- the identification of preliminary alternatives, the three-phase iterative design process, the fourteen technical study elements and the basic features of various technical, participatory and decision-making aspects of the study process -- all have their origins in the BTPR Study Design, the importance of which is discussed in the preceding chapter.

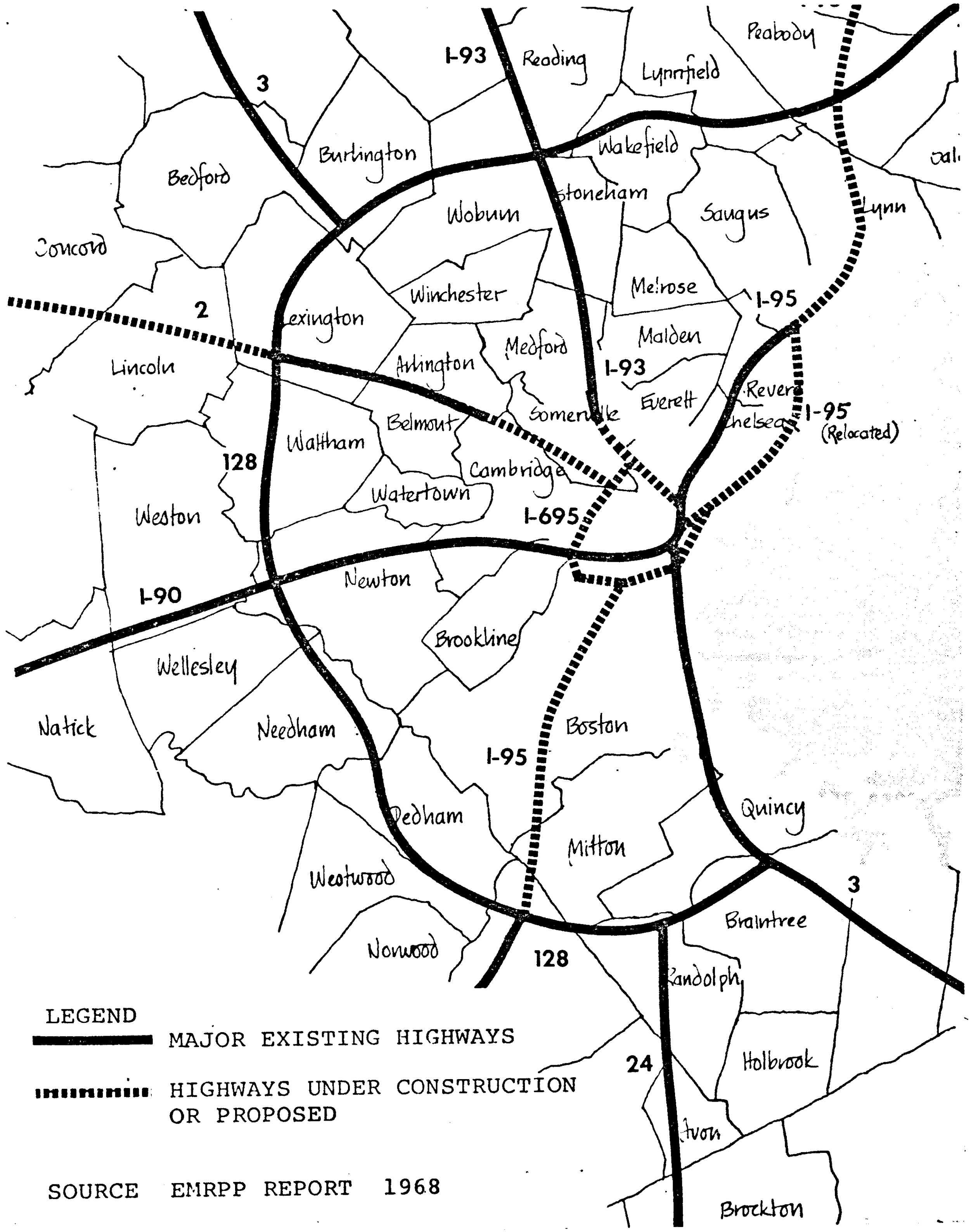
The following subsections describe the essential features of the study process which made demands on my problem solving process by establishing criteria and setting constraints and by influencing my task objectives and information state at various points in the development of alternatives. These features include the BTPR and I-95R contexts, the principal technical objectives, the organization and interaction of the technical staff and participatory process and the major study products and decisions. Once a general understanding of the task environment and my problem space is achieved, problem solving behavior in the conceptualization and design development of alternatives can be analyzed.

BTPR Context and Objectives

Many of the once most beautiful cities in the United States are today permanently scarred by wide swaths of steel and concrete highways intended to relieve severe congestion and halt economic decline of our dense inner city core areas. Until very recently, the interstate highway program, with its 90 percent federal funding, proved all but irresistable to budget-constrained planners and politicians seeking instant (or at least high-visibility) solutions to their city's ills.

In Boston, a comprehensive transportation plan for the Boston metropolitan region known as the Eastern Massachusetts Regional Planning Project (EMRPP), a cooperative effort of state transportation agencies and local municipalities, had been completed in 1968. Using advanced computer-assisted planning techniques, it closely integrated highway and transit planning for the first time. The EMRPP adopted a comprehensive set of goals and objectives and formally acknowledged the shift in public attitudes and governmental policies toward greater emphasis on social, economic and environmental values in transportation planning. However, the EMRPP accepted as committed the prior highway and transit plans for the area inside Route 128, a circumferential highway roughly 10-12 miles from the Boston core. Completion of the proposed highways, shown in dotted lines on Figure 3, would effectively complete the regional highway plan first developed in 1948, shortly after World War II. (Acceptance of these

Figure 3: EMRPP Recommended Highway Plan



plans by the EMRPP is a testimony to the persuasive power of a clear and seemingly rational diagram).

Widespread public discontent following the publication of the EMRPP plan centered around the continued planning and land acquisition for I-95 and I-695, the so-called Inner Belt. The extent and intensity of public demonstrations forced the Governor to declare a moratorium on further action on these segments in February of 1970.

A Task Force appointed by the Governor was charged with the development of a Study Design, the principal objective of which would be to establish a process -- the BTPR -- which would produce a "balanced transportation development program" for the metropolitan core. Final decisions would be made by the Governor based on "program packages."[30] All assumptions, criteria, options and conclusions would be surfaced for public discussion and debate. To accommodate this objective, a broadly-based participatory process was devised which would seek public consensus regarding each facility and would inform the ultimate decisions to be made by the Governor. All plans and decisions would be based on a balanced set of criteria representing the values of all concerned groups.

The BTPR was designed for three iterative plan-making cycles or phases beginning in August of 1971 and lasting a total of eighteen months. Decisions were to be staged to reduce the number of alternatives under consideration at each phase and to proceed with the implementation of some projects as soon as decisions could be reached. The fundamental objectives of the BTPR were facility-oriented:

1) Determine whether or not the EMRPP highway and transit proposals should be constructed.

2) If yes, determine where should they be located, at what level of service and with what configuration of alignment, profiles, interchanges/stations and joint development provisions.

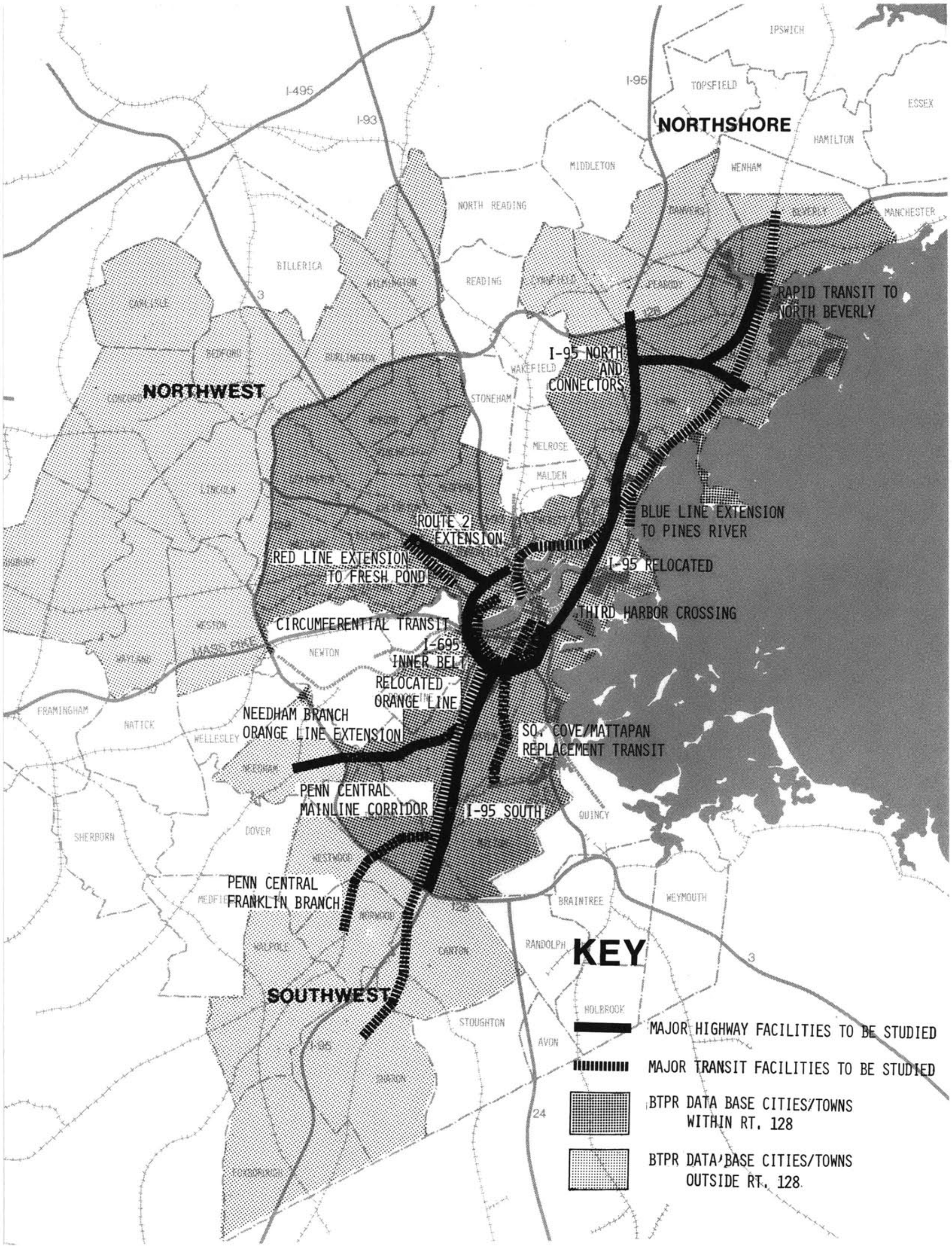
3) If no, determine what (if any) facilities should be built and, again, where they should be located and with what level of service, configuration and joint development provisions.

I-95R Context and Objectives

The BTPR process was managed by dividing the region into three study corridors: North Shore, Northwest and Southwest. The geographic definition of the cities and towns included in each corridor was based on the facilities identified for study at the outset of the study process. The North Shore Corridor, which included I-95 North, I-95 Relocated and the Harbor Crossing, was defined as a wedge-shaped sector of the metropolitan region comprised of 19 different cities, towns and Boston communities. This corridor or subregion extends north and east of the downtown core from the Boston communities of Charlestown and East Boston to Route 128. Figure 4 shows the relationship of the North Shore Corridor to the Boston metropolitan region and the other BTPR corridors and includes the major proposed facilities to be studied during Phase I.

In general, the distinguishing characteristics among the North Shore communities are typical of similar sectors of older American cities with essentially concentric growth characteristics. The inner communities are largely working-class bedroom communities for the high intensity commer-

Figure 4: BTPR Corridors and Major Facilities Under Study



cial and industrial areas of the metropolitan core. Most have sustained substantial decreases in population in the last decade with a concurrent loss of industry and suburbanization of available jobs. The transportation problems of these inner communities stem largely from local highways overloaded with through traffic from outer communities and from deteriorating or otherwise inadequate public transportation. The more affluent and less dense but growing outer North Shore communities rely principally on the automobile for mobility and provide the greatest pressure for additional highway capacity to serve both their local and core-oriented trip needs.

The proposed alignments for I-95 Relocated (I-95R) lay almost totally within the city of Revere, a bedroom community located at the transition area between inner and outer North Shore communities. Revere is served by rapid transit and was included in the Inner North Shore for BTPR purposes. The MBTA Blue Line terminates in Revere providing rapid transit access to Revere Beach, Suffolk Downs Race Track and Wonderland Dog Track, major regional recreation resources and traffic generators.

During the three-month first phase of the BTPR, the principal objectives in the conception of alternatives for I-95R were included in the objectives for the identification of North Shore Basic Choices. To paraphrase the Study Design, these were:

1) To articulate, through the participatory process and the analysis of existing technical data, the principal transportation problems and transportation-related issues and opportunities in the communities of the North Shore;
2) To analyze the advantages and disadvantages of previous transportation proposals in a systematic fashion;

3) To develop and analyze a wide range of new transit and highway alternatives providing equal or better transportation service than previous plans but with fewer community impacts;

4) To review findings with North Shore participants and to provide a basis for Phase I decisions and define more clearly the range of alternatives to be given more detailed analysis in subsequent phases.

Phase II design for I-95 Relocated covered roughly months four through twelve of the BTPR contract. The basic difference between Phase II and Phase I was the greater depth and detail of design allowed by the additional time assigned to Phase II, and the integration of more conventional design methods of the various BTPR disciplines than was characteristic of Phase I. The principal technical objectives of Phase II were threefold:

1) Using sketch design methods, to develop and evaluate a range of facility alternatives integrating local and regional objectives at different levels of transportation service within the Basic Choices defined in Phase I;

2) To identify and develop a full-range of program package elements for each facility combination selected for final evaluation, including housing and business relocation, environmental impact offsetting measures, joint development opportunities and implementation strategies;

3) To prepare a final report fully evaluating and comparing each alternative on a wide range of criteria including

economy, transportation service, safety, community quality, acceptability, adaptability, etc. -- some 70+ criteria in all.

As in Phase I, each of these objectives was to be carried out with the widest possible participation by community groups and local representatives. As noted in the Study Design, "the objective of creating a truly effective. . .participatory process is the principal reason for several phases."[31] The interactive nature of the technical process was intended to permit feedback from participants to guide the reformulation of plans and designs in subsequent cycles.

Technical Staff Organization

At its peak the BTPR technical staff was comprised of some sixty-five professionals from a consortium of seven major consultant firms and several special subconsultants.[32] The disciplines represented on the staff included system analysts, transportation planners, architects, engineers, economists, lawyers, transit specialists, housing relocation specialists, ecologists and biologists. There was also a semi-autonomous community liaison staff composed of sociologists and community planning specialists.

In general, each discipline assumed responsibility for specific tasks and study elements spelled out in the Study Design. Since Phase I was intended as a period of creativity, of expanding the number of alternatives available for consideration, the Study Design called for the application of "sketch planning and sketch design approaches used in the urban planning and architectural professions."[33] While the use of these techniques was envisioned as an interdisciplinary effort, the graphic skills required and the implicit emphasis on "intuition" and "creative synthesis" rather than the conventional rational engineering location analysis resulted in de facto technical leadership by the BTPR architects. As a consequence, the corridor technical teams were structured around the key role of the architect as the initiator of alternatives. Work programs developed by the architects, using the Study Design description of Study Elements, defined the content and format of information required by other disciplines in order to facilitate rapid development of sketch plan designs.[34] These work programs became the basis for the management of staff resources in each corridor and subarea.

During Phase I, most of the other disciplines busied themselves developing the data bases required for the evaluation of the basic choices which the architects generated for each corridor. Specialized teams such as those for systems analysis and transit developed their own work programs and integrated their findings into the architects' sketch planning process.

In a complex task environment with a highly compressed time schedule and limited staff, the determination of what steps are required, what information will be collected and how personnel resources will be used, quickly becomes crucial to the success of the project. At no other point in the BTPR was the exercise of experienced judgment more apparent (or more valuable). Certain kinds of information are required at specific stages in any design process. Many of them (computer network analyses, user surveys, property ownerships, building condition surveys, etc.) require comparatively long lead times. Planning for the availability of this information relied heavily on the Work Programs developed by the more experienced BTPR personnel based on their involvement in previous similar processes and their perceptions of the BTPR context.

The commitment for final decisions by the Governor for facilities in the North Shore was only ten months from contract signing -- considerably shorter than commitments in the Southwest and Northwest Corridors. Consequently, during the start-up stages of Phase I, four of the seven BTPR architects -- two experienced and two relatively inexperienced (including myself)[35] -- were assigned to the North Shore Corridor. One of the experienced architects took charge of developing the work program, coordinating the technical process and staffing requirements, while the other took the lead in expediting the participatory process start-up, making presentations, and coordinating technical team interfaces with the Working Committee, Steering Group and community officials. During this initial period, the two inexperienced architects were principally involved in task-oriented support roles, and along with economists, engineers, environmentalists, transportation analysts, and other disciplines, they assisted in the development of the general planning base of demographic, social and economic factors necessary to understand forces, trends, and needs in the North Shore communities.

In order to make the most efficient use of staff resources after this brief start-up period, the North Shore Corridor was divided into three geographic subareas for more detailed analysis. The other inexperienced architect and I assumed responsibility for the Inner North Shore subarea which included I-95R and the Harbor Crossing. In Phase II, I assumed total technical coordination responsibility for I-95R and shared this responsibility on the Harbor Crossing with one of the experienced architects. The overall organization of Phase II technical work was coordinated through two kinds of teams: facility-oriented teams, each directed by an architect; and regional system-oriented teams, e.g., economics, transit, transportation systems.

As might be anticipated with an interdisciplinary consortium comprised principally of non-Boston-based firms, few team members had worked together professionally previous to the BTPR. Of the four full-time architects on the Skidmore, Owings and Merrill payroll, for example, only one had been an SOM employee prior to the BTPR. As a consequence, a good deal of Phase I energy went into establishing basic communications and discovering each other's professional strengths, limitations, and preferences. Most interaction was intradisciplinary, e.g., between architects. This was particularly true for the inexperienced architects who spent much of their time modeling behavior and developing form-related patterns and problem solving methods appropriate to their perceptions of the architects' role in the BTPR. Closer collaboration between disciplines was to await a transition from the more intuitive stages of Phase I sketch planning to the rational and more quantitative analyses required in later design and evaluation stages. Several examples of intensive interdisciplinary interaction are described in the section on Design Development.

<u>Participatory Process Organization</u>

The participatory process was designed to achieve the broadest possible exposure of the technical process to each affected community and interest group. The Study Design delineated several mechanisms intended to assure "responsible, effective, informed participation by all vitally interested groups." These included representation on the Working Committee and Steering Group, a community liaison program of briefings, workshops and public meetings designed to provide two-way information flow and a technical assistance program to provide expert staff to translate the ideas of private groups and municipalities into concrete proposals. All BTPR meetings, technical memoranda, data base information and drawings were open to continuous public review.

A separate semi-autonomous Community Liaison Staff was set up to facilitate the interface between the technical staff and community groups. While this staff played a vital role in scheduling meetings and keeping a finger on the pulse of the community, it became apparent early in the process that the presence of a "middleman", however objective, was inimical to the objectives of direct interchange and dialogue between the technical process and the community. As a consequence, the architect, as technical synthesizer, spent at least half of his productive time preparing for and interfacing with the Steering Group, Working Committee, North Shore Steering Committee and various community groups, public officials and private citizens.

The community interface during Phase I was probably as close as the BTPR process came to Arnstein's definition of true "partnership"[36] in the technical process. The architect relied heavily on community input, particularly for the articulation of community-perceived transportation problems, for the development of a relevant planning base context, and for input and review of the alternative concepts developed. In general, it was a time of "proactive" (versus passive or reactive) community input to the BTPR process. The more active participants tended to be those community representatives, officials and organized groups charged with or concerned about comprehensive community issues of growth and development or with neighborhood preservation and the maintenance of community quality. The voices of local property owners and vested economic interests were to await the more definitive stages of design provided by Phase II.

Initial exchanges with each community usually began with introductory data-gathering meetings with city officials. These meetings provided the technical staff with an initial sense of community objectives and priorities with respect to a broad range of transportation, development and environmental issues. Field reconnaissance and initial sketch planning by the architect generated the initiation of subsequent meetings with various city officials and community groups to get further clarification of specific problems identified at earlier meetings and to solicit response to initial sketch plan ideas and concepts as they were developed.

The introduction of new alignments and concepts immediately generated new participants, usually individuals or groups who could be adversely affected by the new proposals. With the multiplication of new sketch plan alternatives from three different North Shore subareas, it quickly became apparent that the participatory process required modification to include both in-depth consideration of local issues with local interest groups as well as a more broad-ranging set of regional issues with the overall North Shore Steering Group. The notion of subcommittees corresponding to the geographic subareas was proposed by one of the experienced architects.

The idea was to use these subcommittees as consensus-making groups for decisions of local importance (e.g., alignment trade-offs, joint development emphasis, etc.), keeping the overall Steering Committee intact for "ratification" of subcommittee consensus and as the appropriate forum for such issues as regional development goals and the balance between highways and transit. The subareas quickly became the locus of citizen participation as opposition or support generated around alternatives developed for specific facilities in each subarea. Eventually, citizen input was most effectively articulated at the scale of each city and town impacted by the alternatives; i.e., at the local community scale.

Principal Study Products

The BTPR produced innumerable technical memoranda, studies, reports, maps, charts, drawings and computer printouts. Many of these products were used to inform the technical development and evaluation of alternatives; others were designed to communicate complex ideas to community participants; still others were intended only to document the BTPR study process. Several interim/progress reports plus the final reports for each facility were designed to facilitate the decision-making process.

Phase I produced two principal products for review and decision-making. The first was a "Preliminary Definition of Issues" for each of the North Shore subareas. This document summarized the major issues identified at that point relative to transportation service, economic and community development, housing and business displacement, environmental issues, and neighborhood cohesion and social impacts. Each issue was identified as being either of regional or local community importance.

This product thus served as a summary statement of issues and problems perceived at both scales. Community reviews resulted in substantial agreement (if not consensus) that the major issues had in fact been identified. Moreover, this product became the basis of local community criteria in subsequent design and evaluation of alternatives.

The second principal Phase I product, the North Shore Progress Report, synthesized the findings in the Inner North Shore with those of the other subareas. It identified the Basic Choices for the entire corridor and illustrated different policy approaches in a set of seven potential Program Package combinations of different highway and transit facilities from each subarea.

The Phase I Report and the response it generated became the principal inputs for a series of meetings and briefings designed to inform the Governor's decision-making process. The architects' role in these sessions consisted of making summary presentations of principal findings and alternatives and clarifying technical issues and possible implications. The Governor's Phase I decisions narrowed the range of options to be given further consideration and provided a focus for Phase II design effort on each facility.

Although the North Shore architects were principally responsible for the content and format of these reports, important contributions were made by the transit team, economists, environmentalists and other disciplines. In addition, special response forms developed by the community liaison group were included with each report soliciting community response to guide decision-making with respect to Phase II study priorities.

The principal Phase II product was the final report describing and evaluating six fully designed alternatives for I-95 Relocated and the Revere Beach Connector. This 250 page document was a combination Draft Environmental Impact Statement, Preliminary Location Report and Program Package Evaluation Report. It required the coordination and synthesis of extensive inputs from all of the BTPR disciplines. My role in the development of these reports and study products and the decisions resulting therefrom are described in the third and fourth sections of this chapter, following "The Genesis of the Problem Space."

The preceding section has described the BTPR task environment with emphasis on those features which had the greatest influence on my problem solving behavior. Before we can analyze specific episodes of behavior, however, we need to know something about how I perceived the BTPR task environment and my role in it. In addition, since I was "inexperienced" with respect to transportation planning and design, it would be instructive to analyze my adaptation to this new design context and how I "learned" to design highway and transit facilities.

The problem space, according to Newell and Simon's IPS model, is the problem solver's internal representation or image of the task environment. The problem space contains a representation of the initial situation presented to/interpreted by the problem solver, an image of the final goal/state, various intermediate states and objectives, imagined or experienced, and any concepts the problem solver may use to describe these situations to himself. The problem space is a dynamic entity; it evolves continually as problem solving progresses and the problem solver responds to the changing demands of the task environment. It includes not only the patterns and programs relevant to the particular task, but also all of the subjective knowledge relating the values and attitudes of the problem solver toward the task environment.

The next several subsections describe how my problem space developed. First, a vignette of my initial perceptions of the task environment and my role in the BTPR. Next, a description of the Beverly-Salem Bridge episode, a three-week "sketch problem" at the outset of the BTPR which provided a model of appropriate problem solving behavior. Here I discovered that in order to solve transportation problems in the BTPR context I first needed a means of characterizing possible solutions. The third subsection describes how this was accomplished by using selective perception and sketching to acquire a "library" of form-related patterns which dealt with highways and transit systems and their relationships to the man-made and natural environment. Once acquired, I needed some means of organizing these patterns in such a way as to be able to generate elements of a set of possible solutions in some specific order. This was accomplished by the development of conceptual frameworks which is described in the fourth and final subsection.

Once the formation of the problem space is described, we will be ready to investigate the stream of behavior produced when I focused on a specific task environment, selected an objective and became a determinate problem solving "system".

Perception

My perceptions of the BTPR task environment and my role in its technical process changed dramatically during the eighteen-month project. At the outset of the process, there were all the anxieties and self-conscious concerns that perhaps all "inexperienced" architects feel on the eve of their first "real" job.[37] I wasn't sure exactly what my role would be or what skills would be required, or, worst of all, whether I could "cut it". There was a strong desire to succeed, however, and motivation seemed to make up for initial deficiencies in technical skills.

I recall reading the Study Design and the SOM subconsultant contract, but also remember that these documents provided more questions than answers with respect to my role and how to proceed with problem solving. In sum, they served to raise my perceived I.Q. (Ignorance Quotient) and to escalate my anxiety level to a point somewhere between frenzy and paralysis. The simple fact is that at the outset of the BTPR, I did not have the necessary vocabulary of transportation-related patterns, conceptual frameworks and programs to fully understand the problem and how to proceed.

Fortunately, there was little time for self-conscious indulgence; after a few days of setting up work spaces and trying to put fifty names with fifty new faces, the BTPR began with a three-week "sketch problem" for the Beverly-Salem bridge on the North Shore. Working closely with two of the experienced architects, my perceptions of the task environment and my role made a quantum leap (fortunately) in the appropriate direction. This brief but synoptic episode provided an excellent model of successful problem solving behavior.

Beginning with support tasks such as preparing graphics for public meetings, researching past plans and proposals and preparing base maps, I quickly developed self-confidence and assumed commensurately more responsibility (or was it vice versa?). Within the remaining fifteen months of the BTPR, I developed alternatives and coordinated the technical process for I-95 Relocated, the Revere Beach Connector, the Blue Line extension and the Winthrop Connector and shared these responsibilities for the Harbor Crossing and Central Artery. In addition, I prepared an analysis of interstate connectivity alternatives for the Boston region and designed the transit stations for the MBTA Red Line extension at Alewife Brook.

One of the most pervasive role perceptions, one which undoubtedly had its roots in my previous two years at MIT, was the idea that my technical efforts to develop alternatives served a higher objective, namely, assisting each community to come to grips with the complex issues posed by the BTPR. It was this perception that manifested itself in my "basic orientation" toward the participatory process and which defined my role as "neutral" with respect to interposing my own values and biases in the development and evaluation of alternatives. Subsequent sections in this chapter will illustrate the effect of this role perception on the choice of information and the development of alternatives.

Orientation: The Beverly-Salem Bridge

In an effort to promote high public visibility for the BTPR and to test the operation of the participatory process in the North Shore, a small-scale, ostensibly separable issue -- the Beverly-Salem Bridge -- was selected for analysis at the outset of Phase I. With the information gathered from field reconnaissance and previous proposals, seven sketch plan alternatives including the pre-BTPR plan were developed by the two experienced North Shore Corridor architects during the first three weeks of the BTPR. Input from many BTPR disciplines -- engineers, environmentalists, economists, etc. -- contributed to the evaluation of alternatives.

As mentioned earlier, this brief episode provided an excellent orientation period and model of problem solving behavior. I went with the experienced architects on reconnaissance trips and noted their perceptions, studied their sketch designs and listened carefully to their exchanges with each other and with other BTPR staff members. I learned not only what kinds of form-related patterns were useful but also something about how to acquire and use them.

It was hoped that consensus on a single alternative could be reached by the North Shore Steering Group (the citizen group representing the BTPR North Shore communities) and that the Governor could announce the results at the end of Phase I as a demonstration of the decisive nature of the process as envisioned by the Study Design. In spite of well planned and concerted efforts by all concerned, including many community meetings, the best that could be mustered from the Steering Group was a narrowing of alternatives from seven to five (and this resulting from a "sense of the meeting" determination by the State Secretary of Transportation and the DPW Commissioner).

Notwithstanding the failure to reach consensus, however, this brief exercise, as a synoptic encapsulation of the entire BTPR process, provided many important insights for the technical team with respect to the interaction of technical and participatory aspects of the process. It was also important in establishing BTPR technical credentials and credibility on the North Shore. Finally, and perhaps most significantly, the Beverly-Salem Bridge analysis facilitated a fast orientation and start-up for the BTPR staff, establishing initial patterns of problem solving and interactive behavior which became a datum for the future role development of each individual.

Pattern Acquisition

At the outset of the BTPR, the ability to assimilate useful information by BTPR staff persons depended on whether they had appropriate conceptual frameworks which would allow them to integrate new information from the task environment which could be used in anticipated problem solving contexts. For the BTPR architects, such frameworks for internal representations were necessarily figural* since their usual mode of conceptualization made extensive use of sketch design techniques.

Newell and Simon have shown the importance of an orientation period for all problem solving tasks. The problem must first be recognized and understood. Particularly in new or complex tasks, considerable time may be spent building up the "extended knowledge state". Since I had no appropriate conceptual frameworks at the outset of the BTPR, the orientation period was very much like learning a new "language", and much time was spent building up a basic vocabulary of appropriate transportation-related design examples (patterns). Recognizing and understanding a problem includes the recognition of the possibility and nature of a solution. Thus my first task was to acquire the means to characterize a wide variety of possible highway and transit solutions. Once this was accomplished, I had to organize these patterns into conceptual frameworks and develop rules -- programs of particular pattern linkages -- for using them. Finally, I had to be able to recall (STM retrieval from LTM and EM) both the specific patterns and the programs for using them in a sequence appropriate for the particular design task.

In the BTPR context, to find examples of form solutions (good and

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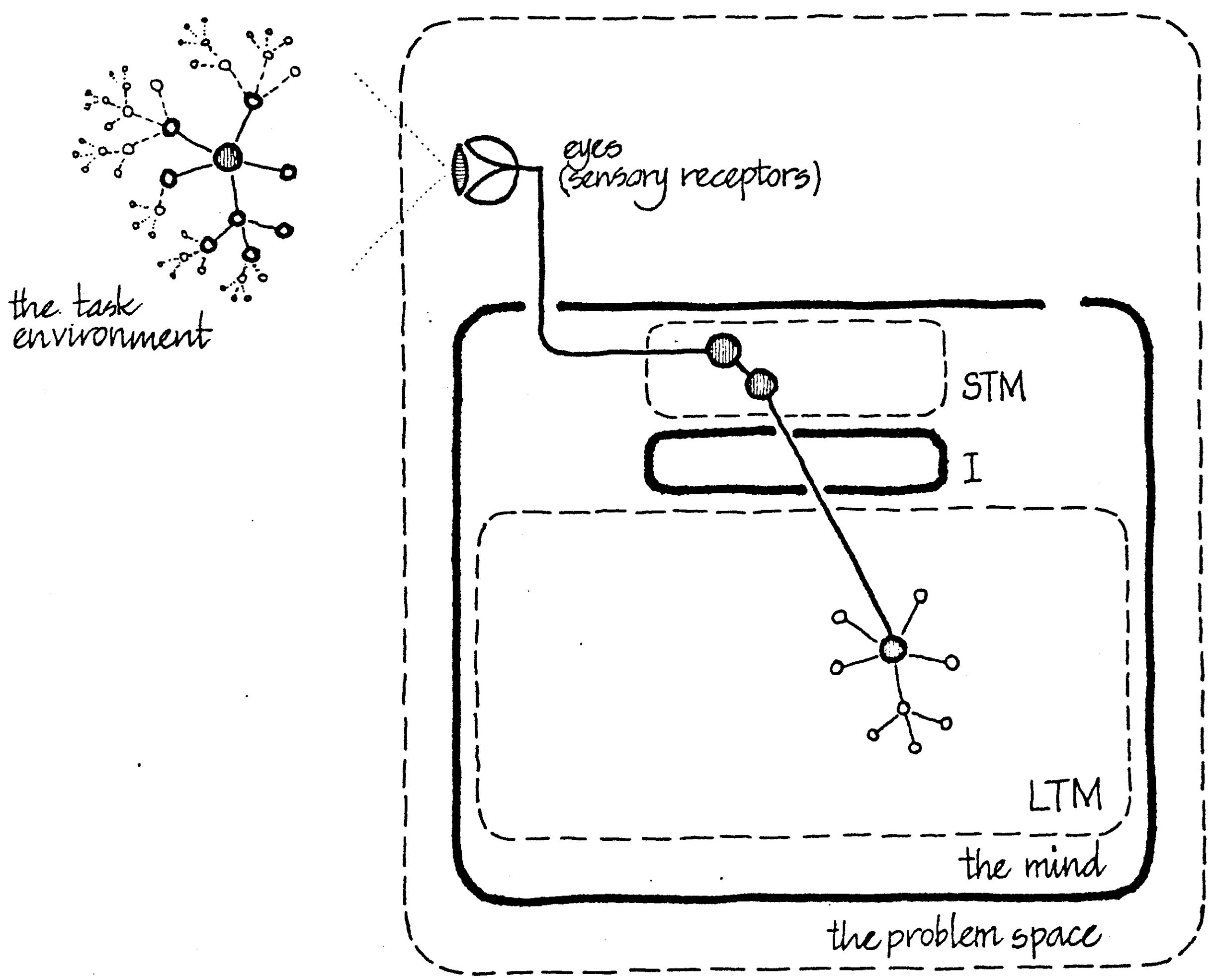
* Figural information is information in concrete form as perceived or as recalled in the form of images. The term "figural" minimally implies figure-ground perceptual organization.

bad), all one had to do was to get in his car and start out. Thus, throughout Phase I, I spent many days in field reconnaissance analyzing the figural content of highways -- various widths, alignment geometrics, profiles, edge conditions, intersections, adjacent topography and land use -- all the form-related aspects I though might be useful in sketch designing. Gibson (1968) calls this process "learning the affordances of objects", those distinctive features of things which make them useful to the observer.[38] By focusing my attention on these specific aspects of the built environment, I quickly developed a kind of heightened sensitivity to everything about highways. On reconnaissance trips, it was as if I had programmed my perceptual mechanisms (eyes and brains) to screen out all "irrelevant" data from the built environment and to selectively search[39] the remaining information for the best interpretation of available data on highway form elements for addition to my expanding vocabulary of patterns. This state of heightened sensitivity toward anything to do with highways and transportation was for a time a most compelling obsession.

Perceptual selectivity, or more precisely, "selective attention", is a form of perceptual development which results in what Gibson calls "economical perception".[40] It is the ability to avoid distraction -- to concentrate on one thing at a time in the face of everything going on in the environment -- and yet to accomplish as much knowing as possible. Perception must be quick and efficient, such that the information registered about objects and events becomes only what is needed, not all that could be obtained. This "schematic tendency" enabled me to pick up only that information from a complex of stimulus information required to identify a form element economically. Pattern categories developed in this manner were thus keyed to particular structural features and attributes which I could immediately detect in subsequent fields of environmental stimuli. The information processing linkages of pattern acquisition during reconnaissance are illustrated in Figure 5.

Pattern acquisition through the abstraction of figural content directly from the environment was supplemented by studying a variety of books, reports, photographs and design manuals which not only assisted LTM pattern development but also became EM sources for future reference.

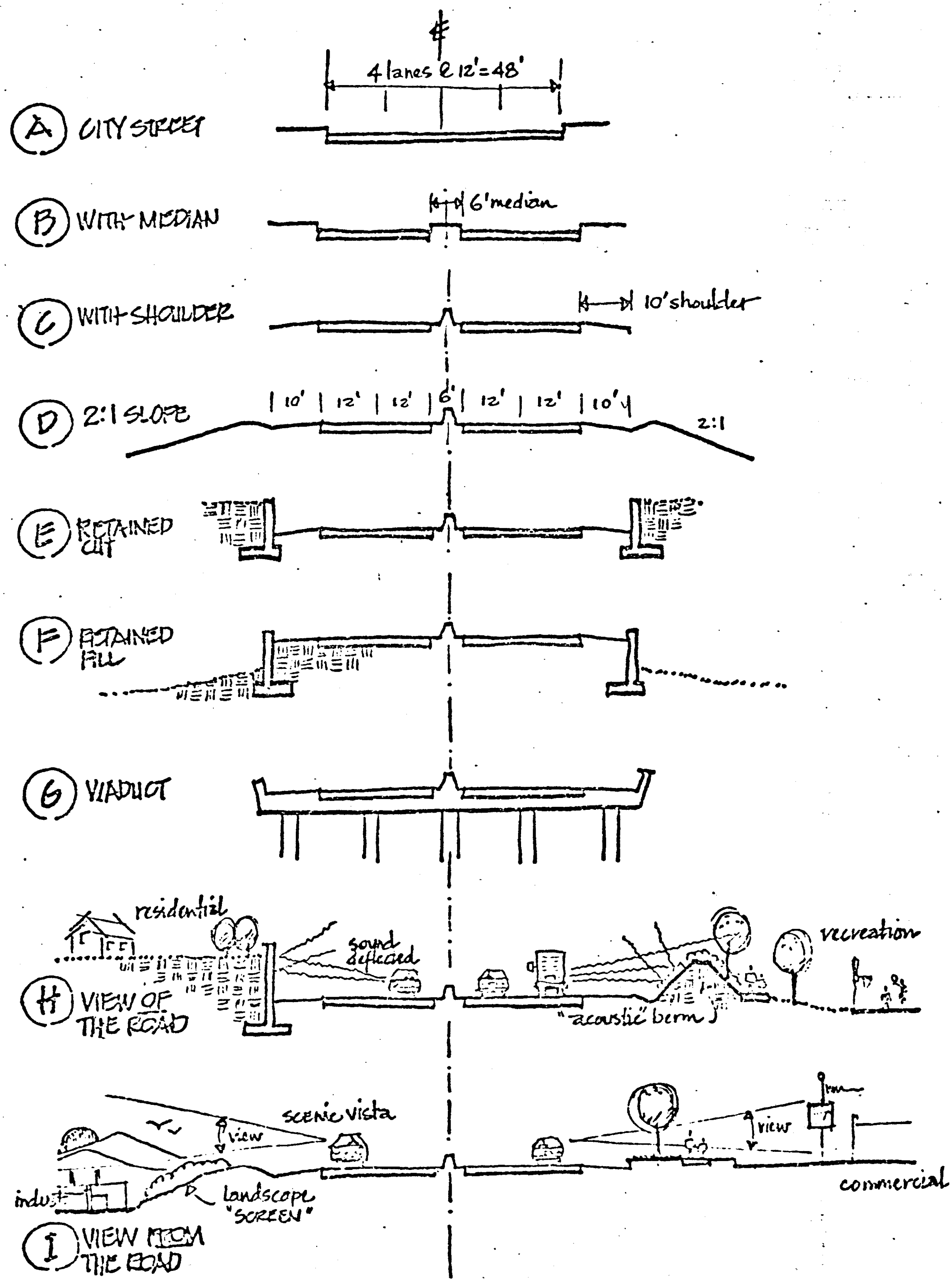
Figure 5: Pattern Acquisition by Selective Perception



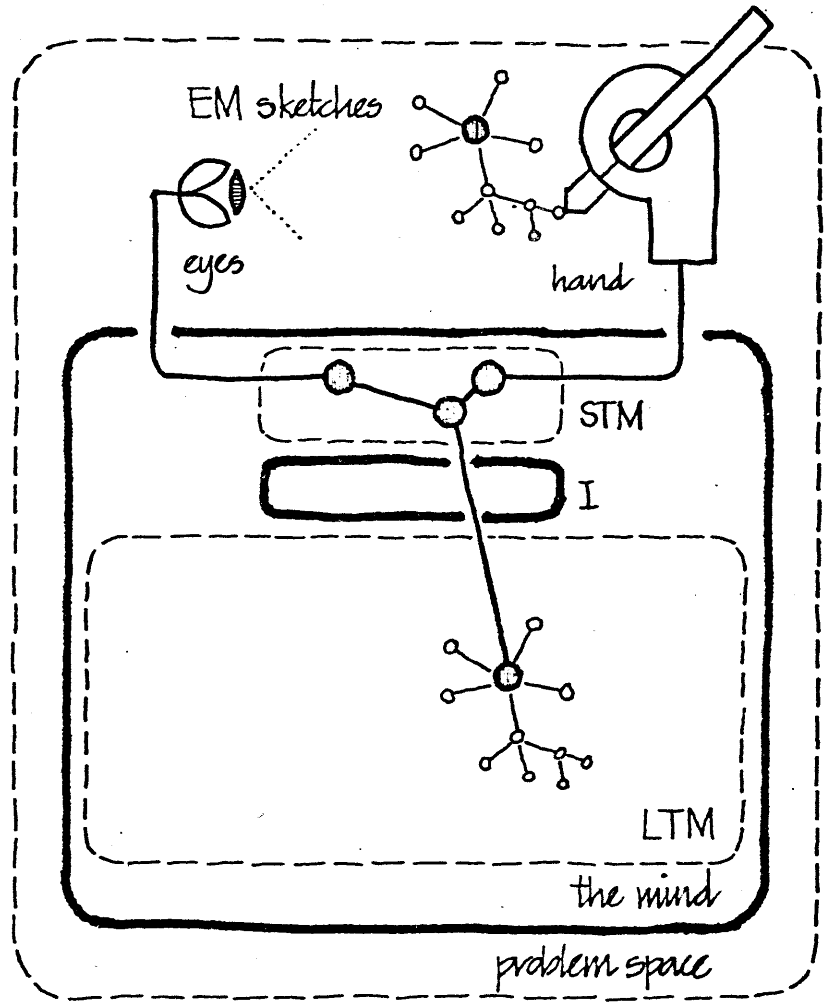
Most valuable were those which presented ostensibly complex technical information in a thorough yet concise manner easily comprehended by visually-oriented architects.[41] Often such research had the effect of suggesting form hypotheses which would stimulate a specific pattern search during a subsequent reconnaissance trip, thereby further increasing perceptual selectivity.

In addition, sketching and doodling helped reinforce LTM pattern development through simple graphic explorations of various form elements suggested by reconnaissance and research. Beginning with simple line diagrams of basic highway pavement cross-sections as shown in Figure 6, I gradually embellished these with a variety of possible edge conditions -- curbs, barriers, shoulder and slope profiles, landscaping, pedestrian walkways, etc. -- then began to graphically explore the adjacent visual and land use implications of these various sections. Most of these graphic manipulations were not at this point seeking solutions to particular problems, but were rather testing hypothetical combinations of various highway form elements. Figure 7 illustrates the information processing linkages between EM graphics and LTM patterns during episodes of sketching.

At the same time, development of these diagrams served to increase the amount of information (symbols) encoded with each LTM pattern, combining many form elements into a smaller number of more powerful patterns. STM can handle only a limited number of patterns or "chunks", at any given moment, shown empirically to be 7 $\pm$ 2.[42] Further, the number of patterns or symbol chunks that can be manipulated in STM does not vary between individual problem solvers (assuming normal levels of intelligence).[43] But the <u>content</u> of symbol chunks does vary; hence, more "powerful" patterns

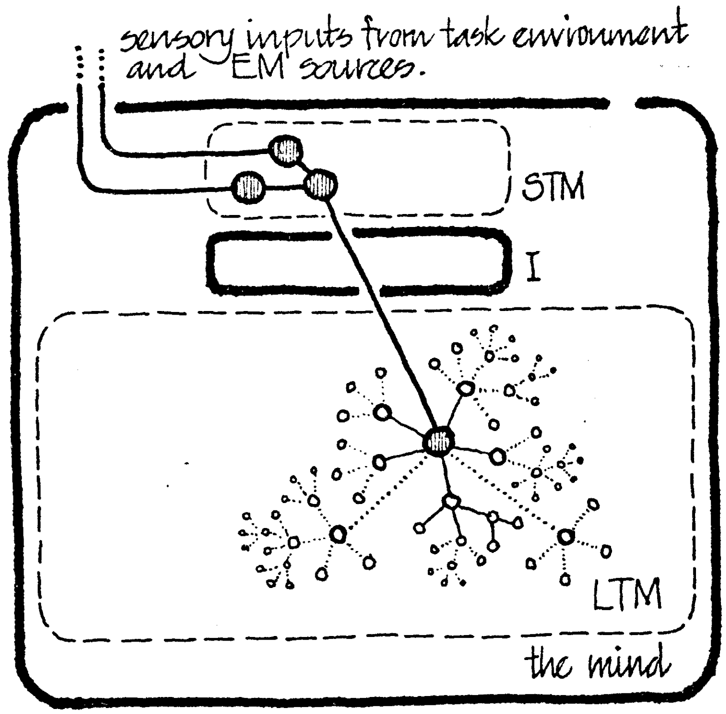


4 lanes @ 12'=48'
A CITY STREET
B WITH MEDIAN
6'median
C WITH SHOULDER
10'shoulder
D 2:1 SLOPE
10' 12' 12' 6' 12' 12' 10'
2:1
E RETAINED CUT
F RETAINED FILL
G VIADUCT
residential
sound deflected
recreation
H VIEW OF THE ROAD
"acoustic" berm
scenic vista
view
landscape "SCREEN"
indus
commercial
I VIEW FROM THE ROAD



are created by increasing the bits of information stored with each pattern, building larger and larger chunks, each containing more (form-relevant) information than before. Figure 6 illustrates this progression for highway cross-sections. Figure 8 is an abstraction of the same process, showing the recording of pattern additions (dotted) in LTM.

During pattern development, two complementary memory subprocesses modify the patterns, making them more efficient for use in sketch designing. Arnheim (1971) has identified these subprocesses as "leveling" and "sharp-



ening".[44] In leveling, forces inherent in the pattern itself or in the surrounding field of LTM patterns tend to simplify the pattern's memory trace by shedding details and refinements and increasing symmetry and regularity. At the same time, however, a counter-tendency is at work to preserve and indeed sharpen the distinctive features of the pattern. These two tendencies serve to clarify and intensify the visual concept of each pattern's memory trace. Further, repeated experiences with the same or similar pattern stimulus (e.g., during sketch design or reconnaissance trips) produces new memory traces which do not simply re-enforce existing ones but subject them to unending modifications to increase their perceptual efficiency and thus their effectiveness in sketch design problem solving. Traces resembling each other will make contact and strengthen or weaken or replace each other.

The result of these subprocesses is a storehouse of ordered visual concepts, some clear-cut and simple, others fragmentary and complex. All sorts of connections tie these images together into organized clusters or families of concept patterns. Formed by innumerable thought operations, patterns become related by similarity and associations of all kinds, including geographical contexts, fragmentary features or even time sequences. Figure 9 illustrates two pattern families in LTM related by common pattern elements.

Developing "rules" for the use of particular patterns required an understanding of the functional requirements of highways and their implications on physical design considerations. But the identification of functional requirements presupposes a grasp of the time and notion attri-

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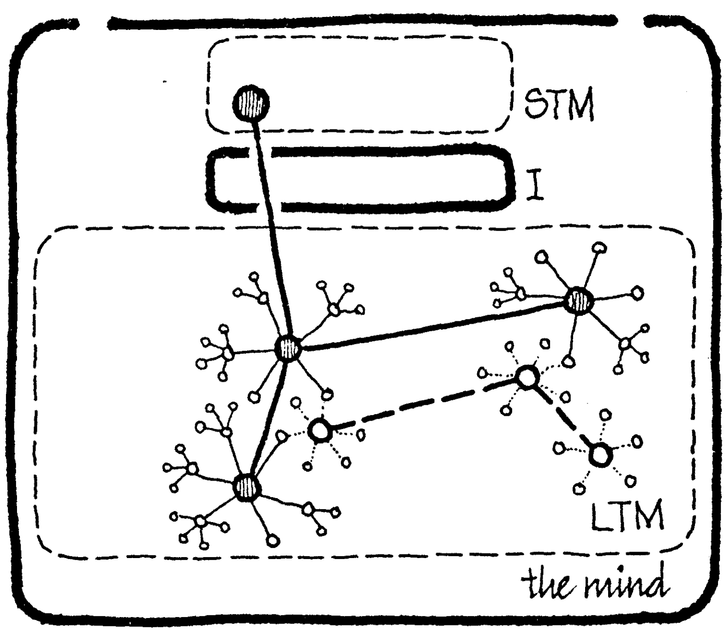
Figure 9: Pattern Families in LTM



butes that characterize highways as "flow systems".[45] To this end, I spent many hours observing traffic conditions, identifying design factors that appeared to influence congestion or reduce safety, and developing mental images of such terms as "peak hour volume", "design capacity" and "level of service". Eventually, I was able to translate the "foreign language" of traffic analysts into recognizable form patterns, a language I could understand. Thus, the semantic content of such terms as "design speed" and "sight distance" could be translated into alignment geometrics, and "a 1980 demand of 35,000 ADT" would conjure mental images of various combinations of highway widths, levels of service, edge conditions and intersection characteristics. By adding dynamic functional attributes to the form patterns in LTM, I gained conceptual understanding of highways not only as static spatial elements of the built environment, but also as important form generators of "adapted space".

Thus, through the use of various techniques -- reconnaissance, research, sketching, and the automatic memory processes of leveling and sharpening -- I gradually built up a library of transportation-related pattern "templates" which could be employed during sketch design to explore alternative form relationships between adapted space and flow systems.

The pattern acquisition process was, of course, guided by my understanding of the Phase I task objectives. Patterns were recorded both in LTM and in EM sketches with as many BTPR-relevant symbols as possible. For example, since a primary Phase I objective was to locate alternative transportation corridors with a minimum of disruption to the fabric of adjacent communities, it was important to record relevant contextual information -- edge conditions, adjacent land uses, functional and aesthetic implications, etc. -- with each pattern. Thus, the manner in which patterns were formed and linked to create usable templates for use in sketch designing and the generation of new alternatives, depended on my notion of what problem solving strategies would be most useful.

Problem solving efficiency, as Newell and Simon have shown, is directly related to the availability of patterns appropriate to the particular task environment. Patterns stored in LTM or located domains of EM (e.g., sketch design elements within foveal view) are equally available since "reading" from either requires times of the same order of magnitude (a few hundred milliseconds). EM patterns not within foveal view, such as might be on a graphic in the next room, or in a book or report on the library shelf, become considerably less available as increasing motor behavior and physical distances are involved in their retrieval. In fact, unless the "addresses" of EM patterns are stored in LTM they are useless to problem solving. As a consequence, greater efficiency generally accrues to the problem solver who has the larger "library" of available LTM patterns and/or who is able, through sketch design techniques, to stimulate additional LTM patterns or acquire new ones.

It should be noted, however, that recording new patterns in LTM requires considerable time (five to ten seconds per symbol) -- much more, for example, than is required to record "addresses" for EM patterns. Of course, the number of patterns that could be recorded in either LTM or EM is virtually infinite. As a consequence, for any given design problem, there is a trade-off requiring judgment as to how much of the total time available should be allocated to new pattern acquisition (and how much of that to LTM versus EM) and how much to design problem solving. This relates to perhaps the most perplexing question in any complex task environment, particularly one as time-limited as the BTPR: how much information is needed to make (design) decisions? At the outset of the BTPR, I did not have sufficient experience to make such judgments with any degree of assurance.

Conceptual Frameworks

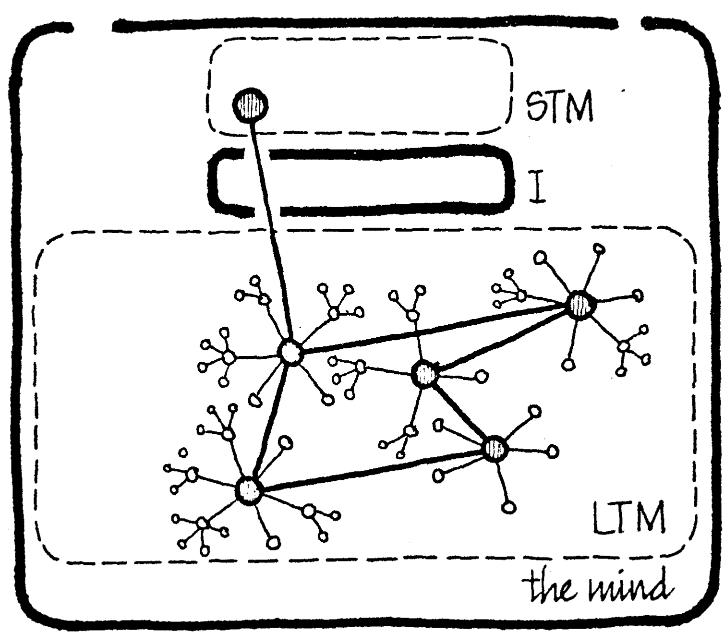
Concept formation takes place whenever new patterns are connected or linked to other patterns of a particular class or category already held in LTM. For purposes of this thesis, families of patterns and the linkages or rules which relate them are called conceptual frameworks. They are developed in response to, and become part of, the problem solver's perceptions of the task environment. They are the spatial organizations or "mental maps" of his problem space.

Conceptual frameworks serve two principal functions: first to guide selective perception and to sort out patterns and other informational inputs into functional categories which conform to the problem solver's image of the task environment; second, and conversely, to provide a means of organizing patterns in a manner such that the problem solver is able to generate (retrieve from the LTM and process via STM) elements of a set of possible solutions to a particular problem or task objective in some specific order during problem solving.

The methodological importance of conceptual frameworks to an analysis of problem solving behavior is discussed in the preceding chapter. This subsection describes how conceptual frameworks evolved and some of the implications for the development of alternatives in the BTPR context. Conceptual frameworks are seen as highly individualized, accounting for much of the variation in problem solving behavior among BTPR architects and particularly between the architects and other disciplines.

Conceptual frameworks are composed of concepts (pattern families) and rules (chains of two or more concepts). Figure 10 illustrates the schematic organization of a conceptual framework in LTM. To learn a concept one must (a) have discriminated between at least two examples of the concept and other objects/concepts and (b) be capable of perceiving the commonality in the two discriminations and responding as if they were the same class of things.[46] An example drawn from the BTPR experience might be a depressed roadway section with retained cuts on both sides, e.g., the

Figure 10: Conceptual Framework in LTM

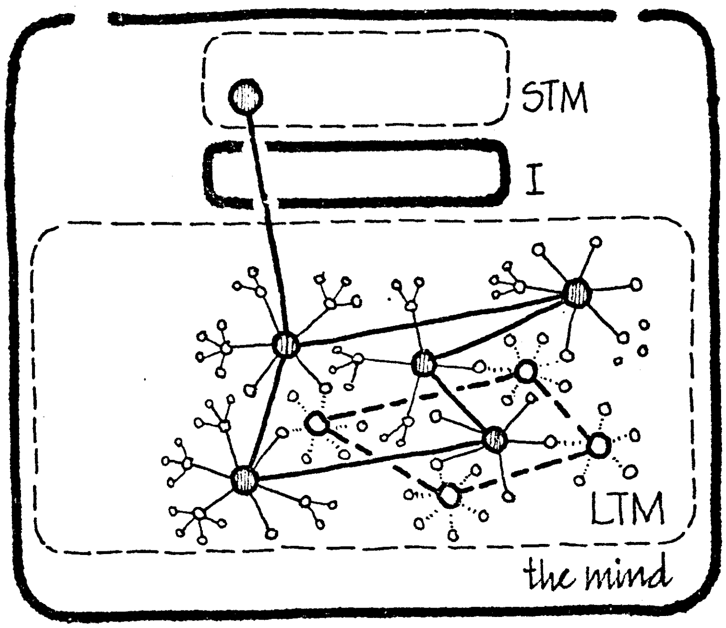


Mass Pike in downtown Boston or the Cross Bronx Expressway in New York. Once the concept is learned, one is able to identify other examples without further learning.

Rule learning is exemplified by making the correct responses to the information contained in the relationship between the concepts (patterns) which make up the rule. An example of a rule using the concept of depressed roadway sections might be stated, "Depressed roadway sections with minimum cross sections (i.e., retained cuts on both sides) should be considered for use only in dense, urban areas." The rule relates the concept of a depressed roadway section to the concept of dense urban areas. The relationship expressed in this example is not hard and fast and there may, in fact, be exceptions to such a rule; it implies the knowledge of a number of criteria -- economics, subsurface conditions, community cohesion factors, etc. -- which must be evaluated for the specific problem context. Other rules relating simpler concepts are subject to fewer exceptions and may be stated with greater certainty;[47] e.g., "The minimum radius of curvature for a roadway with a design speed of 50 mph is 830 feet." Knowing the needed rules (or how to acquire them) and being able to recall and apply them to the problem are prerequisite internal conditions of successful problem solving.

The chapter on METHODOLOGY introduced three conceptual frameworks which I used to organize patterns for use in sketch designing. Each framework was associated with a different scale of the BTPR context: regional, town/community and local neighborhood. These frameworks were developed through a process of pattern association as they were needed. The earliest to develop were those which assisted in the pattern acquisition process described earlier. For example, two conceptual frameworks, the view of the road and view from the road embodied very different sets of criteria or rules for relating patterns. As a consequence, they programmed very different selective attention searches during reconnaissance. Thus, the view of the road associated patterns and pattern families such as earth berms, acoustic walls, cut-and-cover construction and depressed roadway sections -- patterns which tended to reduce the visual and functional intrusion of highways on the adjacent natural or residential/ neighborhood environment. The view from the road, on the other hand, linked patterns relating to smooth geometrics, scenic vistas, landscaped edges screening industrial areas and blending with the natural terrain, beautifully designed bridges/viaducts and handsomely crafted highway hardware, etc. -- patterns which enhance the experience of driving.[48] Conceptual differences between these two frameworks are illustrated in diagrams "I" and "J" of Figure 6. Notwithstanding fundamental differences, there are many patterns -- e.g., elements of landscape buffers -- which may belong to either or both of these conceptual frameworks depending on the particular context. Such a relationship between frameworks might be represented internally as illustrated in Figure 11.

These two conceptual frameworks were first used in problem solving during the brief Beverly-Salem Bridge episode described earlier. Properly designed solutions, of course, integrated or "synthesized" the form-related patterns associated with both views. During sketch designing, however, patterns would be recalled from only one framework at a time, depending on which one best suited the current task objectives. In the Beverly-Salem Bridge example, the experienced architects were very con-



cerned about minimizing property takings and the visual intrusion of the proposals on the adjacent neighborhoods. Thus, they gave preference in sketch designing to patterns associated with the view <u>of</u> the road. Patterns stored in LTM under this label were retrieved during sketch designing to explore initial alignments and, once they were drawn by the engineers, to tighten up curves, reduce right-of-way takings, lower the approach profiles, provide new pedestrian and vehicular crossings, etc. Improving the quality of the driver's experience was a secondary objective. The recall of LTM patterns to accommodate this objective required the use of patterns associated with the view <u>from</u> the road.

The ability to shift focus from one conceptual framework to another during problem solving was a key factor in developing alternatives in the

BTPR context. By employing different conceptual frameworks based on different sets of criteria, the architect was able to characterize the demands of the task environment from more than one perspective. He could explore solutions based on criteria which embodied the concerns of the highway user, or concerns of the community resident living adjacent to a proposed highway, or of the environmentalist, or the highway contractors, or indeed of any other interest group. This ability to maintain separate conceptual frameworks and to shift easily from one to the other relies principally on the subtle but crucial shift in perception that the Gestalt psychologists have stressed in studies of figure-ground relationships. The classic example of the goblet and/or two profiles illustrates this phenomennon (Hochberg, 1964). The associations elicited by perceiving the goblet as the dominant organizing feature are entirely different from associations stimulated by perceiving the two profiles. The implications for problem solving are analogous for the difference between the view <u>of</u> versus view <u>from</u> the road. While both figures are within foveal view, attention may be directed to only one figure at a time. The other figure becomes a background blur, secondary in importance and often ignored entirely.[49] The two views cannot be seen simultaneously but rather must alternate.[50]

Figure 12: Figure-Ground Relationship

The problem solving consequences of having more than one conceptual framework are best illustrated by recalling that during pattern acquisition, the self-maximizing characteristics of the mind tend to reduce informational inputs to fit established patterns in LTM. Arnheim's "leveling" and "sharpening" processes and Gibson's "economical perception" are manifestations of these self-maximizing characteristics. Thus, as Arnheim notes, we see what we want to see; we recognize familiar features in a problem situation and immediately classify it and respond to it with well-established behavior. If a new pattern is only slightly different, it will shift toward the established pattern; this results in a "distortion" of the information actually presented. Now if there is more than one conceptual framework with established patterns in LTM, the new pattern tends to move toward the closest or most similar pattern. Thus, the greater the number of conceptual frameworks the less the likelihood of distortion of information from the task environment.[51]

This subsection has described the development of only two of the conceptual frameworks -- the view of versus view from the road -- that I used in the development of BTPR alternatives. These were the principal frameworks used for designing at the local neighborhood scale. The frameworks used at the town/community scale and the regional scale performed similar functions. All of them were spatially-based and enabled me to mentally map elements of the task environment and to organize patterns in LTM for use in sketch designing. Their development and implications for problem solving are described in the nest section.

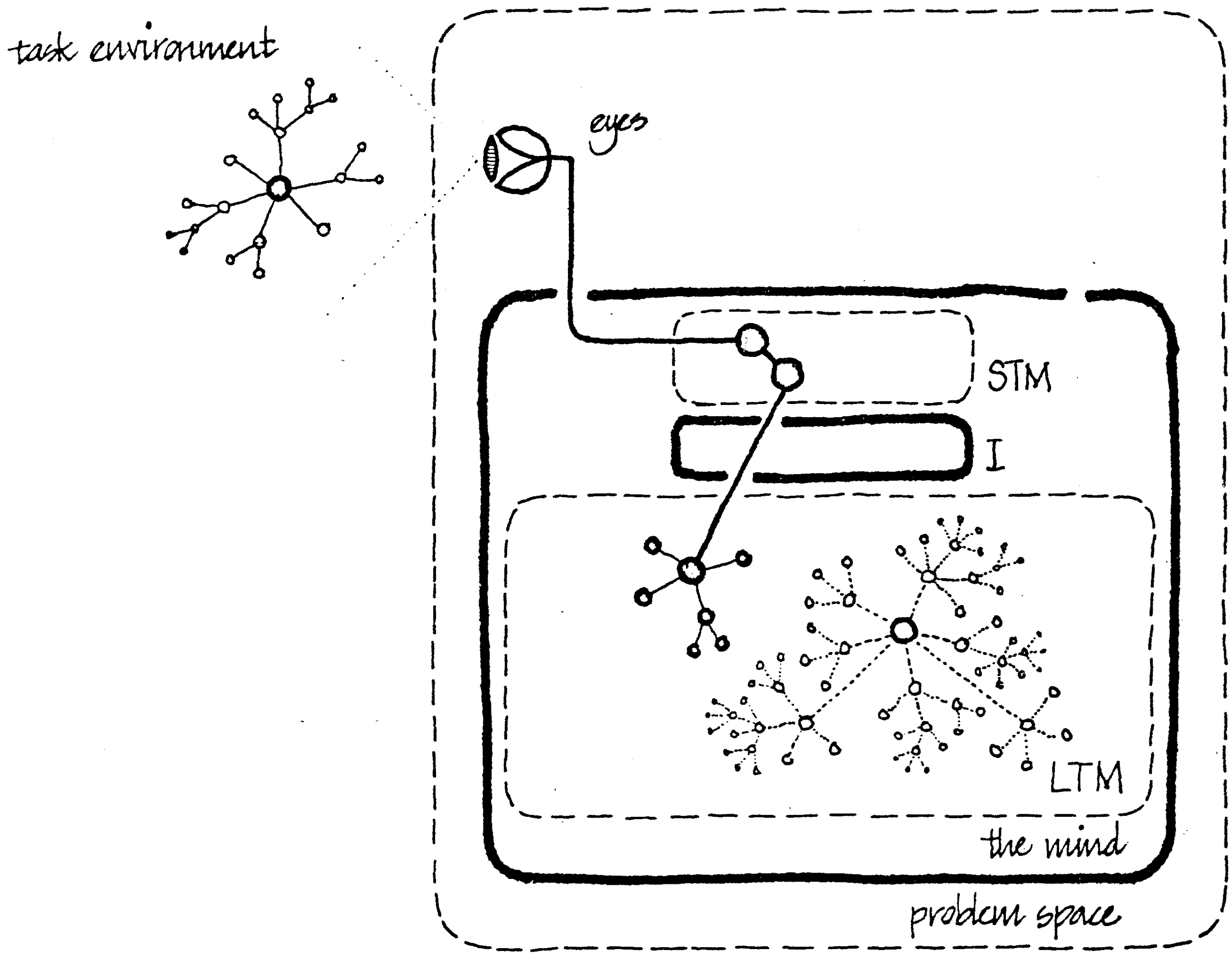
It is quite probable that spatial conceptual frameworks, and certainly the specific content of the form-related patterns acquired during the BTPR, were unique to the author. As Beck (1970) points out, systems of spatial meaning or "spatial styles" are largely personal constructs, analogous to characteristic conceptual, expressive and other personal styles. As they are built up word upon word, pattern upon pattern, action upon action, these styles become more and more a part of the personality structure of the individual.[52] As the personal construct of space is slowly divided into definitive zones with intuitive meanings and expressive character of their own, thus does the spatial field of each task environment become differentially charged with meaning from individual to individual. Foz (1972) found this to be true in his experiments with designers at different levels of skill development.[53]

Further, Beck suggests that particular configurations of the spatial field may be important clues to personality and basic value orientations of the individual.[54] The converse of this is a central premise of this thesis, i.e., that personal values and basic orientations manifested in the BTPR greatly influenced the choice and sequence of use (priority) of information in the development of alternatives.

Comparison with the "Experienced" Architect

The acquisition of new patterns and the development of conceptual frameworks continued throughout the duration of the BTPR. But the major acquisition of new response patterns to perceptual stimuli relating to transportation task environments -- what Kilpatrick (1970) calls the formative learning stage -- took place during the first few months of the BTPR, the orientation period. My vocabulary of organized pattern categories and operational rules expanded with my perceptions of the task environment and appropriate roles. New pattern categories enabled me to make greater use of new informational inputs from the task environment. In Newell and Simon's problem solving parlance, I was finally ready to explore the problem space by selecting patterns from my newly extended knowledge state (LTM and EM) and applying operators or rules to produce a final desired knowledge state or solution. In design problem solving terms, I was ready to sketch design.

A few observations with regard to principal features of the orientation period for the "experienced" BTPR architects may be helpful by contrast to the foregoing discussion. By definition, the experienced architect was armed with a basic vocabulary of patterns appropriate to transportation problem solving at the outset of the BTPR. He was able to make immediate use of information from the task environment to reorganize his previously learned patterns, to identify specific problem-solving tasks and begin work. However, while his orientation period may have been considerably shorter than that required by the inexperienced architect, it was no less important. Failure to restructure and reorganize previously learned patterns to bring them into congruence with the BTPR task environment meant that old patterns were being used to solve new problems. The result is a "distortion" of information from the task environment. As a consequence, the problem solving (or participatory) efforts of such an individual could be rendered ineffective or even counter-productive to fundamental objectives of the BTPR. (It is tempting to put many BTPR participants in this category). Figure 13 illustrates a situation where the problem solver's perception of the task environment suggests two possibilities in terms of previously learned patterns; one LTM pattern is considerably simpler, the other considerably more complex than the actual task environment; use of either pattern would create substantial distortion of information. The figure in-



dicates he has selected the simpler pattern to represent what he sees.

In contrast to the gradual process of pattern acquisition characteristic of formative learning, reorganizational learning apparently occurs in sudden shifts.[55] As incongruities are registered between informational cues from the current task environment and previously learned patterns, greater and greater weight is given to these cues, with the result that radical changes in the patterns and/or pattern-linking programs occur. Such pattern restructuring can take place during problem solving, which allows the experienced individual to be more productive (as a problem solver) sooner than his inexperienced counterpart. He is able to use informational inputs and feedback from the task environment to "re-program" the associations and linkages between patterns as well as to modify or add to the patterns themselves. Ideally, reorganizational learning is an integral part of the individual's problem solving process. "Divergent thinking" techniques developed by de Bono (1970) and "synectic" techniques used by Gordon (1961) may be helpful in this integration.

It is probable that both the reorganizational and the formative processes are at work in almost every instance of perceptual learning and problem solving. Formative learning is the more fundamental and necessarily precedes reorganizational learning. Once basic conceptual frameworks and pattern vocabularies have been established, however, the inexperienced architect is confronted with the same difficulties of pattern reorganization as is the more experienced architect. These difficulties became apparent in developing alternatives for the Harbor Crossing as described in Chapter Three.

The foregoing subsections have described in some detail how both the experienced and the inexperienced architect acquired and conceptually organized form-related patterns and pattern categories appropriate for their technical role in the BTPR context of transportation problem solving. Let us next see how these patterns were used in the analysis of the Inner North Shore subarea and the sketch plan development of Basic Choices.

The first section of this episode described those elements of the BTPR and I-95R task environments which I perceived to make "demands" (i.e., to establish criteria, define task objectives and set constraints) on my problem solving process. The next section described my response to these requirements and the learning process/orientation period during which I acquired appropriate LTM patterns and began to develop the conceptual frameworks which would enable me to explore possible solutions in accordance with my evolving role perceptions.

We are finally(!) ready to look at specific episodes of problem solving behavior. This section and the one which follows provide an analysis of the choice and use of information in the development of alternatives for I-95 Relocated (I_95R) on Boston's North Shore. This section describes the Phase I conceptualization of alternatives, the initial translation of the problem statement into form solutions. The next section describes the Phase II design development of these initial alternatives to produce the final "program packages" upon which the Governor would base his decisions.

The conceptual stage of design -- often referred to as schematic design or the parti stage of design -- is considered (by architects, at least) to be the most important stage in the design process. It is at this point that the architect first begins to explore the problem space, using sketch design techniques to generate diagrams which express both the problem and its possible solutions. In the BTPR context, these diagrams were essentially abstractions composed of related patterns recalled from LTM and various EM data base maps and graphics. Their generation required the intuitive use of divergent thinking and sketch design techniques to manipulate patterns evoked by my understanding of specific task objectives. The task objectives were, in turn, informed by extensive field reconnaissance, interaction with various community participants and the research of previous plans and reports.

The conceptualization of initial alternatives took place during the four-month Phase I of the BTPR. Following the orientation period, which included the Beverly-Salem Bridge episode described in the previous section, the BTPR architects generated a set of <u>Basic Choices</u> -- alternative locations for highway and transit facilities -- for each of the BTPR regional corridors (see Figure 4). The major facilities under study in the North Shore Corridor included I-95 North and its connectors, I-95 Relocated, the Revere Beach Connector, the Harbor Crossing, and the MBTA Blue Line.

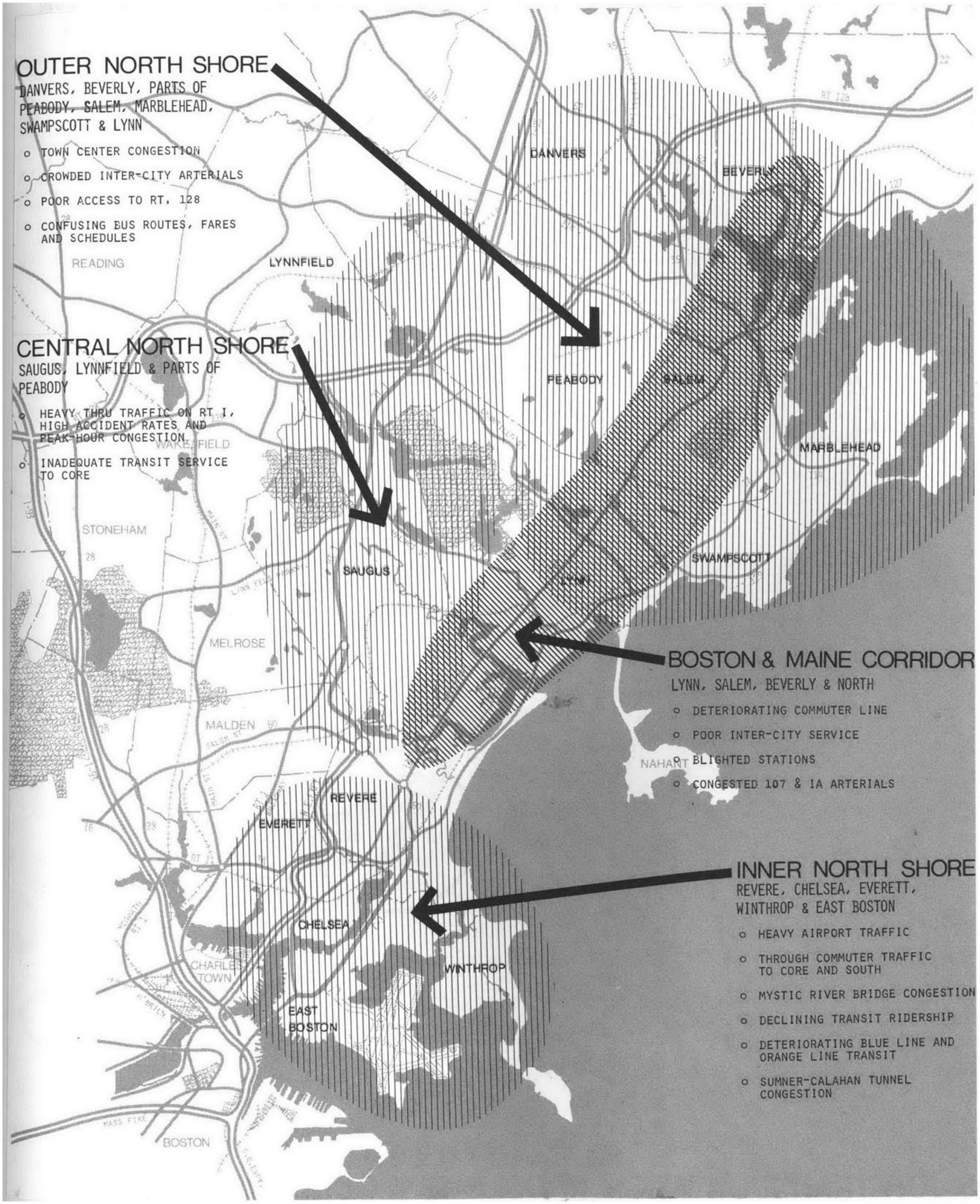
Conceptualization in the BTPR context was relatively straightforward. The BTPR had inherited a set of highway and transit proposals, some of which had first been proposed some twenty-five years earlier. The basic BTPR technical objectives were to determine if these facilities should be built; if so, where; if not, what facilities, if any, should be built and where. Thus, the first step in conceptualization was to identify the principal transportation problems in each community, and next, to evaluate how well pre-BTPR proposals addressed them. Following these steps came an analysis of existing highway and transit resources in each community and the identification of possible new corridors. And finally, all of the information generated during this four-month phase was synthesized into a set of sketch plan Basic Choices and seven illustrative Transportation Improvement Programs for the entire North Shore Corridor. The product of this effort -- the Phase I North Shore Progress Report -- was reviewed extensively with various community groups and officials. It became the technical basis for the Governor's Phase I decisions, which narrowed the range of options to be given further study in Phase II.

The following subsections analyze my role and problem solving behavior during each of these steps.

Problem Definition

As described in the Task Environment section, the North Shore Corridor was divided into three geographic subareas for purposes of Phase I analysis and conceptualization. These are shown in Figure 14, along with the principal regional transportation issues identified for each subarea. I was responsible for the Inner North Shore communities of Revere, Everett, and Chelsea.

Problem definition began with introductory data-gathering meetings scheduled with officials in each city and town. The most productive of these meetings were usually those attended by several city officials (e.g., the city planner, city engineer, police chief, fire chief, the mayor or his representative, etc.) and by several BTPR staff members, including myself, an economist, housing specialist, environmentalist, engineer, etc. Each participant generally had his own set of questions relevant to his particular specialty or concerns. Generally, I would record the exchange of information during these meetings in notes and symbols on city base maps for future reference and reconnaissance. These meetings provided an initial sense of community objectives and priorities with respect to a broad range of transportation, development, and environmental issues. In


OUTER NORTH SHORE
DANVERS, BEVERLY, PARTS OF PEABODY, SALEM, MARBLEHEAD, SWAMPSCOTT & LYNN
o TOWN CENTER CONGESTION
o CROWDED INTER-CITY ARTERIALS
o POOR ACCESS TO RT. 128
o CONFUSING BUS ROUTES, FARES AND SCHEDULES
CENTRAL NORTH SHORE
SAUGUS, LYNNFIELD & PARTS OF PEABODY
o HEAVY THRU TRAFFIC ON RT I, HIGH ACCIDENT RATES AND PEAK-HOUR CONGESTION
o INADEQUATE TRANSIT SERVICE TO CORE
BOSTON & MAINE CORRIDOR
LYNN, SALEM, BEVERLY & NORTH
o DETERIORATING COMMUTER LINE
o POOR INTER-CITY SERVICE
o BLIGHTED STATIONS
o CONGESTED 107 & IA ARTERIALS
INNER NORTH SHORE
REVERE, CHELSEA, EVERETT, WINTHROP & EAST BOSTON
o HEAVY AIRPORT TRAFFIC
o THROUGH COMMUTER TRAFFIC TO CORE AND SOUTH
o MYSTIC RIVER BRIDGE CONGESTION
o DECLINING TRANSIT RIDERSHIP
o DETERIORATING BLUE LINE AND ORANGE LINE TRANSIT
o SUMNER-CALAHAN TUNNEL CONGESTION
DANVERS
BEVERLY
READING
LYNNFIELD
PEABODY
SALEM
MARBLEHEAD
STONEHAM
SAUGUS
SWAMPSCOTT
LYNN
MELROSE
MALDEN
NAHANT
REVERE
EVERETT
CHELSEA
WINTHROP
CHARLESTOWN
EAST BOSTON
BOSTON
RT 128

addition, since I was still in the formative learning stages of pattern acquisition and conceptual framework development, I learned a great deal about how other BTPR disciplines conceptually organized and structured task environment information.

Through field reconnaissance following these meetings I would confirm the location and extent of the problems identified, noting and recording on maps each point of congestion, high-accident/safety hazards, poor access, and any other area of "poor fit" between various highway and transit flow systems and their adjacent adapted space. Reconnaissance was supplemented by research of various reports, master plans, and previous transportation studies, and by numerous additional meetings with community groups, agencies, and officials. I developed simple graphic symbols for various classes of issues and problems -- points of congestion, major traffic generators, proposed transportation and development projects, etc. -- and produced a summary entitled "Preliminary Definition of Issues" which included a list and graphic for review by each community. The initial graphic for Revere, for example, is shown in Figure 15. As perceptions change during problem solving, the definition of problems becomes more clear. Smaller or minor problems tend to be subsumed under larger, more generic problems. Thus, the amount of information appearing on this graphic was later reduced to show only the major transportation problems and conditions. The graphic prepared for the final report is shown in Figure 16. This reduction or compression of information in EM graphics was very similar to the chunking of information in LTM, described previously. "Leveling" and "sharpening" of patterns in LTM thus have their corrollaries in the compression of many details into a few clear symbols in EM graphics.

Figure 15: Preliminary Definition of Issues: Revere

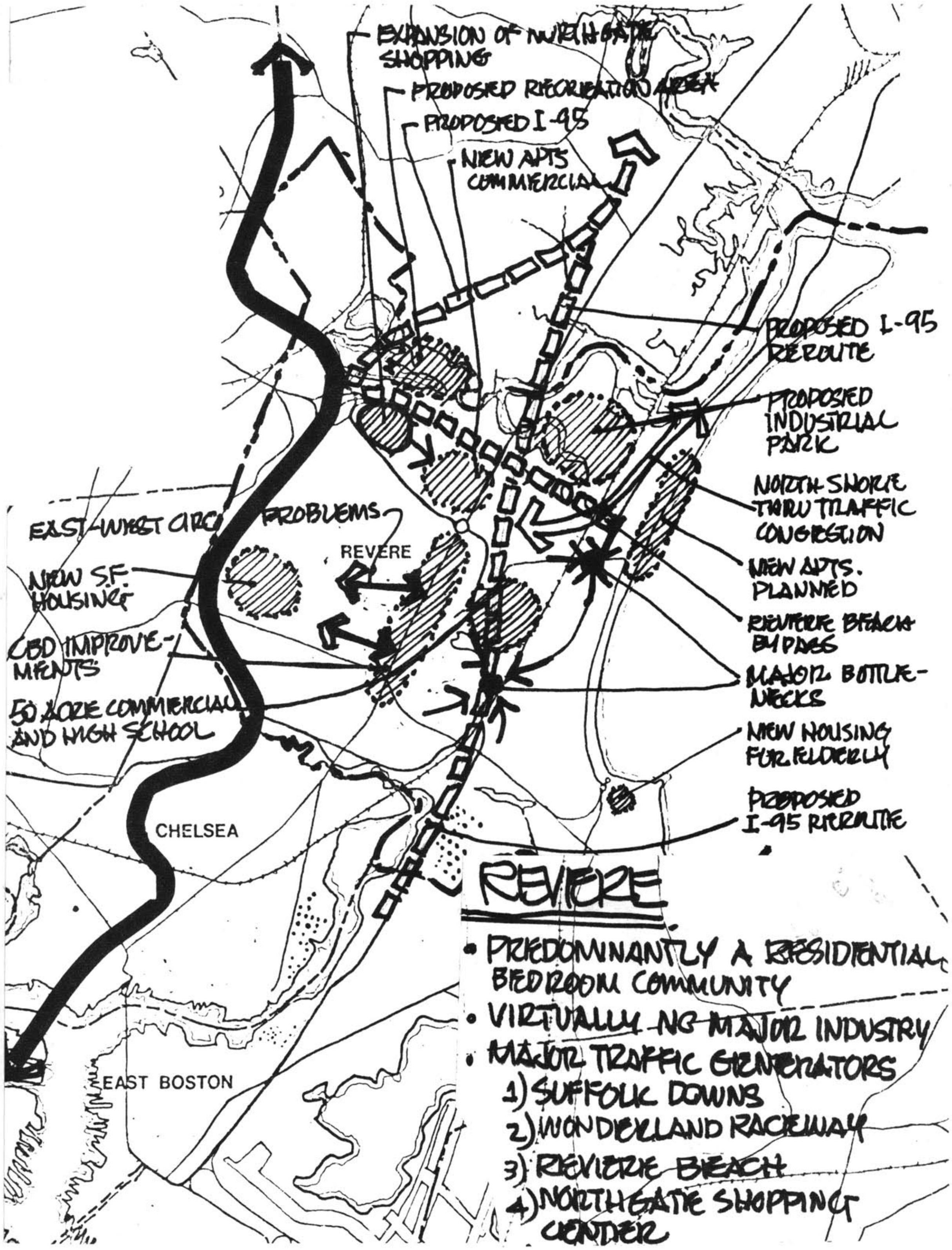
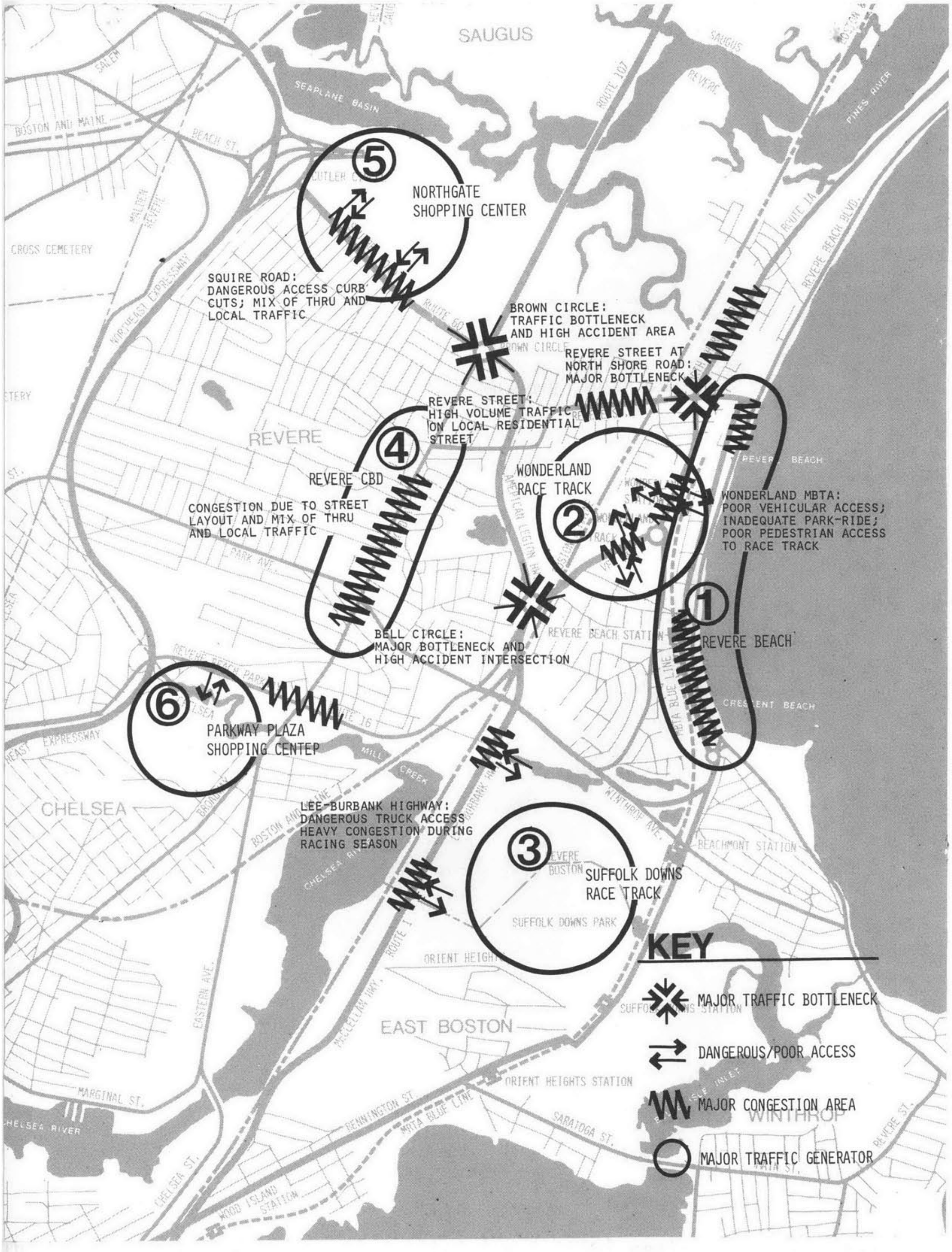


Figure 16: Major Transportation Problems and Conditions



Evaluation of Previous Proposals

Each issue on the Inner North Shore summary list was identified as being either of regional or local importance. Significantly, of the thirty-two transportation service issues identified in the I-95 Relocated subarea, only six were of regional importance; the remaining twenty-six were issues of importance to the respective local communities. Thus, the preponderance of perceived transportation problems in this subarea were problems that were not likely to be addressed by a facility designed to satisfy primarily regional needs, e.g., the pre-BTPR proposals for I-95R.

Actually, very little productive time was spent evaluating pre-BTPR proposals. It was clear at the outset that the location of these facilities had been based on core-oriented regional mobility considerations and their alignments dictated primarily by capital costs and interstate highway geometrics. The proposed section of I-95R through Revere, indicated by a dotted line on Figure 15, would sever portions of three neighborhoods and would displace between 165 and 400 households, according to Revere officials. Based on the criteria outlined by the Study Design, which emphasized social, economic and environmental criteria (in addition to transportation service characteristics), the pre-BTPR proposals were clearly non-options.

Survey of Existing Resources

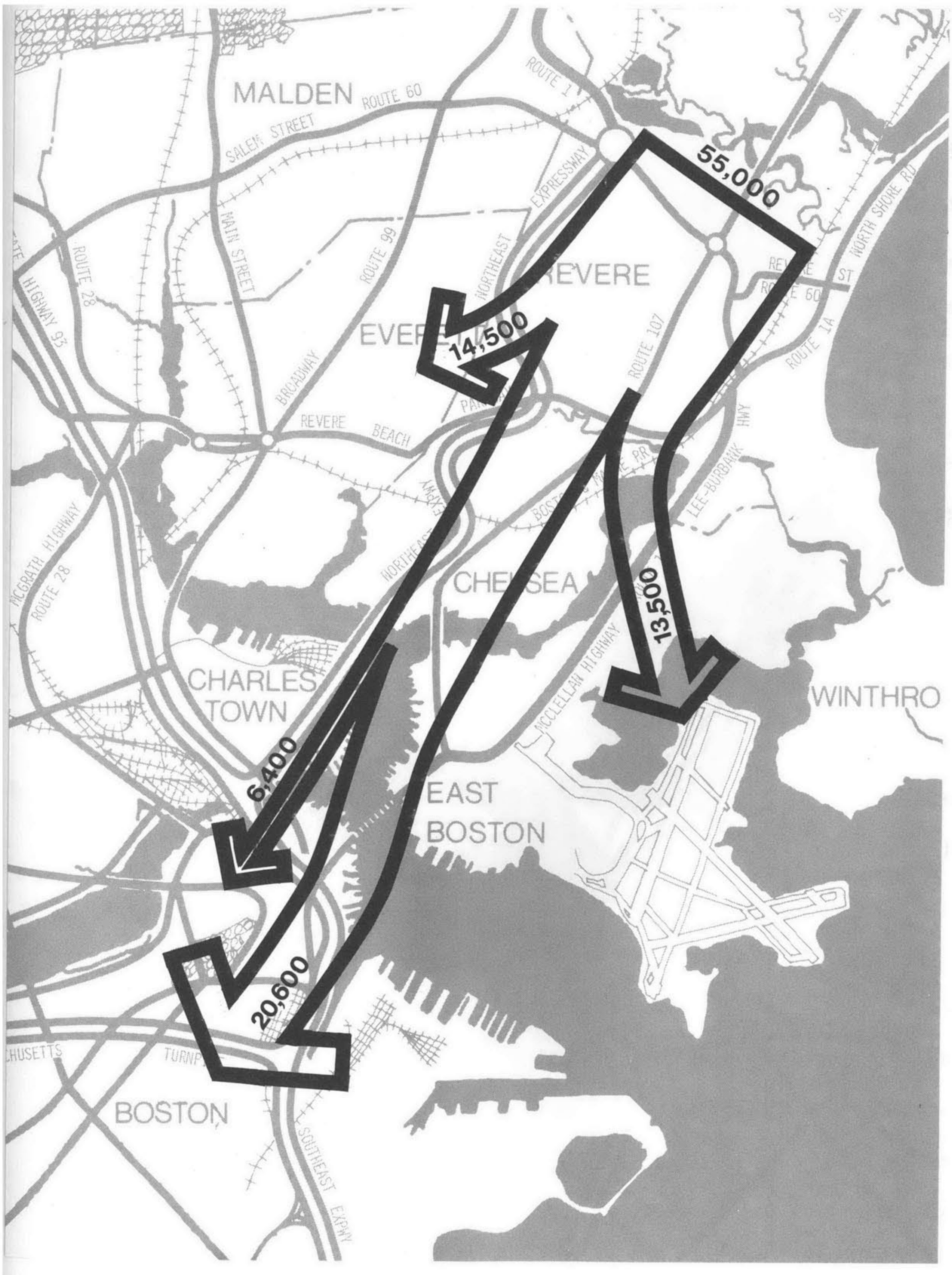
The next step in subarea analysis was a survey of existing resources. All existing highway and transit segments which might be used in addressing the transportation problems of each community were identified on base maps. Thirty-one such links were identified for initial analysis in the Inner

North Shore subarea. Volumes and capacities were mapped for each link, along with notes collected during reconnaissance regarding adjacent land uses, traffic conditions, congestion points and a general assessment of its potential to address identified transportation issues. Significant adapted space and demographic resources were also mapped for each community. These included generalized land uses, neigborhood boundaries, socio-economic factors (auto ownership, percentage of population over 65 years and under 21 years, low-income areas, etc.), the location of development proposals and other factors influencing mobility needs.

By the end of the problem definition and survey steps, I had added significantly to my growting "library" of LTM and EM patterns. Aided by reconnaissance, maps, aerial and eye-level photos and sketches, families of patterns constituting conceptual frameworks began to develop at the North Shore/regional scale as well as at the town/community scale. At the larger North Shore scale, these conceptual frameworks or "mental maps" were comprised of gross patterns of open space and adapted space areas overlaid by major highway and transit flow system networks. Information "attached" to these frameworks included the location of major regional traffic generators/destinations, quantification of major vehicular flows and person-trip demands, and other data produced by the traffic systems analysis. Thus, for example, I knew that 55,000 southbound vehicles passed through Revere each day on three major arterials: Route 1, Route 107, and Route 1A. Figure 17 shows the final report graphic of this information, which was used in the identification of new corridors.

At the town/community scale, the conceptual frameworks included patterns with much greater density and variety of information. The mental

Figure 17: Destination of Traffic Entering Revere from North



maps of each community utilized a schema of spatial organization similar to Lynch's (1960) five elements of paths, districts, edges, nodes, and landmarks described in the preceding chapter. Building on the pattern acquisition process described in the preceding section (Genesis of the Problem Space), each highway or transit path segment became a framework for encoding features of the adjacent adapted space, including the boundaries and demographic characteristics of neighborhoods, land use districts (commercial, industrial, residential, etc.), and the location of important natural features and community landmarks. Eventually, each community-scale conceptual framework evolved into a relatively comprehensive matrix of paths (auto, pedestrian, rapid transit and commuter rail) relating a patchwork of districts and neighborhoods and defined by physical and/or social edges, landmarks and nodes.

Identification of Potential Corridors

In beginning the sketch plan development of alternatives, I was well armed with a growing vocabulary of transportation-related patterns and conceptual frameworks at each relevant scale. The principal task objectives as I perceived them were twofold: first, the regional-scale objective of locating new highway and transit alternatives which would provide a balanced regional plan with equal or better transportation service but with fewer community impacts than previous proposals; and second, the community-scale objective of identifying opportunities to relieve locally-perceived transportation problems and at the same time maintain or enhance the integrity of existing neighborhoods and socio-economic networks. The strategy used to accomplish these objectives was to explore alternatives which met community-scale objectives first and then to adapt these to the demands of the regional objectives.

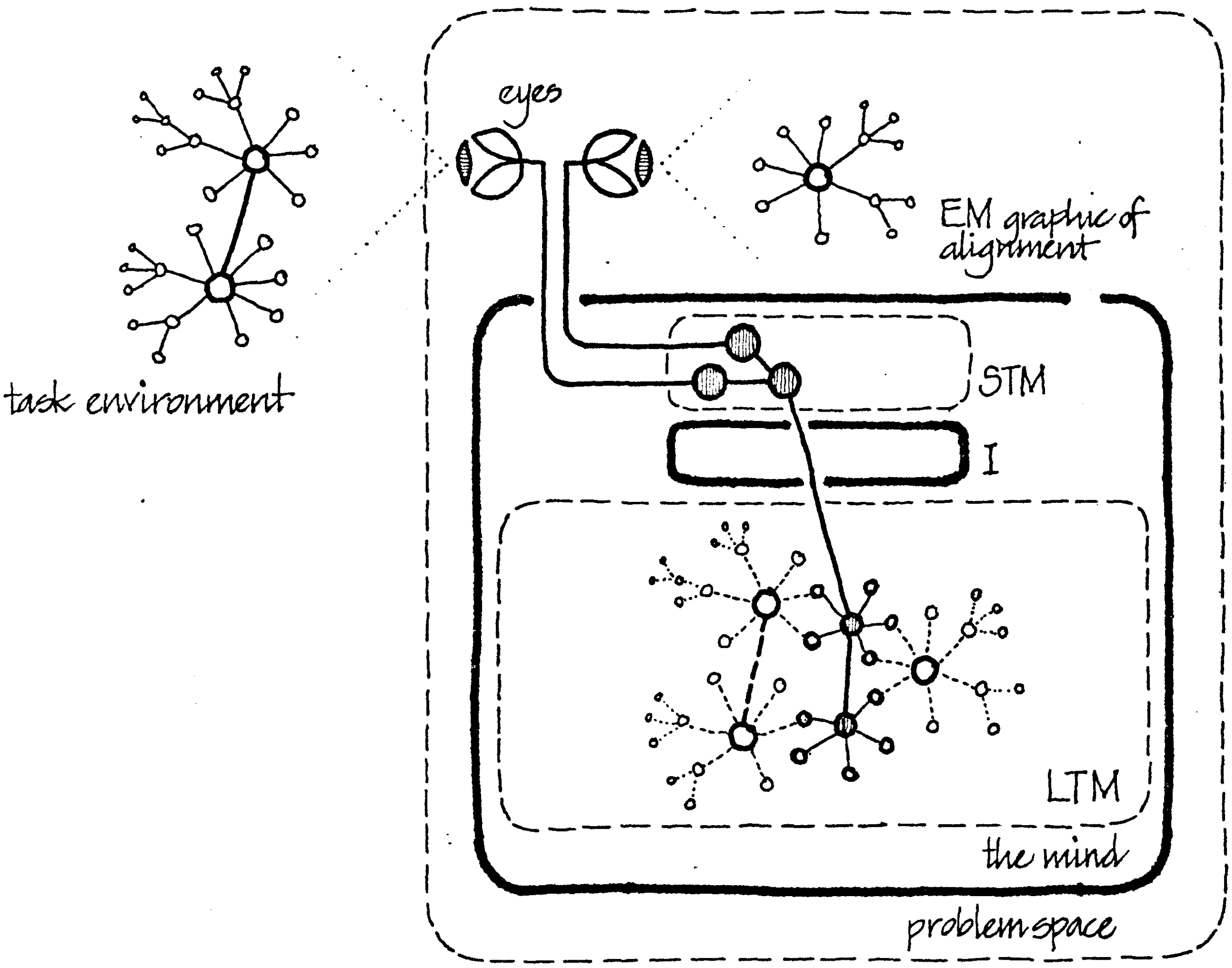
Sketch plan problem solving thus began at the community-scale. Using felt tip pens and tracing paper over aerial photographic bases,[56] I explored a variety of ideas using patterns recalled from LTM mental maps and various EM data graphics. First, I explored ways to increase the effectiveness of existing highway and transit paths to "solve" community-perceived problems. In many instances this matching of problems with possible solutions seemed like the easiest step in the process. Solutions often seemed to "leap out" (of LTM) at the mere suggestion of a problem. Thus, the problem of north-south through traffic (55,000 vehicles per day) in Revere immediately stimulated the recollection of possible ways to increase the use of the Northeast Expressway Corridor, which I knew from my survey had capacity to spare in the segment through Revere. New interchanges with feeder streets, the addition of movements and improved access ramps at existing interchanges and the addition of lanes at points of congestion were all explored with quick sketches and diagrams. Similarly, the need for improved east-west mobility for local Revere residents suggested a variety of possible improvements for the Revere Beach Parkway/Mill Creek Corridor. Proceeding in this manner, I developed a "shopping list" of possible improvements for virtually every arterial and major feeder street in each community.

The apparent ease of this process is easily understood by reflecting on the learning process described earlier and the contents of my (internal) problem space. By this time I had developed a relatively extensive library of LTM patterns comprised of highway form elements, i.e., all of the characteristics of cross-sections, turning radii, intersection designs, profile and edge conditions, critical dimensions, etc., that I thought might be important in designing. I had also developed extensive mental maps of the communities in the Inner North Shore subarea, each organized by conceptual frameworks which facilitated the integration of enormous amounts of otherwise nonsensuous (meaningless) data. As a consequence, the mention of a problem with a geographic referent to one of my mental maps immediately makes all of the information stored under that "address" in LTM available for STM processing. At the same time, the manner in which the problem is stated immediately suggests a family of potential solutions composed of highway-related LTM patterns. We know from Newell and Simon's work that STM processing of LTM patterns is virtually instantaneous, i.e., on the order of a few hundred milliseconds. Little wonder then that possible solutions seemed to "leap out" of my mind.

Once existing paths were evaluated, I began to search for possible new paths by exploring the edges of existing neighborhoods and the boundaries between different land uses. Initially, these were drawn as felt tip lines on 1:400 aerial photo bases using data base maps of land use and neighborhood boundaries as EM references. Each sketch plan alignment was a tentative assumption or hypothesis about the relationship of a new path to a particular task environment context, mediated by the requirements of the task objective. These sketch plans were what Alexander (1964) has called "constructive diagrams"; they related an unclear set of forces to one another conceptually. By describing both the context and the form simultaneously, they provided a bridge between my understanding of the requirements of the task environment and my images (LTM library) of possible solutions. They actually made it easier for me to understand the problem.

Like most hypotheses, these diagrams of potential highway paths preceded the precise knowledge which could prescribe their alignment on rational grounds. They were products of invention, of divergent thinking and abstraction; they could not have been derived by deductive methods. Once drawn, each alignment had to be "tested", sometimes by checking larger-scale base maps, but more often by field reconnaissance. The perspective view of a road is often markedly different from the way it appears in plan and profile.[57] In addition, every representation, short of the actual artifact it models, contains only a limited representation of the form: the form itself embodies qualities that are always more than the sum of their quantifiable measures.[58] As a consequence, measurements of a <u>representation</u> often exclude significant information. Measurements in the "real world" context, i.e., through reconnaissance testing, obviously come much closer to an approximation of the perspective view of a road actually built in that environment.

Armed with my sketch plans on aerial photo bases, I would walk each potential alignment, testing my sketches by visually imagining ("holographically", if you will) the roadway occupying the three-dimensional space of its real world context. As Arnheim (1971) has noted, once the problem solver is armed with the image of what to look for, the desired pattern can be directly perceived in the problem situation, however complex that environment may be.[59] Figure 18 illustrates schematically the information processing relationships of patterns residing in LTM, EM sketches and the task environment during reconnaissance testing. Note that the mind uses other LTM patterns (solid) to test "goodness of fit" between EM alignment & task environment. By this time, of course, I was very familiar with the cross-sectional characteristics and categories of edge conditions as-

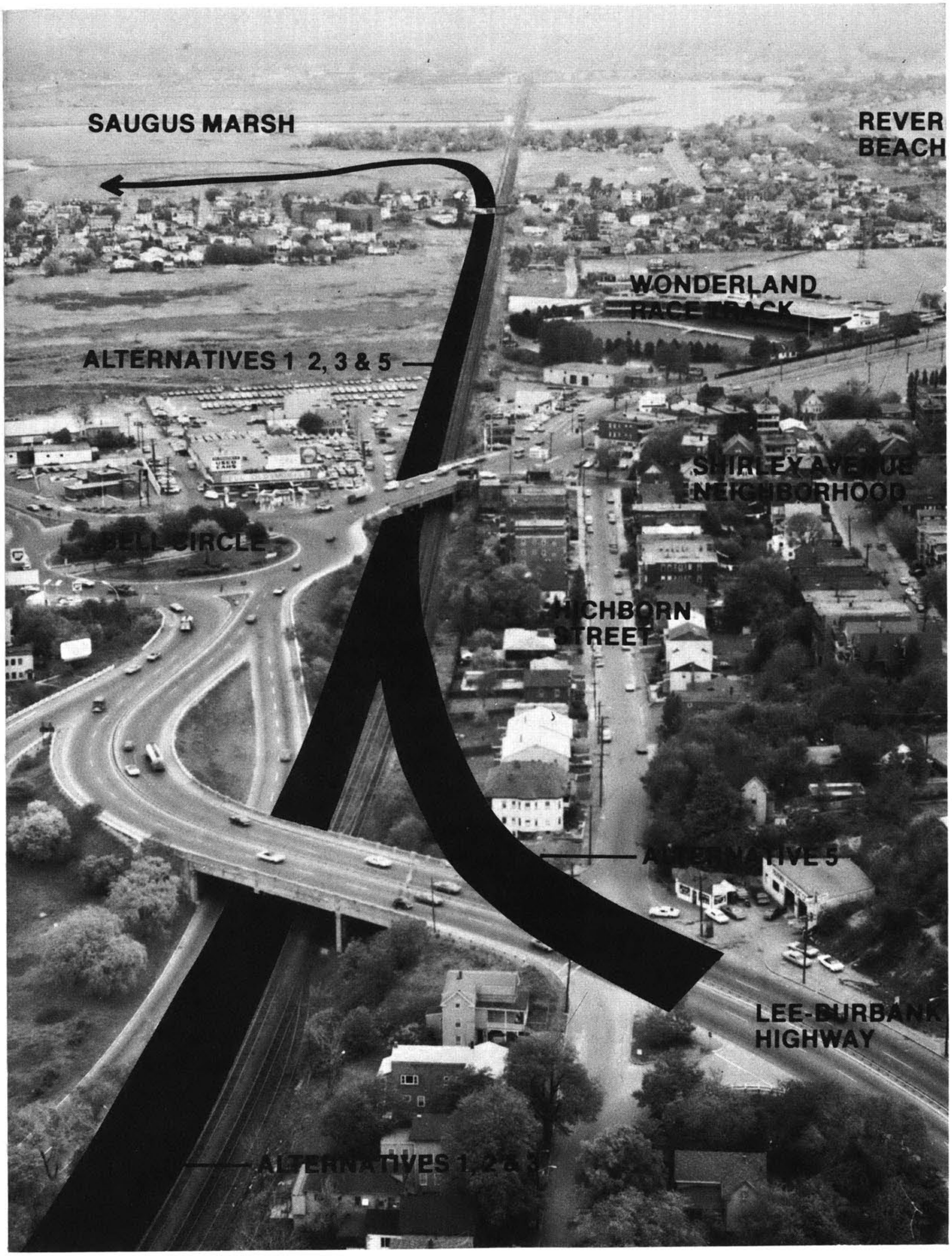


sociated with different highway profiles. By walking along the hypothetical centerline of a proposed alignment, I could easily assess its feasibility in terms of probable takings of residential and commercial buildings, possible environmental impacts, visual disruption and other criteria relating to "goodness of fit" between flow systems and adapted space. If necessary, I would pace off a right-of-way width at critical points and make notes of dimensions and clearances on my sketches for use in later sessions of sketch designing. At a minimum, reconnaissance testing would indicate whether the idea had sufficient merit to warrant further analysis and sketch planning. If not, additional effort would be terminated and the next alignment tested. Figure 19 gives a sense of what I "saw" during reconnaissance testing of potential alignments in the Boston and Main Corridor.

Through this alternation of sketch planning and reconnaissance testing a number of alternative transportation improvement corridors -- both existing and proposed -- were identified for each subarea community. Generally, each alternative would address either north-south or east-west movement needs. The feasibility of each alternative had been evaluated sufficiently at this point to give some indication of its potential for further study. It is important to note that this community-scale analysis did not assume the construction of a new expressway facility through the subarea, but rather focused on identifying potential improvement corridors which would address local community-perceived transportation needs.

Next, I undertook the regional-scale objective of locating alternative corridors for the pre-BTPR interstate highway and transit proposals. Since these facilities were intended principally for regional through travel, they would necessarily traverse through several subarea communities. The design of these alternatives thus required me to think conceptually at the scale of the entire Inner North Shore subarea, and no longer in terms of individual communities. The simplest description of the interstate highway problem statement at this scale was: identify alternative corridors for a four to eight lane expressway conforming to interstate design standards and connecting the Massachusetts Turnpike and Southeast Expressway in the Boston core with Logan International Airport in East Boston and either

Figure 19: Boston and Maine Right-of-Way Corridor Alignments



I-93 in Medford and/or the proposed I-95 North at the Revere-Saugus line (see Figure 4).

Sketch planning began by exploring various combinations of corridors already identified at the community-scale analysis to determine which (if any) could be combined and adapted to create alternative alignments meeting the regional requirements of the interstate facilities. For example, corridors identified in Revere for possible improvements to local east-west and north-south movements were analyzed to see if they could be adapted as links for I-95 Relocated as well. It is worth noting that in each BTPR corridor, where regional facilities could be derived by adapting potential solutions first conceived at the community-scale -- as was the case in Revere -- the alternatives thus developed met with relatively little community resistance. Where this step was unsuccessful, i.e., where there was a fundamental mismatch between community-perceived options and the requirements of the regional facility -- as was the case in East Boston -- the alternatives met concerted, ofttimes bitter, community resistance. (The East Boston case is described in the next episode.) The five principal corridors located in Revere are shown in Figure 20.

The basic iterative format of the sketch planning process described earlier -- an alternation of sketch design generation of ideas followed by field reconnaissance testing, data gathering, and then further sketch designing -- was followed until a set of Basic Choices for these regional highway and transit facilities emerged. Figure 21 illustrates this process schematically. Note that patterns are mutually reinforced in LTM and EM by this iterative "eyemindhand" processing. Very few sketch plan iterations were required at this point, only enough for a general evaluation of each schematic alternative. The intent of Phase I was to identify a range of alternatives which would be

Figure 20: Alternative Corridors and General Land Use

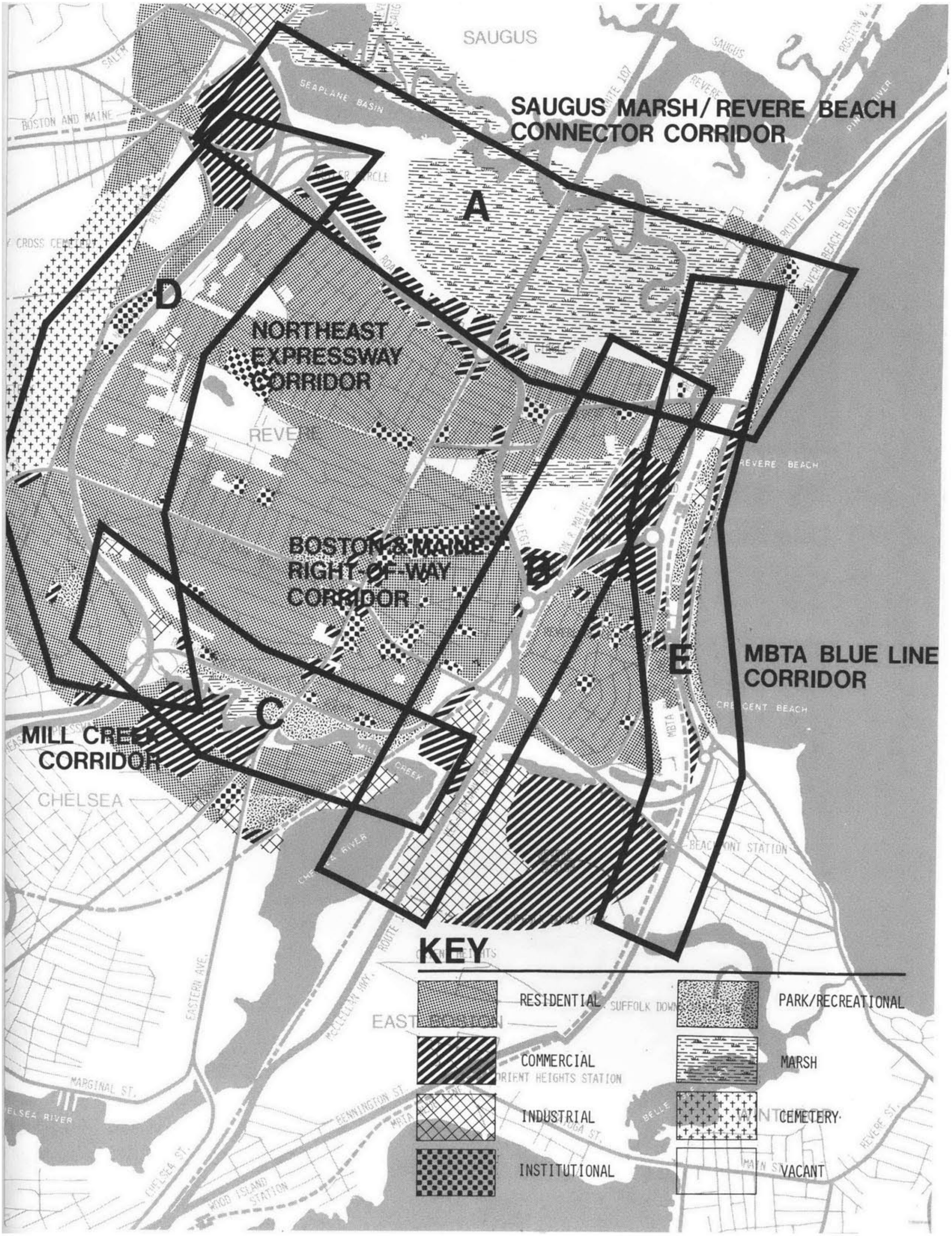
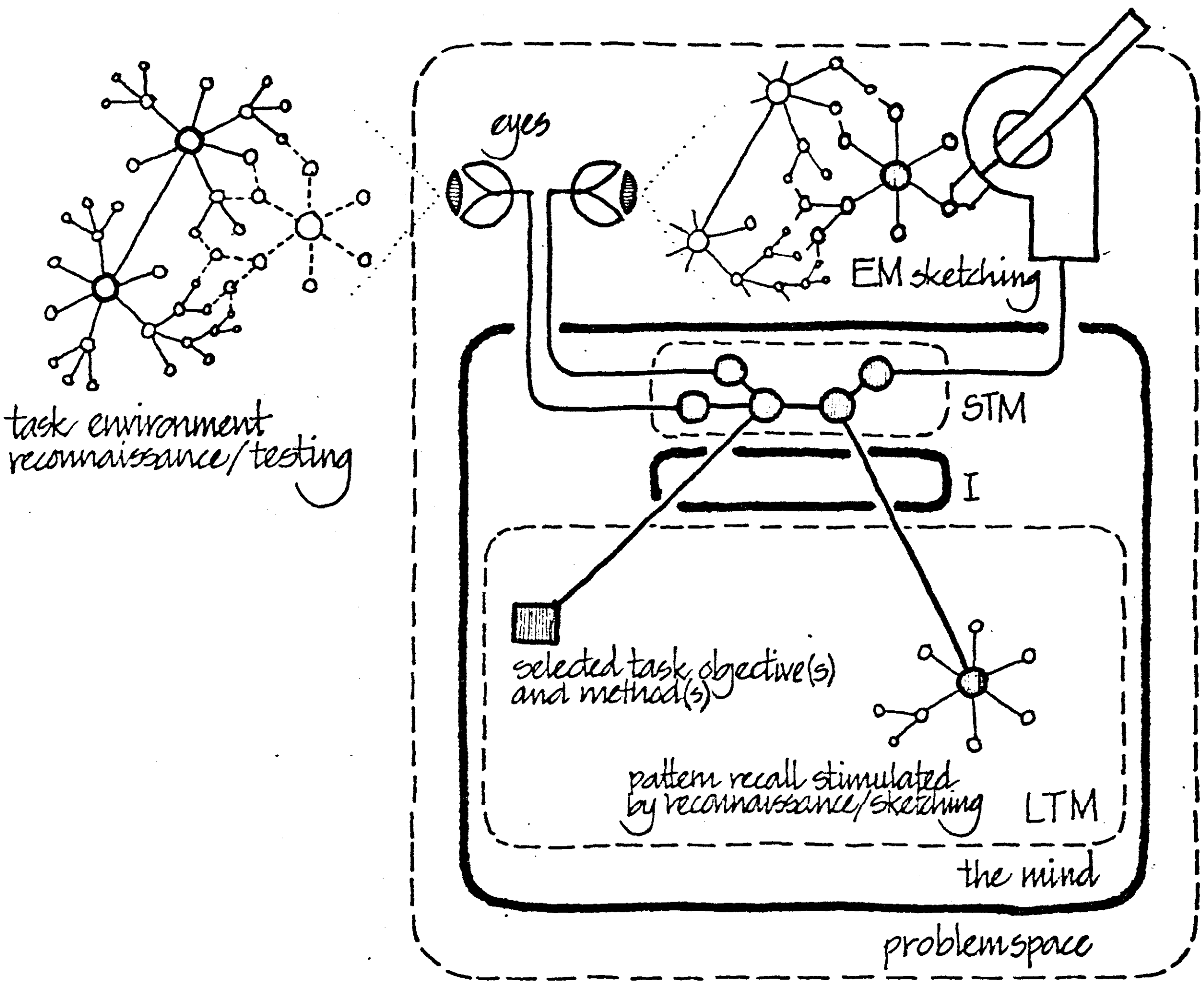


Figure 21: Schematic Organization of Sketch Designing

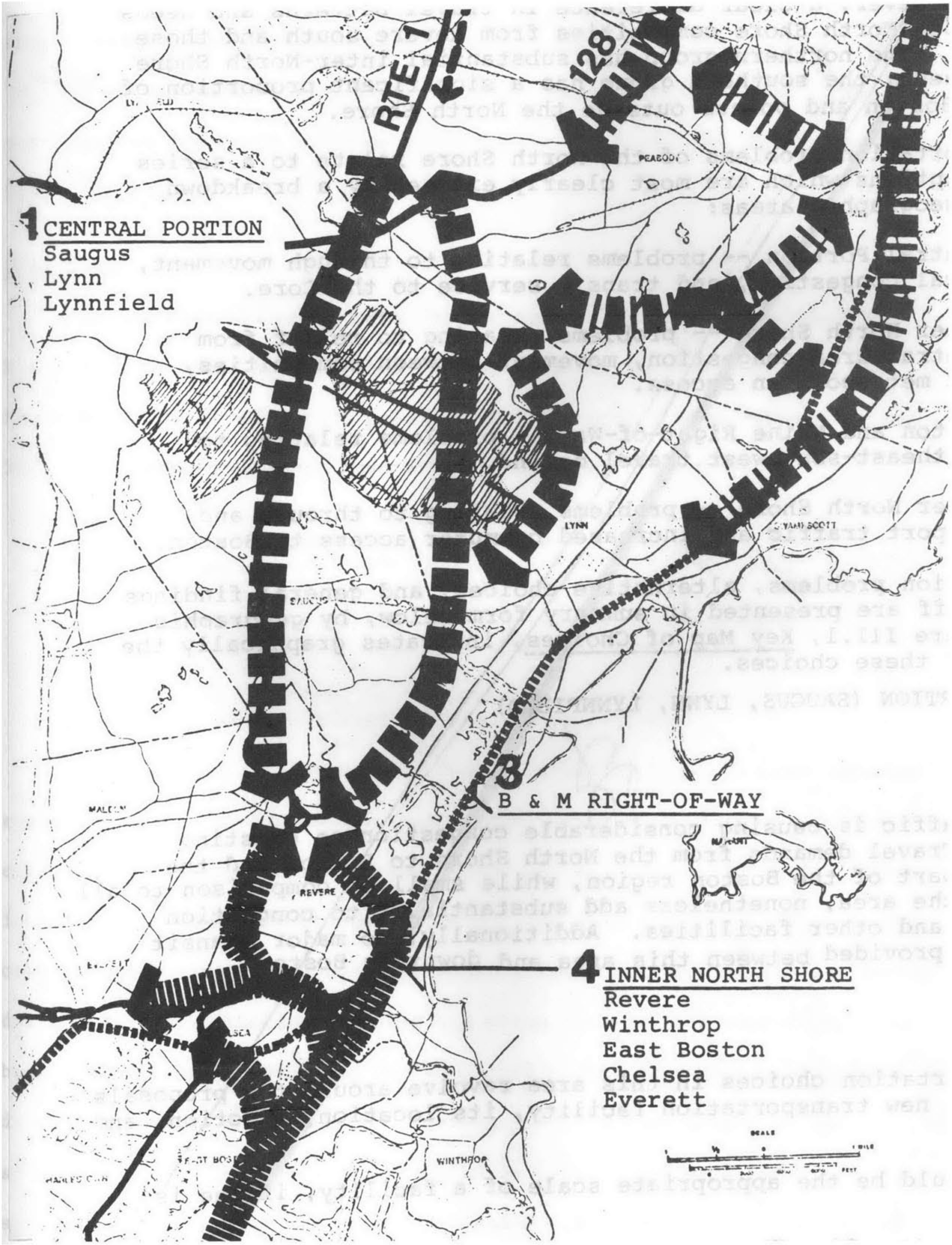


given further study in Phase II. Thus, there was relatively little "risk" involved at this stage and a rather high degree of intuition and informed judgment was exercised. Actually, very little "hard" data -- 1990 design year demand, subsurface conditions, precise boundaries of historic and environmentally sensitive areas, etc. -- was available at this point.

Basic Choices

Three months of intensive analysis and broad-brush sketch planning in each community and subarea were synthesized by the four North Shore architects into a set of Basic Choices for the entire North Shore Corridor. In addition, seven preliminary program packages illustrating four policy approaches to North Shore transportation improvement were developed. These were presented, along with subarea summaries of the principal transportation problems and findings and a Proposed Phase II Work Program in the Phase I "North Shore Progress Report". Figure 22, from this report, shows the Basic Choices by subarea for the major facilities under study in the North Shore. With respect to transit, the regional transit team had identified a variety of improvement alternatives to be given further study in Phase II. Many of these were tied to various highway access improvements.

In sum, the Phase I results indicated there were viable alternatives to each of the major pre-BTPR facilities proposed in the North Shore. In some cases (e.g., the Outer North Shore) the pre-BTPR proposals did not appear to address the most pressing transportation problems of the communities in that subarea and completely new alternatives were conceived. For virtually every pre-BTPR proposal, alternative corridors were identified which would result in substantially less disruption to the communities and at the same time address many heretofore unrecognized community-perceived issues and objectives. In Revere, for example, the corridors identified for I-95 Relocated Basic Choices would take through traffic <u>around</u> Revere, utilizing either existing flow system corridors or open space edges. The maximum takings envisioned for the most disruptive of these alternatives was about fifty residential units and for the least disruptive, about twenty. In contrast, the pre-BTPR proposals for I-95 Relocated generally cut diagonally across the city, resulting in takings estimated variously from 165 to 400 residences.


RTE 1
128
1 CENTRAL PORTION
Saugus
Lynn
Lynnfield
LYNN
REVERE
3
B & M RIGHT-OF-WAY
4 INNER NORTH SHORE
Revere
Winthrop
East Boston
Chelsea
Everett
WINTHROP

The results of the subarea synthesis and the North Shore Progress Report were reviewed with various community groups and city representatives in each subarea, as well as with the North Shore Steering Group. This report and the community response to it became the basis for the Governor's Phase I decision.

Decisions

Following a series of briefings by the BTPR staff for the Governor, his staff and other key decision-makers, Governor Sargent concluded the four-month conceptualization phase of the BTPR with a news release (December 29, 1971) announcing that Phase I of the BTPR had demonstrated:

1) "that all of the old expressway plans for the region within Route 128 require, at the very least, major modification;

2) that there are many new and exciting alternatives which have not previously been seriously considered; and

3) that open planning, in close consultation with local officials and interested private groups, can work."

In narrowing the options for further study in Phase II, the Governor reasoned that eight-lane-scale expressways within Route 128 were "clearly excessive" and dropped from further study all expressway facilities greater in scale than four conventional highway lanes plus two lanes for buses and other special purpose vehicles. The net effect of this decision was to redefine the transportation problems for which the pre-BTPR expressways had been rational solutions. The design of new radial expressways to accommodate peak-hour travel demand to downtown Boston was no longer an appropriate solution to the (new) problem. As will be seen in the next chapter, this strategy of redefining the problem played an important role in developing alternatives for the Harbor Crossing.

On the North Shore, the Governor also dropped the pre-BTPR alignments for I-95 North, I-95 Relocated and the Harbor Crossing, on the basis of their severe community impacts and the preliminary evaluation of new sketch plan alternatives which would require considerably less disruption.

Figures 23, 24, and 25 indicate the facilities dropped and the transit and highway facilities to be given priority consideration during Phase II.

Figure 23: Facilities Dropped from Further Consideration

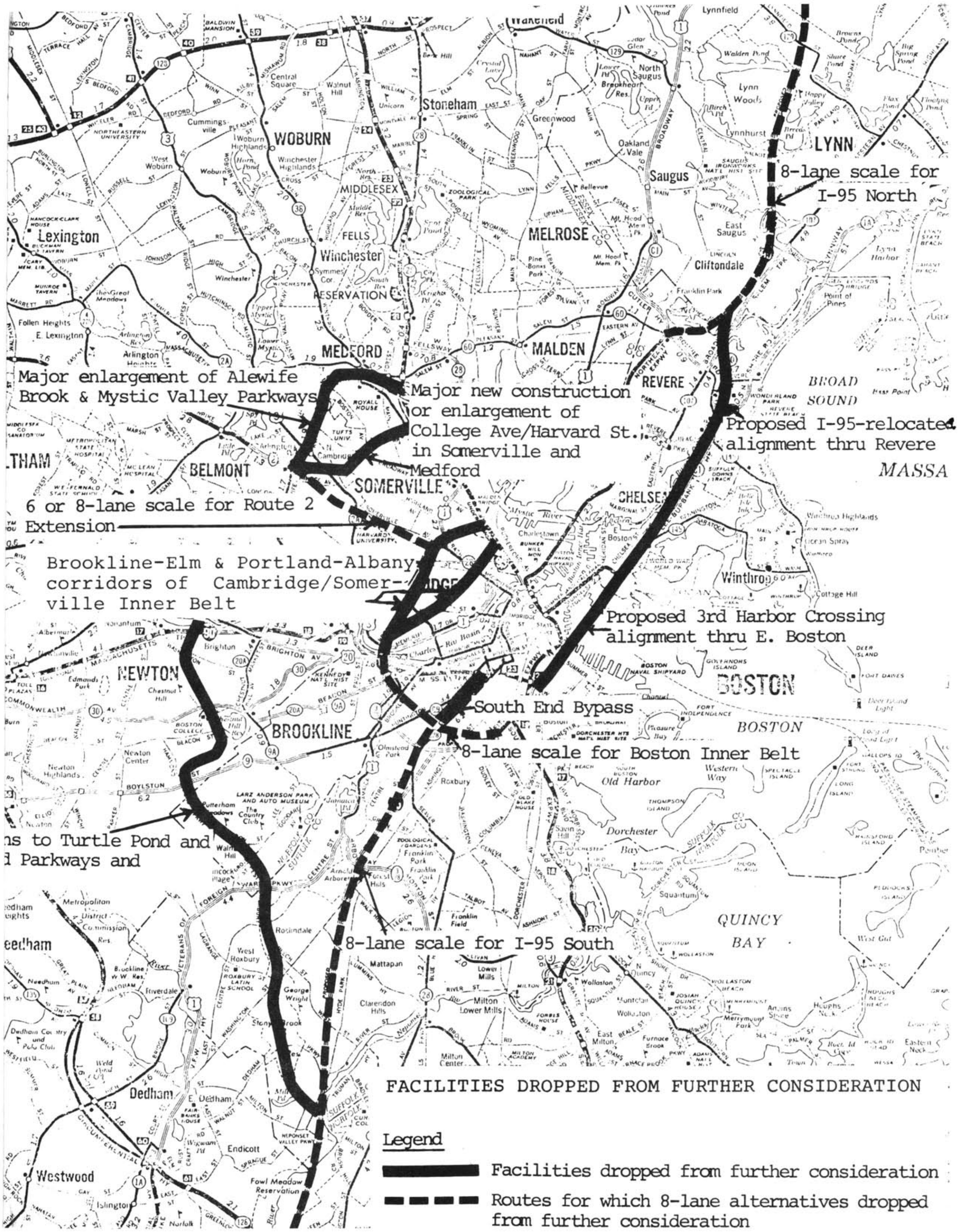


Figure 24: Facilities to be Given Priority Consideration During Phase II - Highways

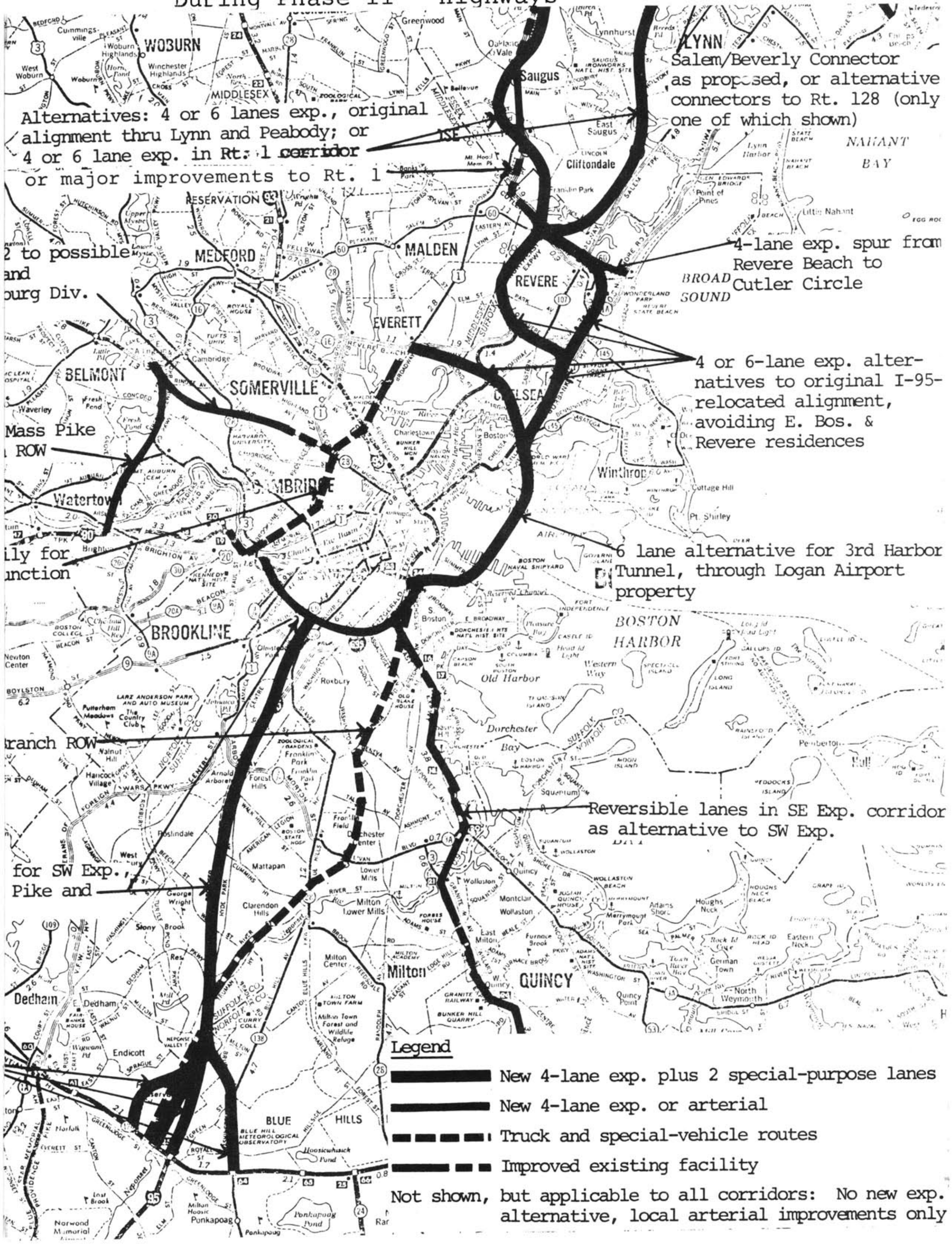
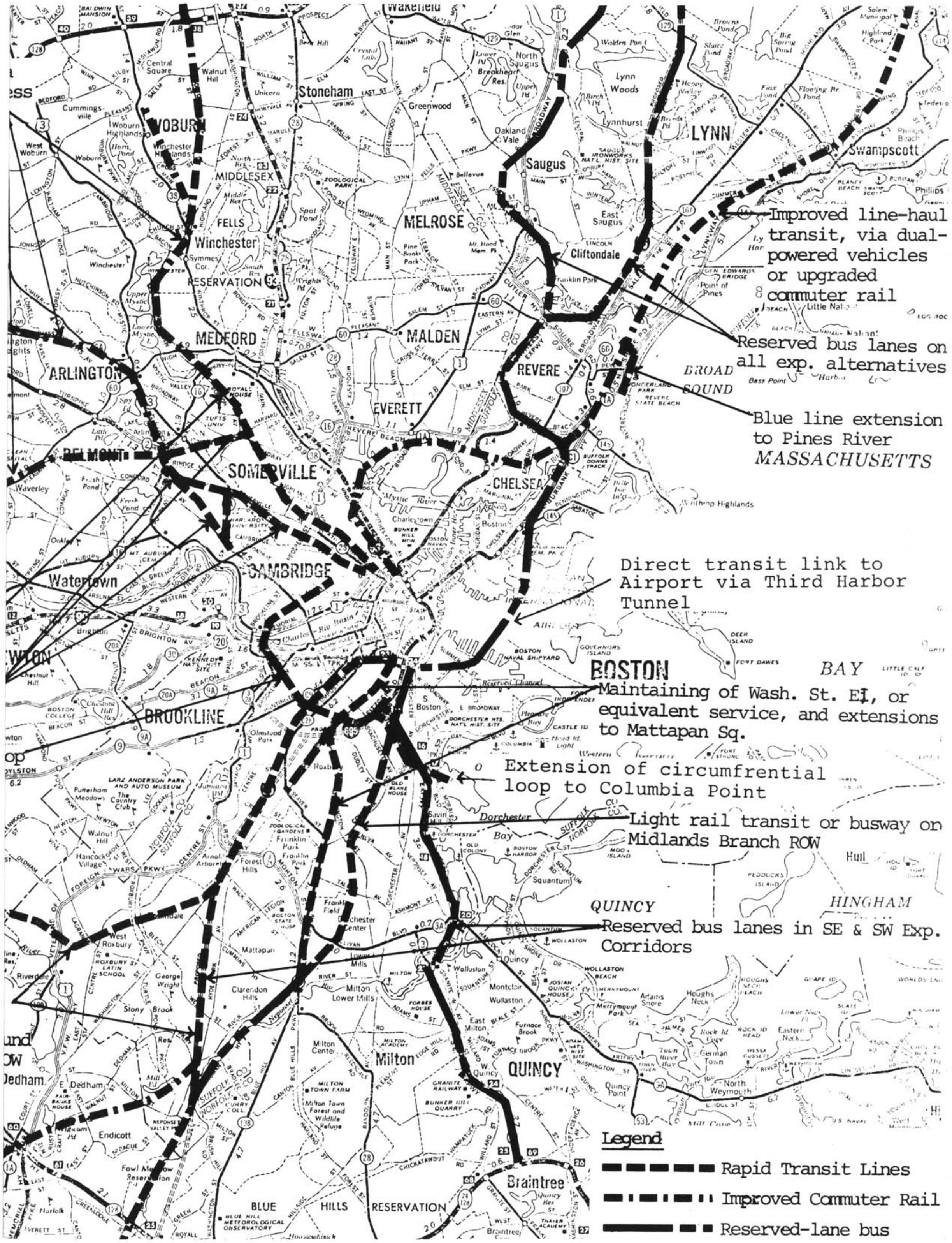


Figure 25: Facilities to be Given Priority Consideration During Phase II - Transit



The Governor's Phase I decisions set the stage for the next iterations of analysis and design. The pre-BTPR alternatives for I-95 Relocated had been eliminated from further study and the conceptual Basic Choices developed in Phase I were selected for priority consideration in Phase II. In addition, in the I-95R subarea, the Revere Beach connector, the Blue Line extension and the provision of busways in all expressway options were singled out by the Governor for priority analysis.

Phase II lasted roughly seven months, from the end of Phase I to the completion of the final report. This section analyzes my problem solving behavior in the development of six alternatives for I-95R during this time. All of these alternatives concentrate new construction in the five Revere corridors identified in Phase I. Four of the alternatives will be expressways, two with special-purpose busways and two without. A fifth alternative envisions construction of new arterials but no expressways, and the sixth alternative will be limited to grade separations and other improvements to the existing flow system network.

The focus of the analysis is on my design strategy, motivations, choice, and use of information during the evolution of these six alternatives. A few highlights of other aspects of my role as technical coordinator are presented to illustrate the interplay of management, technical and interpersonal skills required in deriving the final set of alternatives.

Design Strategy

The overall strategy for the development of alternatives was set by the requirements of the Study Design and the management of the BTPR technical process and staff. This strategy utilized an iterative process, integrating information from several scales and a broad spectrum of participants to guide the design process. For purposes of problem solving analysis it is useful to differentiate three stages of cycles of scale integration. Each successive stage is characterized by a greater level of design detail and by the integration of more rational, quantitative methods of engineering and design.

The first stage, described in the preceding subsection, integrated information from the subregional scale (North Shore), the subarea scale (e.g., Inner North Shore) and the town/community scale (e.g., Revere) to produce the initial concepts or Basic Choices. The second stage involved another cycle of sketch planning (within these Basic Choices) and the integration of information from the subarea, town/community and local neighborhood scales to develop a set of specific highway and transit alternatives. The third and final stage of design development synthesized inputs primarily from the town/community and local neighborhood scales to produce the joint development and program package elements for each alternative. This section describes my role in the second and third stages of design development for the I-95R alternatives.

The ability to work at several scales simultaneously was extremely important to design problem solving in the BTPR task environment. As we have seen in previous subsections, I developed different conceptual frameworks to organize information at each scale and from different viewpoints within each scale. (A summary of the principal conceptual frameworks operating at each scale is provided in the chapter on METHODOLOGY.) As a result, I could conceive of alternatives to meet the particular set of issues, criteria, or perceptions that were endemic to each scale and interest group. These alternatives were likely to be very different in content and purpose. (This was especially apparent in the Harbor Crossing, EPISODE TWO.) This strategy of scale disaggregation enabled me to utilize inputs from a very broad range of sources, many of whose views and interests were mutually antithetical (e.g., developer and conservationist). In addition, it insured the inclusion of critical overlaps of flow system patterns and space-time relationships.

The theoretical importance of having more than one conceptual framework has been touched on in previous sections. As de Bono (1970) has explained, it is easier to establish two completely different patterns (in LTM) than to change an established pattern. This is because the self-maximizing characteristics of the mind tend to reduce or alter inputs to fit established patterns (thus, Arnheim's dictum, "we see what we want to see"). In the BTPR context, if I had no conceptual frameworks appropriate to inputs from the construction union official, or the autoless grandmother, these inputs were useless to me: they went in one ear and out the other. By maintaining different conceptual frameworks and delaying judgment, such inputs could evoke and maintain contrasting patterns over longer periods of problem solving, thus allowing a richer interplay of information in the development of alternatives.

The implication here is that rather than changing conceptual frameworks to suit a given task environment, what is needed are additional frameworks that are different enough to retain their own identity. This, I believe, is the key to developing "well-spaced" alternatives that reflect the intrinsic diversity of values that underlie all broadly-based participatory processes.

The manner in which a problem is perceived determines both the range of possible solutions and the strategy appropriate to its solution. My perception of the primary task objective at the outset of Phase II was to generate and develop a set of equally feasible alternatives (same range of community takings/disruption) which would reflect a full range of transportation-related policy options and which were representative of the contending values of community groups and other regional interests. Within this one problem statement may be seen the basic criteria I used in conceiving potential solutions (takings/community cohesion and transportation service), my rationale for several conceptual frameworks (contending community values) and my basic orientation (toward the participatory process). The "true test" of the alternatives according to my orientation was not so much in their technical merits as in their ability to elicit participation and support from community groups and officials. My primary "covert" objective was thus to develop alternatives that would (a) facilitate community dialogue with respect to the role of transportation in shaping their city's physical and spatial future and (b) focus debate on the specific merits and disadvantages of each alternative and the difficult trade-offs implicit in choosing any alternative (including the so-called "no-build" alternative).

Development of Alternatives

First, a work program was prepared to guide the collection of data required at each of the three scales involved in this stage of design development. Specific tasks were identified for each BTPR discipline.

Whenever possible, this data was displayed on base maps to facilitate additions to my spatially-organized conceptual frameworks as well as to assist in EM mnemonics during sketch design episodes.

Hard data from the systems analysts with respect to a series of Phase I regional network scenarios was not available until very late in Phase II. In the absence of demand volumes and mode split analyses, I was forced to rely on rough estimates and collective judgments in the preliminary sizing of highway segments for each alternative. My response to this situation was to develop a "kit of parts" for each corridor until hard data became available.

Phase II sketch planning thus began with the development of over a dozen combinations of four- and six-lane expressways with and without special purpose busways and with and without a Revere Beach connector. As in Phase I, sketch planning involved an iterative process of exploring possible alignments using tracing paper sketches over aerial photo bases, visually testing each alignment for "misfits" through field reconnaissance or by overlaying the alignment on various data base maps and making adjustments through additional sketch planning. In contrast to Phase I, however, each iteration was increasingly interspersed with consultations with various other BTPR disciplines. Initially, most of the information I sought was from the engineers, usually in regard to alignment and profile geometrics, interchange designs and special roadway cross-sections and edge conditions. As described in the section on pattern acquisition, facility in the use of LTM patterns relating to highway design developed rather slowly at first. Thus, I relied heavily on assistance from other professionals at the outset of each new stage of design development. Figure 26 illustrates the implications of multiple inputs from the task environment on design problem solving. Interaction with various BTPR staff members and community participants stimulated the recall of a diversity of LTM patterns for use in sketch designing. Note that the use of inputs (eg. "c" in Fig. 26) may require a shift of conceptual frameworks and/or task objective/method.

I selected three promsiing sketch plan alternatives and gave them to the engineers for translation to 1:200 engineering drawings. Each sketch plan indicated preliminary roadway alignments, number of lanes, location of interchanges and desired movements and a schematic section indicating typical edge conditions for each corridor. The three alternatives selected were ones which I hoped would provide the most useful information with respect to the relationships between adverse impacts and

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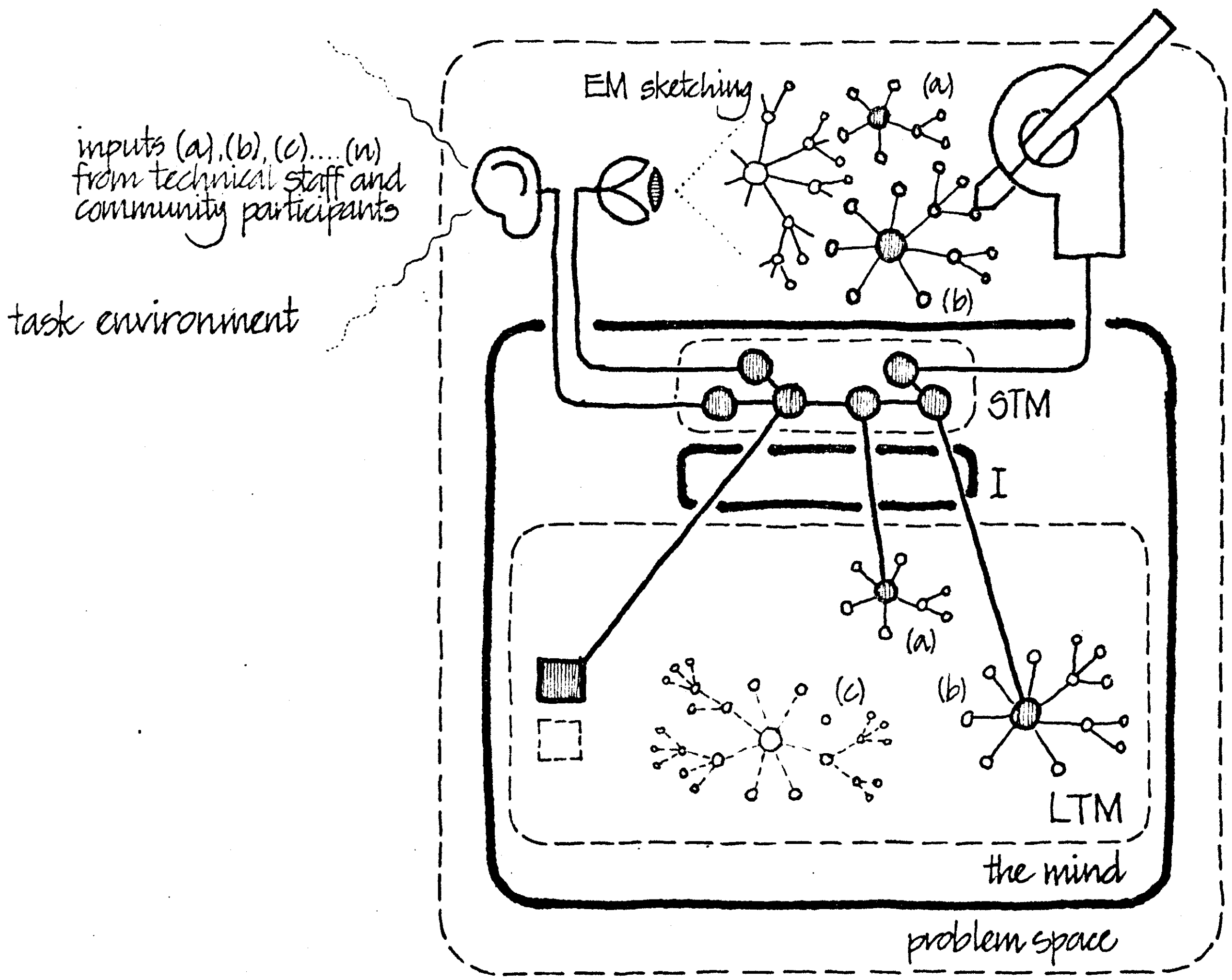
Figure 26: Schematic Organization of Interactive Design Problem Solving

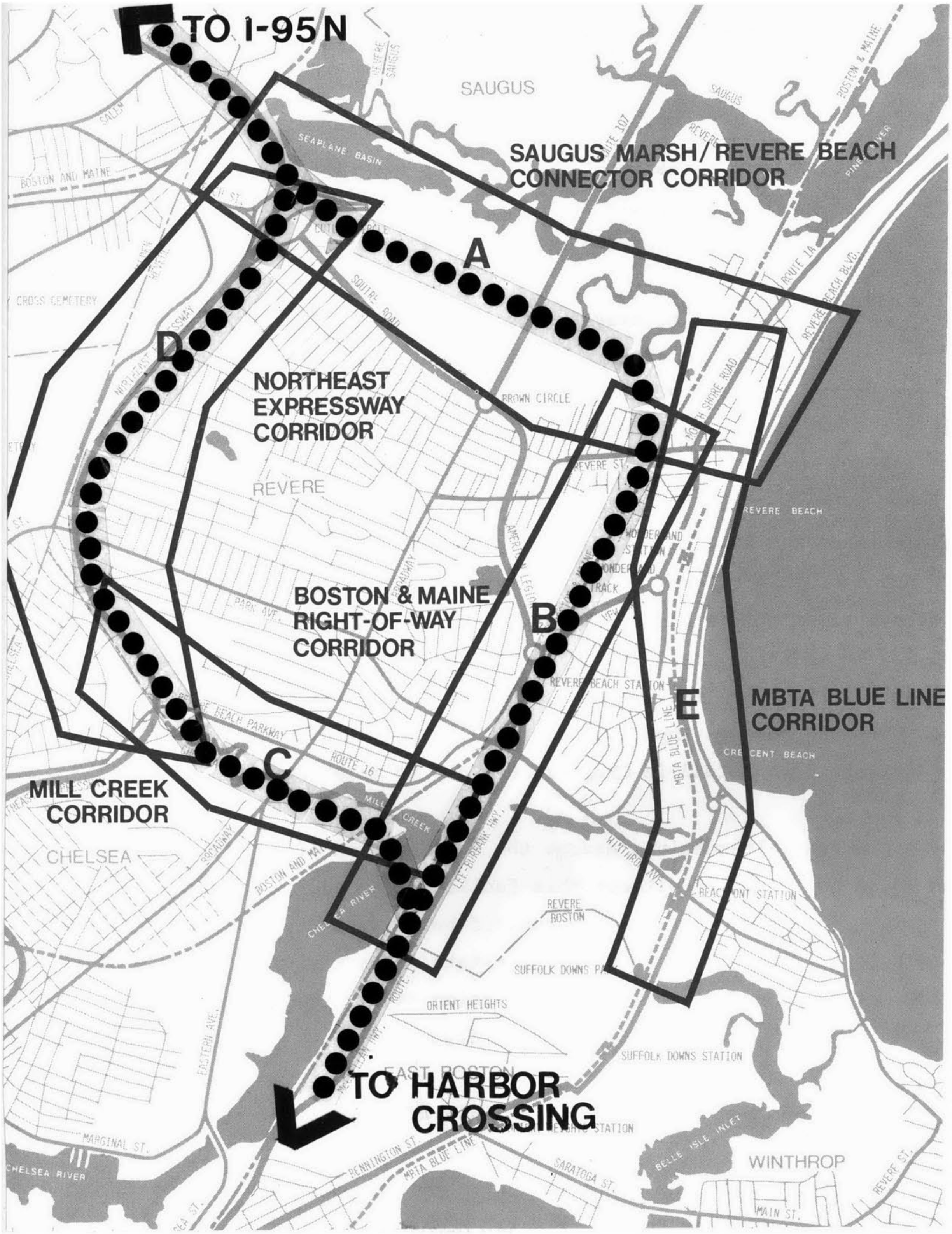


different road widths and alignments.

The results of preliminary engineering were somewhat of a surprise particularly in terms of the right-of-way required and the probable impact of several of the alignments on the adjacent community. In the Boston and Main rail corridor, for example, the difference in takings between four lanes and six lanes was about fifteen households versus over sixty. In addition, the reduction of probable takings for the six-lane alternative would require viaducting over the railroad tracks, thereby visually dividing the community from north to south. This new information led me to search for less disruptive variations.

Through additional sketch plan exploration of new combinations it became apparent that, for the maximum capacity alternatives, combinations of smaller-scale construction <u>in all four</u> corridors would incur less disruption and takings than concentrating all additional capacity <u>in any two</u> corridors (see Figure 27). As a result, alternatives with more than four (new) lanes in any corridor were dropped from further consideration.

Each of these, and countless other decisions, were products of a heuristic search method of design problem solving, combined with continuous interaction with various BTPR staff members and community resources. Guided by the Phase I Basic Choices, which defined the solution in general terms, new information could be used provocatively to factor the problem into subparts and to suggest what solutions or pattern combinations to try next. Each perceived misfit would stimulate the recall of new LTM patterns to try -- a viaduct section, a narrower cross-section, a retained cut, a tighter curve, an acoustic wall, and so on. Each successful application of a recalled pattern to a particular misfit would be recorded (unconsciously, of


TO I-95N
SAUGUS MARSH/ REVERE BEACH CONNECTOR CORRIDOR
A
D
NORTHEAST EXPRESSWAY CORRIDOR
BOSTON & MAINE RIGHT-OF-WAY CORRIDOR
B
E
MBTA BLUE LINE CORRIDOR
C
MILL CREEK CORRIDOR
TO HARBOR CROSSING
SAUGUS
REVERE
CHELSEA
EAST BOSTON
WINTHROP

course) in LTM for future reference. This was a continuation of the formative learning process described in pattern acquisition. And, in fact, each successful matching of task environment condition and LTM pattern contributed to the chunking of larger, more powerful patterns for use as "templates" in future sketch design episodes.

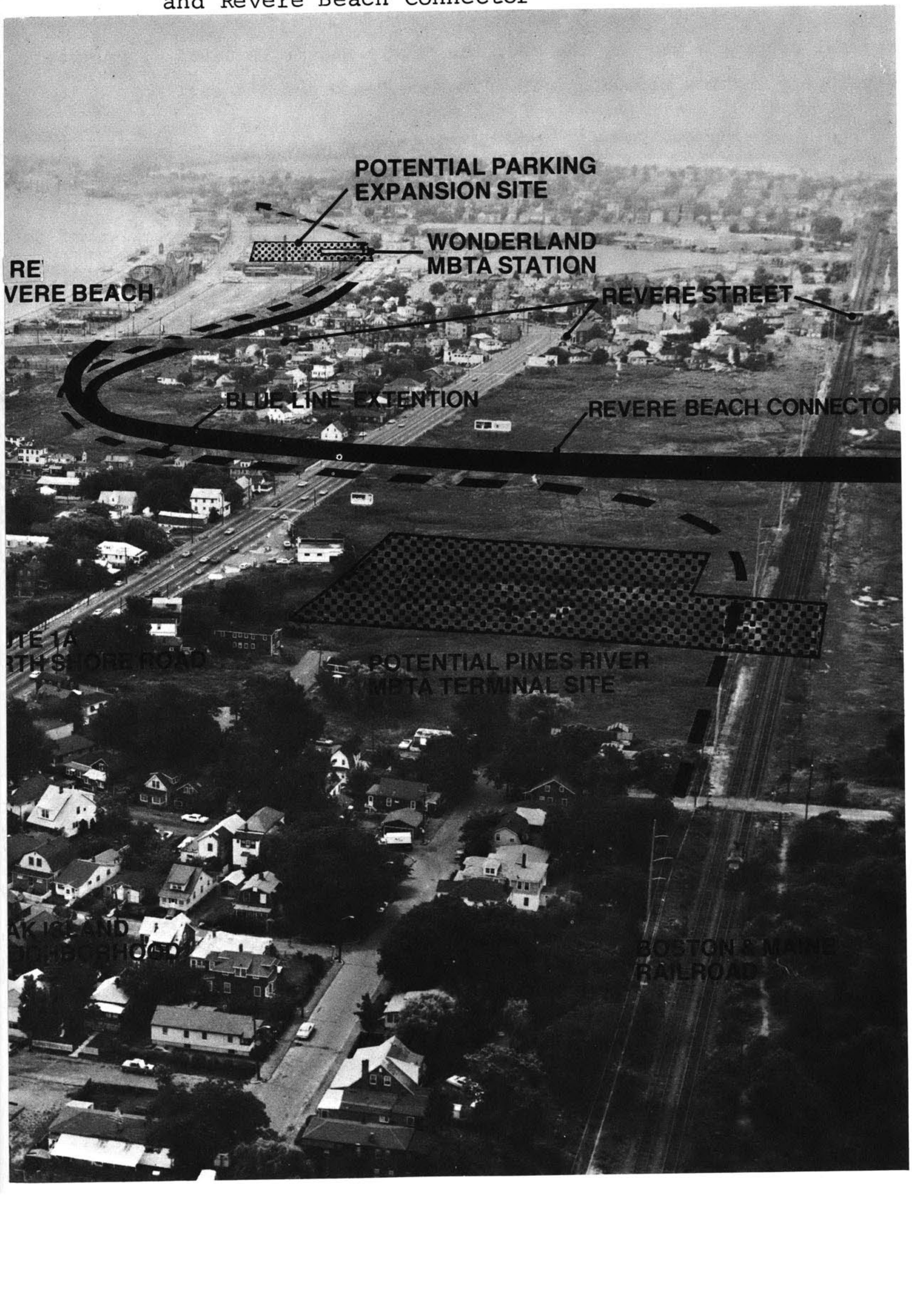
Sketch designing at this stage was employed to explore goal-form relationships suggested by current task objectives. Patterns and problem solving methods were selected from LTM on the basis of my interpretation of the problem statement and my sense of appropriate form-related patterns. Sketch design manipulation of LTM patterns provided insights and information which, in turn, stimulated the recall of other patterns or were used to modify the content of patterns currently in use. Such information might also change my perception of the problem itself, resulting in shifts in objective, appropriate methods or form requirements, thus suggesting new, more appropriate patterns and programs.

Sketch design in this manner might continue for only a few moments or perhaps some several hours with perceptions of form relationships between current patterns providing continuous feedback and stimulating the recall of additional patterns and pattern-linking programs from LTM. The process stopped when I reached a desired point of design development or when I had posed questions which required informational inputs from outside my current problem space, or perhaps when I found I had no appropriate patterns in LTM for the form relationships suggested by current problem requirements. Selective attention to the task environment during reconnaissance often provided the information needed either to reorganize existing LTM patterns or to initiate the acquisition of new patterns.

During this period, the preliminary elements of a "no build" (no new expressway) option were outlined in collaboration with a small team of engineers assigned to this task. The basic technical objective for this alternative was to optimize use of the existing highway network. Essentially, this meant exploring means of upgrading and improving safety and capacity characteristics on existing arterials and redesigning principal bottlenecks and poor intersections. Since one of my "covert" objectives was to produce an alternative that could be supported by community participants who were adamantly opposed to constructing any new roads in Revere, most of the elements for this "no build" alternative were derived directly from the survey of resources and the summary of Major Transportation Problems developed with the community in Phase I.

During this period, I also developed alternative sketch designs for extending the Blue Line rapid transit beyond its present terminus at Wonderland station. The principal constraints to increased ridership on the Blue Line were poor access and inadequate park-ride capacity at Wonderland. Preliminary designs for a new station were made at a site near the Saugus marsh, selected after extensive analysis by the staff ecologists. At the same time, designs for correcting access and capacity deficiencies at Wonderland were initiated. Access requirements at both sites were integrated into ongoing designs for the Revere Beach Connector. The location of the two sites and connector are shown in Figure 28.

Figure 28: MBTA Blue Line Corridor Transit Options
and Revere Beach Connector



Selection of Final Alternatives

When the results of the regional systems analysis were finally available, the information they provided was instrumental in the determination of which expressway alternatives to carry forward into detailed design. With respect to I-95 Relocated corridors, the analysis of computer printouts indicated (1) that the construction of a Revere Beach Connector in Corridor A (refer to Figure 27) was the most important single element in terms of relieving through-traffic congestion on existing Revere arterials; (2) that a new facility in the Boston and Maine rail right-of-way, Corridor B, would provide the next greatest transportation benefits; (3) that a new facility in Corridor C might be essential if a new Harbor Crossing were constructed and no new facility was constructed in Corridor B; (4) that the existing section of the Northeast Expressway in Corridor D did have additional existing capacity, and that the construction of additional lanes in this corridor would be of marginal benefit in comparison to a similar addition in Corridor B; and (5) that the intermediate capacity (four-lane) alternatives for I-95R were adequate to handle target demands and were compatible with alternatives for I-95 North and the Harbor Crossing.

During a subsequent technical management review of I-95 Relocated alternatives, it was possible to reach consensus with the BTPR project manager and North Shore Corridor manager on the selection of final expressway alternatives to carry forward. First, on the basis of the systems analysis and the preliminary engineering estimates of costly bridge reconstruction attendant to any widening of the Northeast Expressway in Corridor B, it was evident that the benefit/cost ratio for this construction was too low. Consequently, alternatives envisioning any construction greater than the addition of new shoulders between bridge abutments were dropped from further study. This is illustrated in Figure 29. Next, when supported by analysis of system compatibility, the earlier higher capacity alternatives were eliminated in favor of similar but smaller capacity (and substantially less disruptive) four-lane alternatives. At the end of this review session, four expressway alternatives had been selected -- two with and two without busways -- for further design development. All four would include a Revere Beach Connector plus complementary improvements to the existing local street network. These four alternatives are shown in Figures 30 through 33.

In light of new information regarding the substantial transportation service benefits of a new facility in Corridor B, I explored the possibilities of constructing a small new arterial scale bypass in this corridor that would obviate the need for new grade separations at two principal bottlenecks as envisioned by the "no build" alternative. Although the community was ostensibly "on record" as supporting the reconstruction of these intersections, preliminary engineering indicated they could result in more residential and commercial takings than any of the expressway alternatives selected for final development. I developed a new sketch plan alternative combining this new arterial bypass with a parkway-scale Revere Beach Connector. The result: a second "no build" or non-expressway alternative that would offer the community another choice midway between the expressway alternatives and improvements to the existing highway system. The transportation service benefits of this new alternative were almost as good as the expressway alternatives; takings were generally lower; opportunities for local joint development greater; and, perhaps most important,

Figure 29: Northeast Expressway Corridor

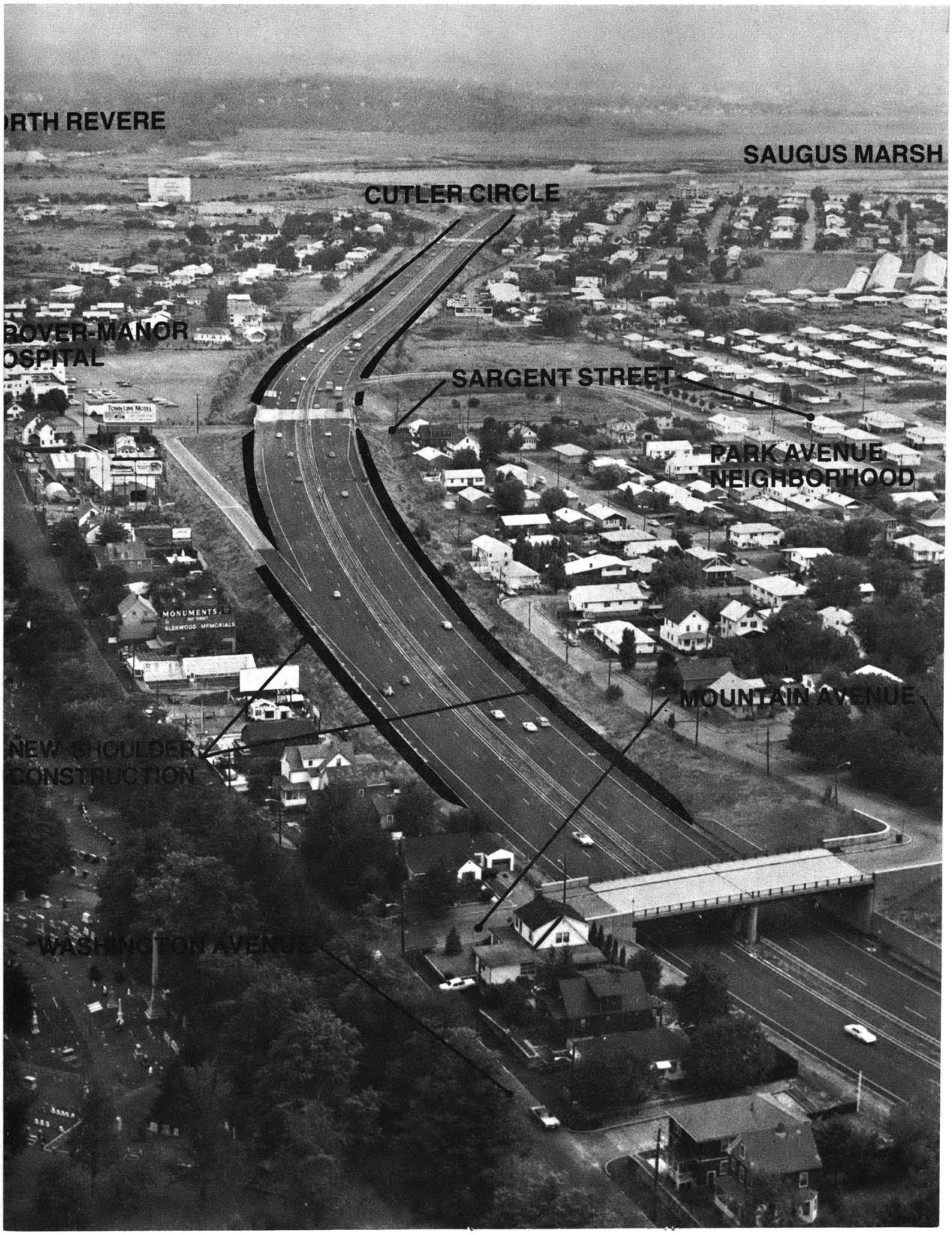


Figure 30: Program Package Concept: Alternative 1

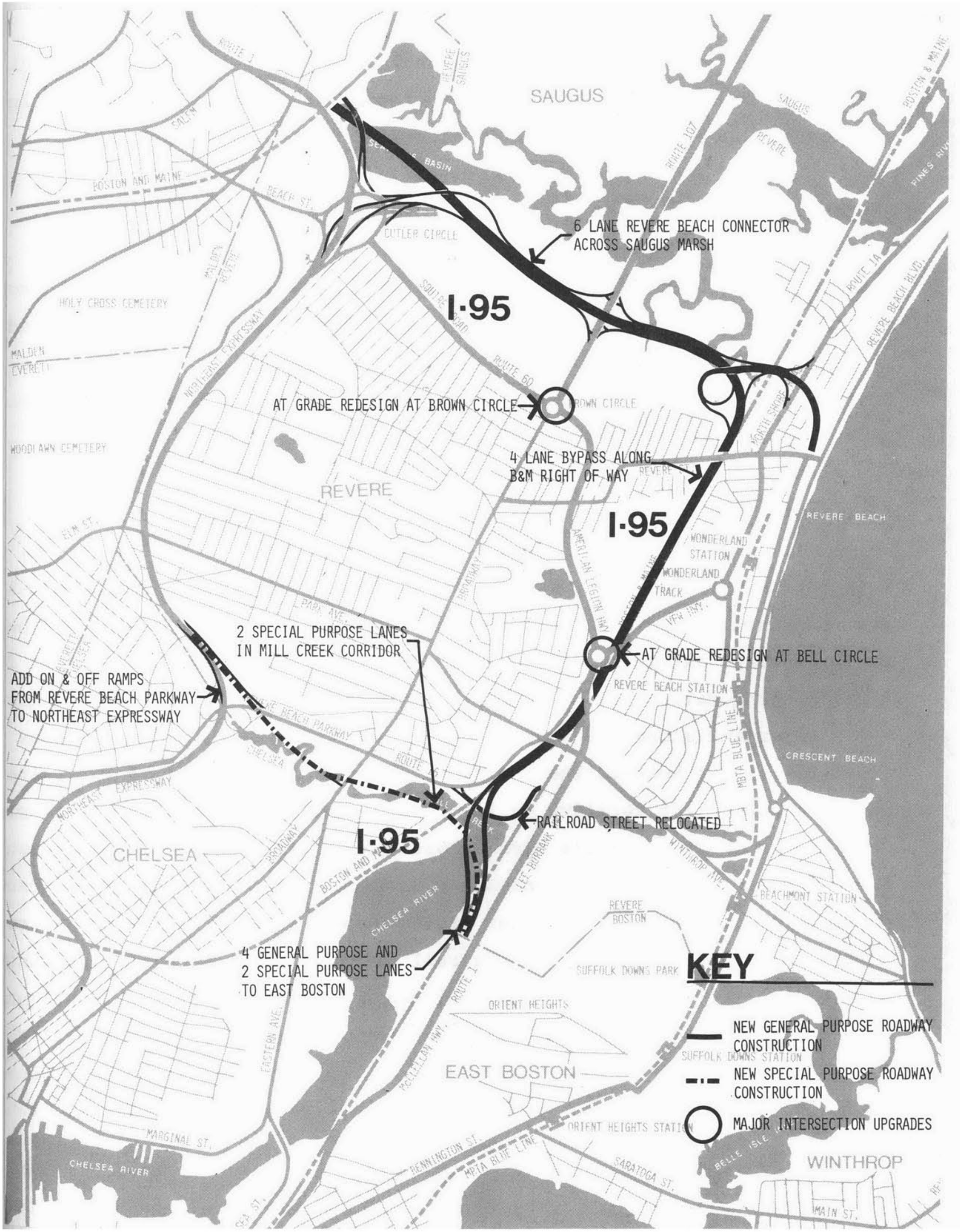
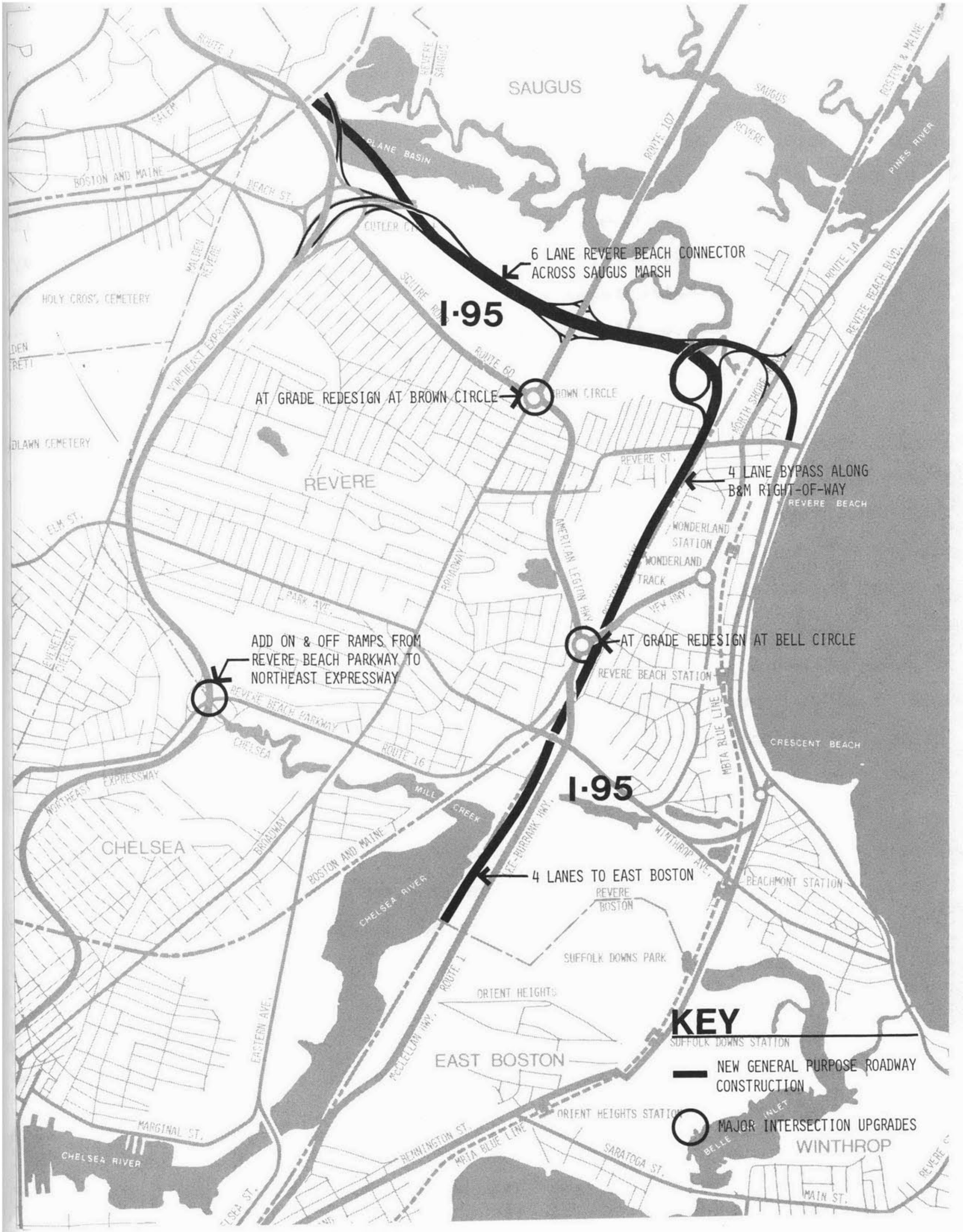


Figure 31: Program Package Concept: Alternative 2



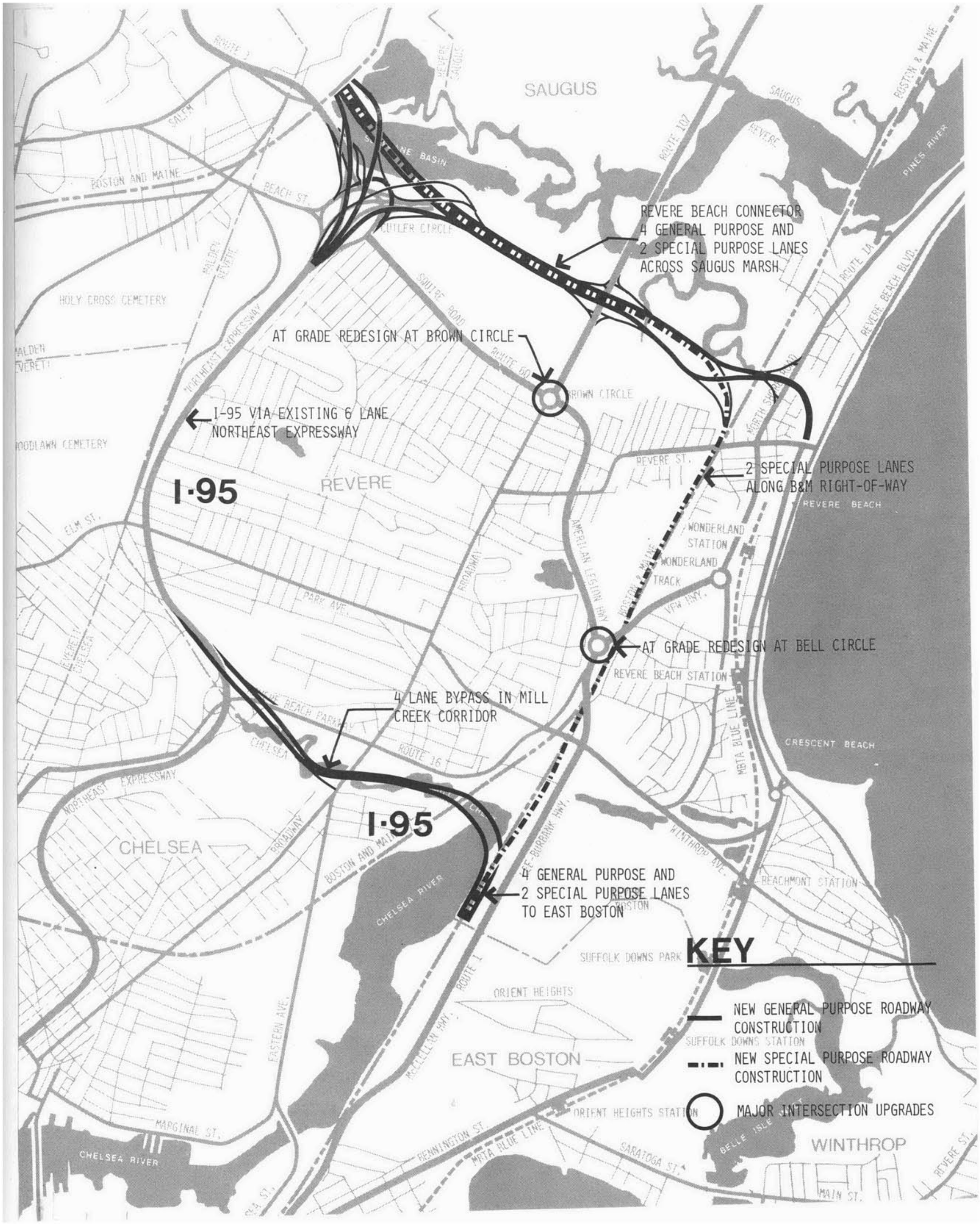
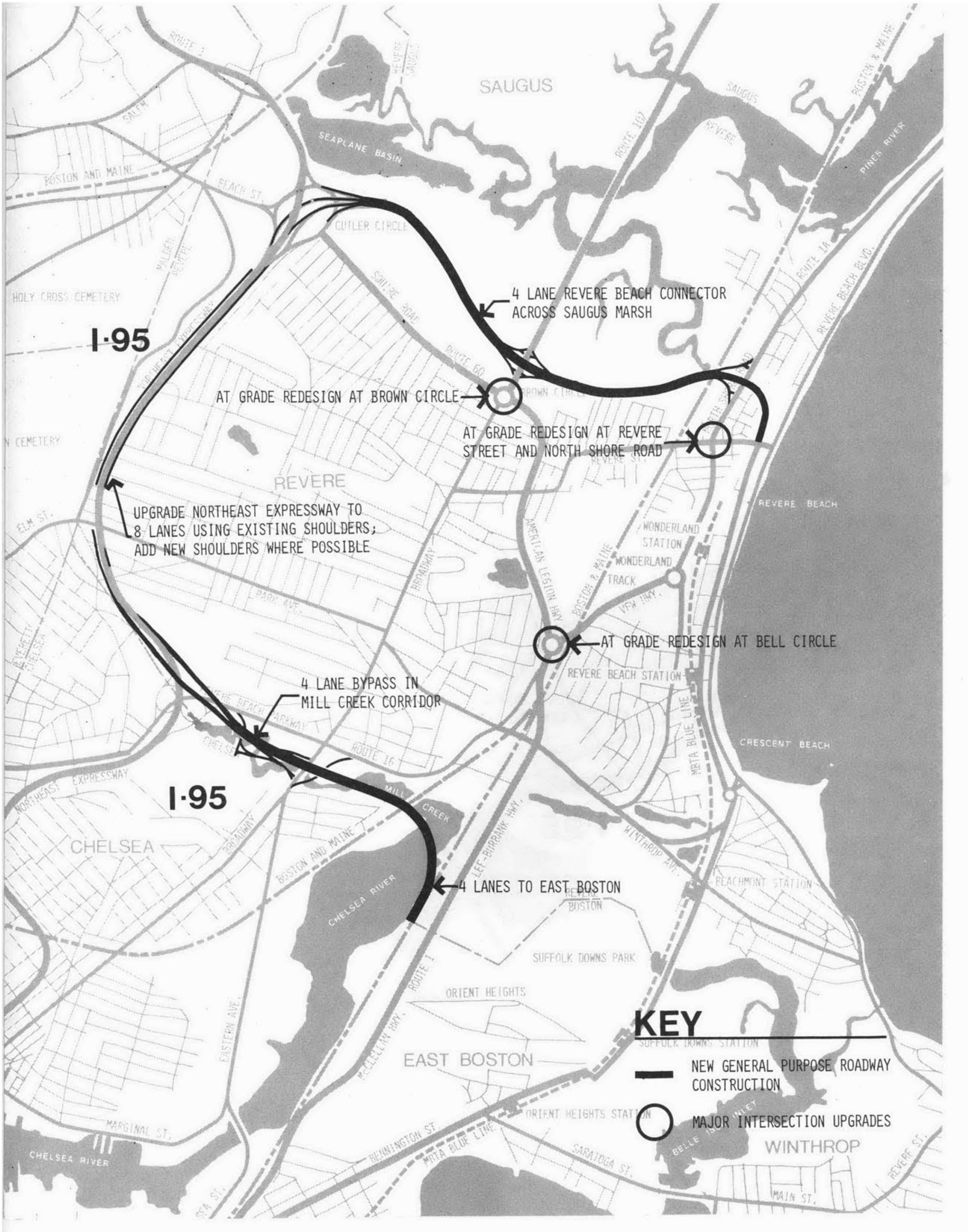

SAUGUS
REVERE
CHELSEA
EAST BOSTON
WINTHROP
I-95
I-95
REVERE BEACH CONNECTOR
4 GENERAL PURPOSE AND
2 SPECIAL PURPOSE LANES
ACROSS SAUGUS MARSH
AT GRADE REDESIGN AT BROWN CIRCLE
I-95 VIA EXISTING 6 LANE
NORTHEAST EXPRESSWAY
2 SPECIAL PURPOSE LANES
ALONG B&M RIGHT-OF-WAY
AT GRADE REDESIGN AT BELL CIRCLE
4 LANE BYPASS IN MILL
CREEK CORRIDOR
4 GENERAL PURPOSE AND
2 SPECIAL PURPOSE LANES
TO EAST BOSTON
KEY
NEW GENERAL PURPOSE ROADWAY
CONSTRUCTION
NEW SPECIAL PURPOSE ROADWAY
CONSTRUCTION
MAJOR INTERSECTION UPGRADES

Figure 33: Program Package Concept: Alternative 4



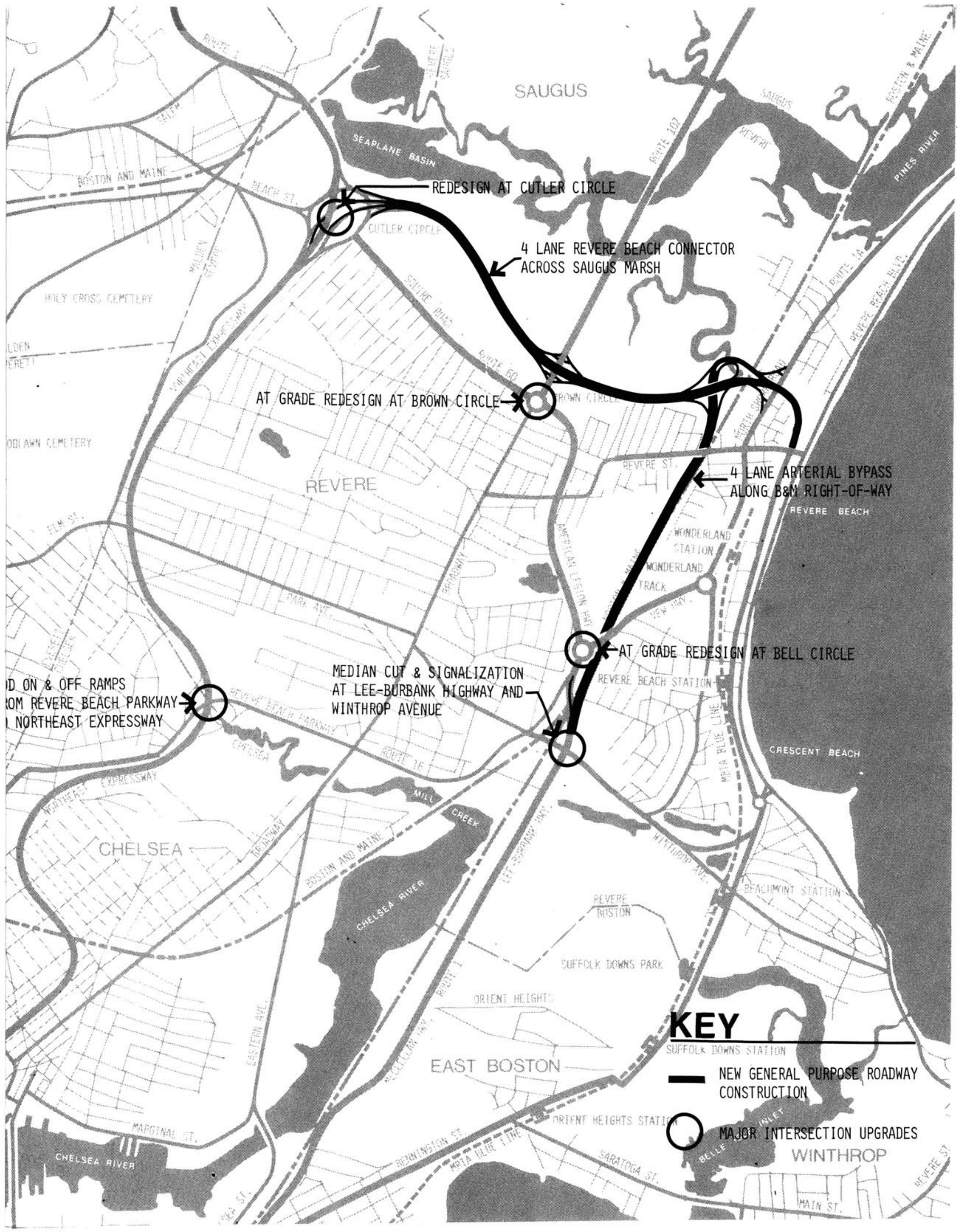
it didn't have the "interstate stigma." Figures 34 and 35 illustrate the two "no build" alternatives.

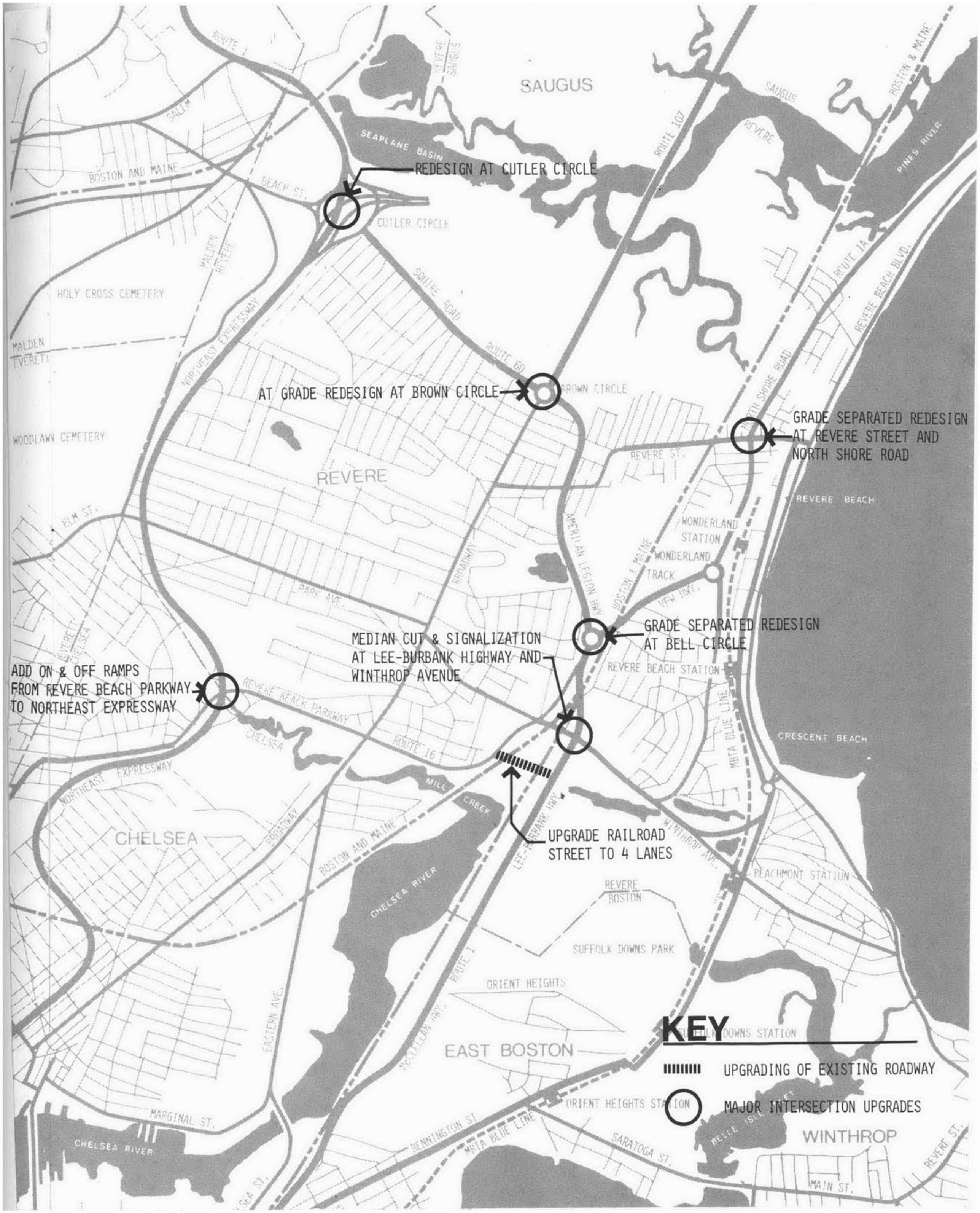
At this point the second stage of design development was complete. Information organized by conceptual frameworks operating at subarea, city and local neighborhood scales had been synthesized to produce six well-spaced alternatives with respect to the policy options (i.e., combinations of highway and transit facilities) outlined by the Study Design.[60] In addition, preliminary estimates of takings indicated that my "covert" strategy of developing alternatives with roughly equal (minimal) takings seemed to be successful (residential takings ranged from a low of 19 to a high of 24). By this strategy, I hoped to redirect community dialogue from simplistic evaluations on the basis of the interstate stigma or the single criteria of residential takings to a fuller debate on the relative merits of each alternative, evaluated on a full range of criteria.

Program Package Development

The third and final stage of scale integration and design development began after extensive reviews of the six alternatives with community groups and officials. This stage responded to as many of the community concerns as possible by developing impact-offsetting measures and joint development programs tailored to site-specific conditions for each corridor alignment of each alternative. In addition to the physical programs, a set of related actions was identified to compensate for the unavoidable consequences of constructing the proposed facilities. These related actions included specific relocation strategies, special payments for affected parties, redevelopment plans and other compensatory programs to be implemented with the transportation project itself. Each highway alternative, together

Figure 34: Program Package Concept: Alternative 5




SAUGUS
REVERE
CHELSEA
EAST BOSTON
WINTHROP
REDESIGN AT CUTLER CIRCLE
AT GRADE REDESIGN AT BROWN CIRCLE
GRADE SEPARATED REDESIGN AT REVERE STREET AND NORTH SHORE ROAD
GRADE SEPARATED REDESIGN AT BELL CIRCLE
MEDIAN CUT & SIGNALIZATION AT LEE-BURBANK HIGHWAY AND WINTHROP AVENUE
ADD ON & OFF RAMPS FROM REVERE BEACH PARKWAY TO NORTHEAST EXPRESSWAY
UPGRADE RAILROAD STREET TO 4 LANES
KEY
UPGRADING OF EXISTING ROADWAY
MAJOR INTERSECTION UPGRADES
SEAPLANE BASIN
CUTLER CIRCLE
HOLY CROSS CEMETERY
WOODLAWN CEMETERY
REVERE BEACH
CRESCENT BEACH
WONDERLAND STATION
REVERE BEACH STATION
BEACHMONT STATION
SUFFOLK DOWNS PARK
ORIENT HEIGHTS
CHELSEA RIVER
PINES RIVER
MILL CREEK

with a set of integrally related actions to reduce adverse impacts and increase potential community benefits, was called a program package.

The development of final program packages, along with comparative evaluations of all the alternatives and the production of the final I-95R report, required inputs from virtually all of the BTPR disciplines and special consultants. As a result, whereas in previous stages I had synthesized selective inputs from others as I needed them, I now found myself at the center of innumerable issues of input content and format -- some minor, some complex -- all requiring coordination, and all demanding my attention (simultaneously, or so it seemed) as the individual possessing the most comprehensive knowledge with respect to the status of alternatives and the I-95 task environment in general. Thus, while my principal technical responsibility at this point was ostensibly concerned with final alignments and joint development issues, my role as a technical coordinator was undoubtedly more important to the process as a whole.

Three strategies were employed to assist in coordination: first,the initiation of small working sessions between various participants to work out specific problems; second, provision of a system using reproducibles to provide immediate access to the latest incorporated changes to the alternatives; and third, holding weekly briefings as a means of keeping all participants current with respect to additions, changes or deletions to the alternatives. These meetings also served as a forum for consensus on technical judgments and to assign responsibility for unresolved issues and appropriate next steps.

A brief example may illustrate the intensity of interdisciplinary interaction during this stage. This example involved an engineer, an economist, an ecologist,a housing relocation specialist and myself in a four-hour session to finalize the design of a grade-separated intersection at Revere Street and North Shore Road (Route 1A). This intersection is one of two principal traffic bottlenecks in Revere and its redesign was an important element of the"no build" alternative.

I had previously transmitted a concept sketch for this intersection to the engineers. An underpass for North Shore Road was proposed despite high construction costs (due to local groundwater conditions), principally because of the greater residential impacts and visual intrusiveness of a viaduct at this location. The economist and housing relocation specialist were assessing the property takings and displacements implied by the engineer's translation of this sketch when they informed me that the takings could be greater for this one intersection redesign than for any of the expressway alternatives! This chance remark initiated an impromptu design session that was typical of interdisciplinary collaboration during this stage of the process. The first action proposed was to reduce the right-of-way width at the intersection by cantilevering the left turn storage langes over the depressed section. Next, on-street parking lanes were eliminated approaching the intersection. And finally, the whole design was shifted to the east, resulting in the elimination of most of the takings from the west side of North Shore Road. Alignment geometrics were also improved slightly, since the shift tended to straighten out of a slight dog-leg at the existing intersection. A quick check of the property and buildings that would be taken indicated a reduction of almost one-half over the previous engineered sketch. The housing relocation specialist noted, however, that the number of families displaced was only reduced by about one-third, due to the takings of two apartment buildings on the east side of North Shore Road. After much discussion, the design was ultimately shifted to the west, resulting in a substantial additional reduction in families displaced at a marginal expense in alignment geometrics. Figure 36 illustrates the property displacement of the final alignment.

As was often the case in these small work sessions, there was little doubt in the participants' minds that the final outcome was most assuredly an interdisciplinary product and would have been significantly different without the inputs of any one of the disciplines involved. My role in many of these sessions was often a minor one content-wise. Frequently, my principal contribution was keeping others focused on the issues at hand and facilitating decisions. This "moderator" role was invariably assisted by the use of sketches and diagrams to summarize data and points of view and to illustrate the cumulative effects of each contribution. Figure 26 shows the schematic organization of my design problem solving behavior during this highly interactive period.

As mentioned earlier, my principal technical responsibility during this stage was for the final adjustment of alignments, and the determination of edge conditions and joint development programs for each segment of proposed roadway. The three pages following Figure 36 (Figure 37a, b and c) illustrate the joint development concepts for the Saugus Marsh Corridor segement, Corridor A, of Alternative 2 (refer to Figure 31). The final alignment was a product of numerous sketch plans and intensive design sessions with (among others) the BTPR engineers and ecologists, North Shore environmental groups, the Revere planning and engineering departments and the MDC, MBTA and DPW.

Figure 36: Property Displaced and Regained:
Area A Upper Revere Street

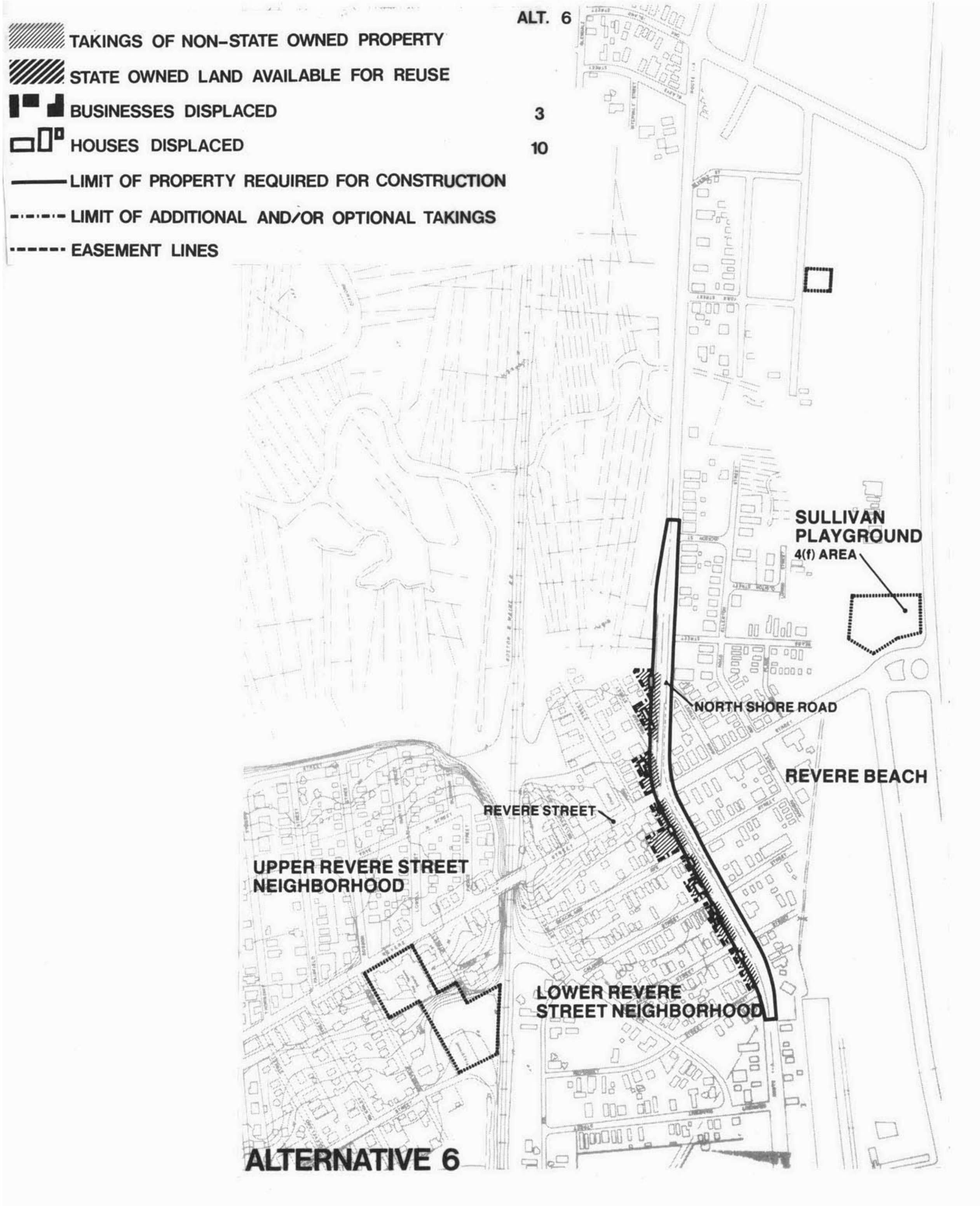
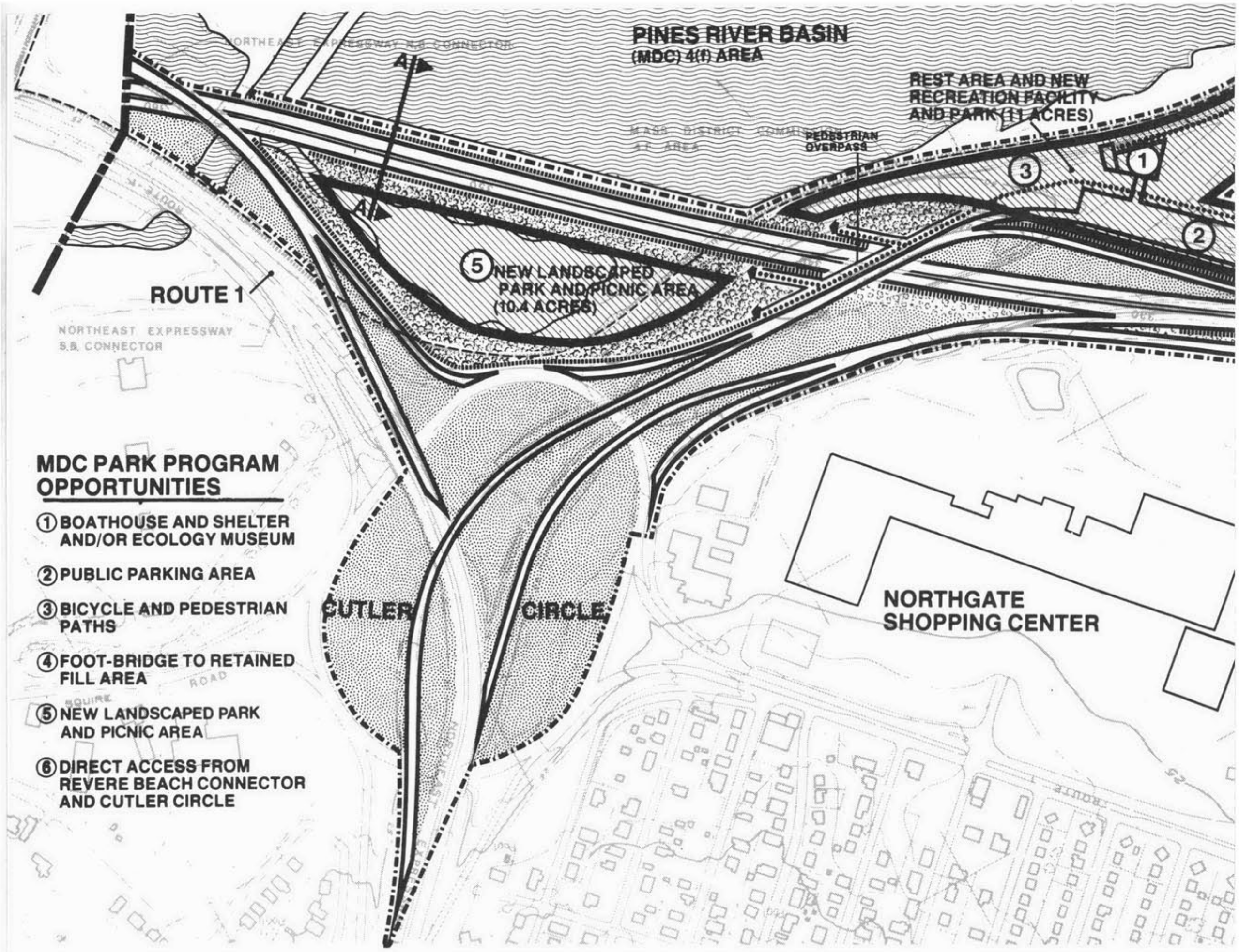
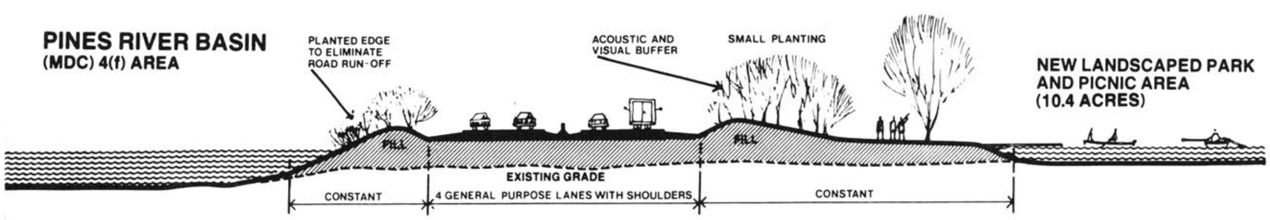


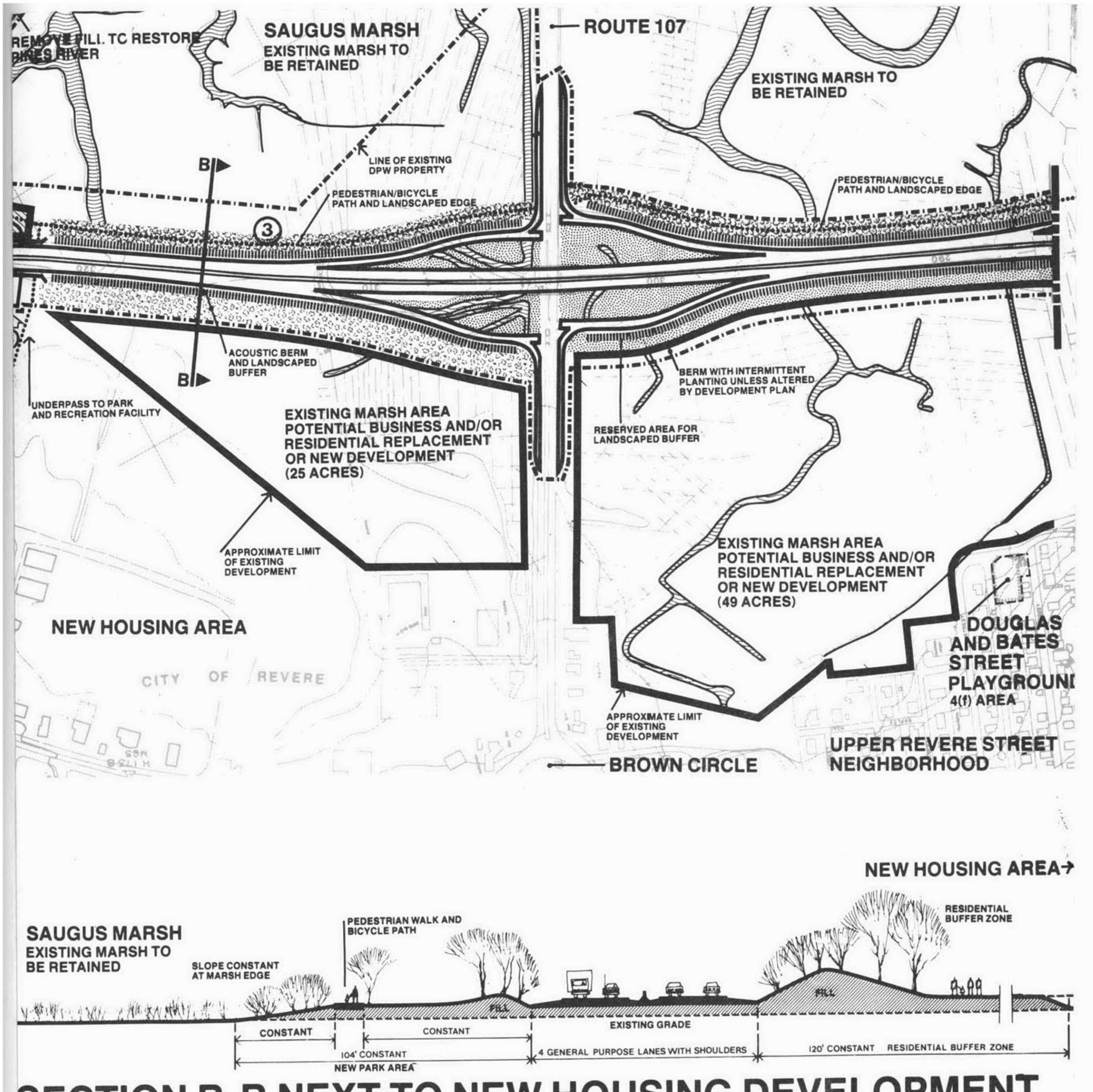
Figure 37a: Joint Development Concepts: Saugus Marsh Corridor





SECTION A-A AT NEW PARK AND PICNIC AREA

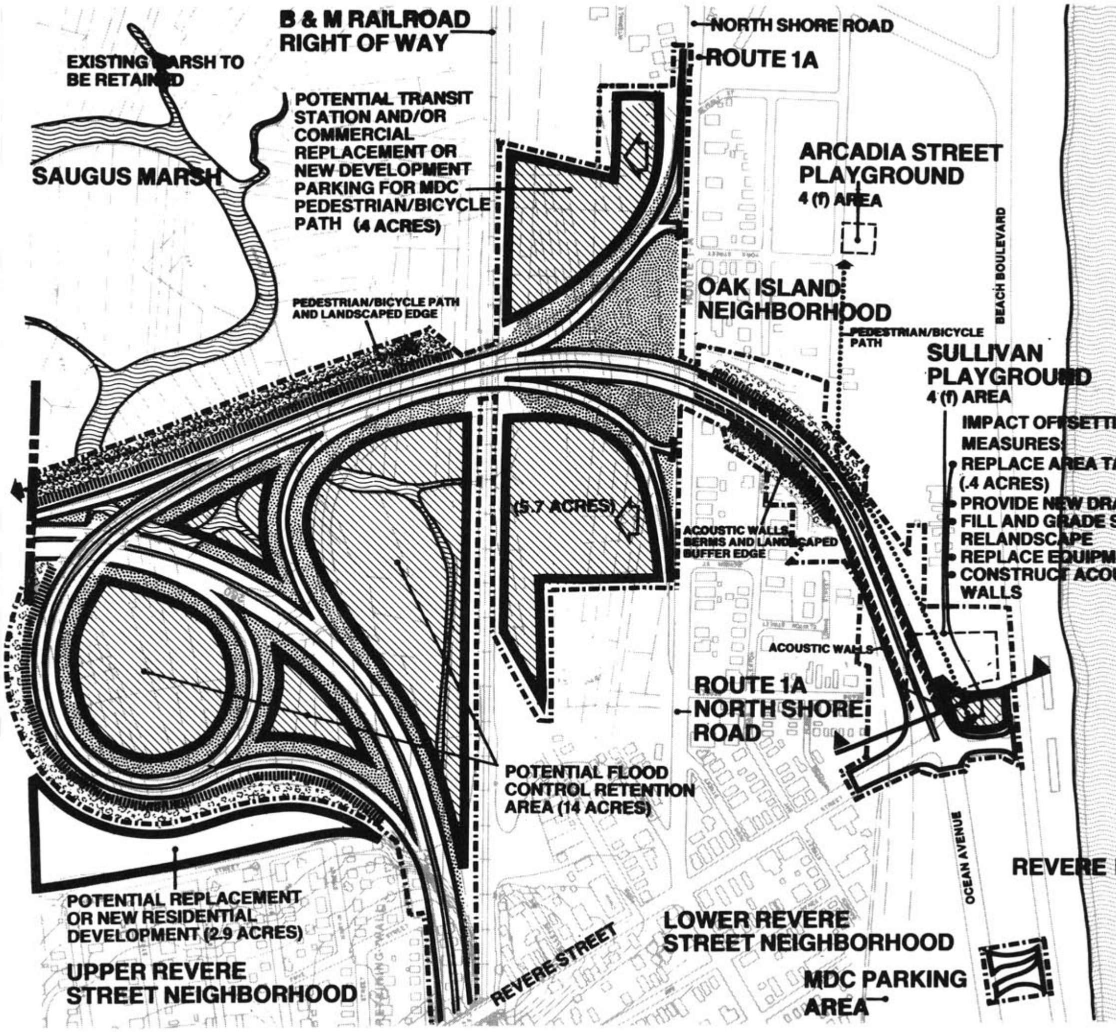
Figure 37b: Joint Development Concepts: Saugus Marsh Corridor

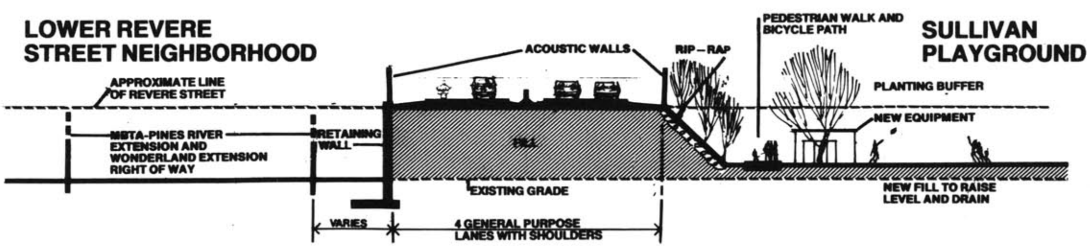


SECTION B-B NEXT TO NEW HOUSING DEVELOPMENT

- ACOUSTIC WALL
- 4(f) AREA BOUNDARIES
- EXTENT OF PROJECT ACTIVITY
- ACOUSTIC BERM AND PLANTING
- PROPOSED BICYCLE / PEDESTRIAN PATH
- IMPROVED ACCESS TO EXISTING OR PROPOSED DEVELOPMENT

Figure 37c: Joint Development Concepts: Saugus Marsh Corridor





SECTION AT SULLIVAN PLAYGROUND

The overall objective of this collaborative effort was to identify the critical elements of "good fit" between the proposed flow system (highway) element and its adjacent adapted space. As in the previous stages of design development, sketch designing was the principal tool of synthesis for all of these inputs.

By this time I had become relatively proficient at recalling appropriate patterns from LTM. In addition, I had produced a large number of EM graphics to use as mnemonics. Thus, the development of typical edge conditions for Revere Beach Connector alternatives utilized earth berms and landscaping to contain highway surface pollutants and create a linear park on the edge of the marsh. Similarly, retaining walls, rip-rap, acoustic walls, and planting buffers were employed in the developed area near Sullivan Playground (see Sections in Figure 37.) The determination of each edge condition began with an assessment of who was being designed for at that particular point on that particular alignment. Was it the driver/user of the highway or the resident/user of the adjacent adapted space? If there was a scenic vista or landmark which could be enjoyed from the road, I would explore LTM patterns associated with the conceptual framework of the driver's <u>view from the road</u>. If, on the other hand, the alignment was in close proximity to a housing area or park -- e.g., Section B-B and the Sullivan Playground section -- patterns associated with the <u>view of the road</u> would be employed. Where there was a <u>choice</u> of which conceptual framework to use, it was almost invariably resolved in favor of the view <u>of</u> the road from the adjacent community. This was a consequence of my perceptions of priority issues and criteria and my basic orientation toward community concerns. A good example of this: the driver on the road segment at

Sullivan Playground is on a fill section and would have an excellent view of Revere Beach were it not for the fifteen-foot acoustic wall which buffers Sullivan Playground from the noise impact of this road segment.

As an aside, it should perhaps be noted that the graphics used for thinking and sketch designing are generally quite loose and schematic, more like Figures 15 and 6. The final report graphics used as examples in this section were designed for communication and documentary purposes. As such, they are several iterations removed from the first rough sketches I produced in my early explorations of the problem space.

Community Response and Decisions

The final Program Packages for I-95R were thoroughly reviewed with the mayor, elected officials, and various civic organizations and community groups. There were few surprises, since most of these participants had been consulted at various points throughout the process. But it was interesting to note the shift in position of many of those who had been most active in making their views known. At the very first public meeting in Revere, the mayor stated that the city was "strongly opposed" to any new expressways. During the problem definition stage, however, it became apparent that the city was in favor of solving the principal problem addressed by the expressways, namely getting through traffic off local Revere streets. They were also in favor of improving access to the MBTA stations and other major traffic generators and of redesigning the intersections of principal traffic bottlenecks throughout the city. When they discovered that the final evaluation of impacts indicated that the residential takings for the no build/no new highway option (Alternative 6) was as great as for any of the expressway alternatives (twenty-four households) they began to look more carefully at other criteria. My hoped-for public debate on the relative merits and trade-offs implied by the alternatives, unfortunately never materialized. Thus, the alternatives were never put to "the true test."

The Governor's decisions with respect to I-95R (six months later): proceed with the Blue Line extension from Wonderland and a parkway-scale Revere Beach Connector in the Saugus Marsh Corridor. No portion of I-95 would be constructed within Route 128.

SUMMARY

This episode has presented an analysis of the origins and inner workings of my problem solving behavior in the role of synthesizer of technical information for the development of alternatives for Interstate 95 Relocated on Boston's metropolitan North Shore. The analysis has heen divided into four sections. The first two sections present the essential elements of the task environment, the principal design tasks, my perceptions of the task and task environment and the organization of my problem solving process to respond to these perceptions. The last two sections trace the interaction of these elements in the conceptualization and development of six alternatives.

The BTPR/I-95R task environment is seen as a very complex problem context. The aggregate of problems and issues confronted by the BTPR staff identify the BTPR as a process that belongs in the category of "metaproblems."[61] Such problems are "solved" by analyzing some of the variables of some of the issues to the extent that some improvements can be planned in some parts of the problem. The trouble with pre-BTPR planning is that the EMRPP and all previous transportation studies of the metropolitan region assumed it was possible to develop <u>the</u> solution: whereas the BTPR recognized that solutions to regional transportation problems are "incremental and disjointed" at best. And indeed, probably any situation perceived as being more desirable than the present situation may be defined as a "solution" to metaproblems dealing with entire metropolitan regions.

The inner workings of my design behavior are also seen as highly complex. (This may account for the existing plethora of theories about design and designing). The I-95R episode has explored the interaction between my design and management/communication skills and my personal (value) orientations which motivated the use of these skills. In episodes of problem solving the analysis of this interaction has focused on the choice and use of information. In developing these themes I must confess a considerable struggle to resolve a particularly vexing dilemma; was it better to have a precise and comprehensive strategy to describe what I considered to be only half of the problem--i.e., the application of Newell-Simon's model to describe the use of information--or was it better to have a crude and less-than-comprehensive strategy for the problem I was really interested in, namely design as behavior, as the interaction of use and choice, facts and values, task and task environment?

I never resolved my dilemma; in deciding not to decide I had to do both! Thus I have attempted a (relatively) rigorous analysis of how I used information during sketch designing and have essentially relied on the reader to "osmote" much of my (partial) sense of what it takes to analyze behavior. The constructs of orientation and the functions attributable to the interpreter in my adaptation of the Newell-Simon model are about as far as I got in this effort.

Sketch designing is portrayed as the key to the use of information in developing alternatives by mediating and synthesizing sensory inputs from the real world, abstracted pattern fragments recalled from LTM, and various EM sources and displays. The essential elements of a graphic model of sketch design organization are presented in the Introduction (See Figure 2). This model is used throughout the episode to explore the operation of my basic perceptual, cognitive and motor fucntions during design sequences.

The later more interactive stages of design development required the continuous integration of information from other BTPR staff members and numerous community participants. This is illustrated in Figure 26.

By the end of my I-95 Relocated experience I had gained considerable confidence in my ability to develop alternatives in the BTPR task environment. Before proceeding to the Harbor Crossing episode which explores the implications of applying my I-95R problem solving "formula" to a very different context, it might be well to summarize my perceptions at this point of the kinds and content of information required to develop alternatives in the multi-disciplinary and highly interactive BTPR context. With each information category is a telegraphic summary of major elements and a brief assessment of their relative importance to my process. The categories are ordered roughly from those which provided quantifiable or "hard" data to those which dealt with "soft" or more qualitative issues.

- o Engineering: Principally highway geometrics and subsurface conditions--Very little highway engineering information was needed during the conceptual stages of alternative development. Rules of thumb for highway geometrics for use in exploring alternatives alignments were assimilated via sketch design. Highway engineers provided hard-line translation of my sketch plan alignments.
- o Traffic: directional ADT and peak hour volumes, modal split, existing highway capacities--Traffic information was necessary to determine the number of lanes required, interchange and intersection configurations etc. Due to long start-up time for computer model, this information came too late to input to initial concepts; used principally to verify my judgments and to size each facility link. I needed to know

only enough about forecasting methodology to interpret data outputs from the system.

- Economics: subregional growth trends, community economic profiles, development areas, impact assessments--In the conceptual stage, I used only very general economic information, mostly that which could be graphically mapped, e.g., the locations of commercial and employment centers, high growth areas, planned development sites, etc.; more detailed information relative to impacts was useful in making adjustments to each alignment and in developing relocation and joint development concepts.
- Environmental: community open space, parks, and recreational areas, historic assets, etc.--As with economic information, I initially used only very general information, principally size and location of each facility, which could be easily mapped. The relationship between communities and their natural and historic assets and the valuing of these by the architect was crucial to fulfillment of the concept of "equity" employed by the BTPR. Proposed alignments had to avoid these areas insofar as possible to minimize "4(f)" impacts. More detailed information locating property lines and assessing impacts was required to finalize each alignment, and develop impact offsetting measures.
- Ecological; marshes, watersheds, aquifers, and other environmentally sensitive natural areas and wildlife systems--Location and extent of each area was needed in the initial sketch planning stage. An appreciation of broad concepts of ecology was important to the "equity" principle regarding impacts: unlike parks and other environmental

assets, impacts to natural systems are generally permanent; There is no substitute for a marsh. I relied heavily on the staff ecologists for data and judgments during each phase of alternative development.

- Social: community demographic profiles, neighborhood boundaries and characteristics, community values, goals, and perceptions--Information in this area was essential and continuous from the very outset of the project, from definition of the problem through the selection of final alignments, and evaluations. Technically competent alternatives could have been developed without this input but, like the pre-BTPR alternatives, would have met with implacable community resistance. If there was any "art" in the development of alternatives, much of it dervied from the ability to interpret community values and needs and to integrate the implications into the alternatives as they evolved.
- Political: city, town, and ward boundaries, elected representatives and spokesmen, community groups and organizations--Understanding the political context, i.e., the sources and processes of decision-making, is important to prevent the technical process from being subverted or co-opted on the one hand, and to use the technical process to make the political (decision-making) process more responsible on the other. Responsible community advocacy, I believe, must operate within this framework.
- Spatial and aesthetic: flow system-adapted space relationships and compositional opportunities of urban elements (district, path, edge, node, landmark)implied by goal-form analysis--This is the architect/ urban designer's traditional domain. Information relating spatial elements provided the core of conceptual frameworks for alternative generation and facilitated the assimilation of all other information.

In several instances however alternatives rationalized on aesthetic/design criteria conflicted with other criteria and values more important to the community. In the Harbor Crossing case, for example, considerable effort was expended in exploring various ways to depress the "visually blighting" viaduct section of Route 1 near the airport, only to discover that the community perceived the viaduct as one of the few real barriers to further airport expansion into the community.

The foregoing summary is, of course, very general, almost cursory; it conveys little of the range and volume of information which seemed to bombard me on a daily basis. But this is undoubtedly true of all intensive projects and accounts for much of the heady sense of excitement at the time and the great sense of accomplishment once the project is over. The amazing thing about this list then is that it does pretty well cover all the relevant informational inputs to my problem solving process.

Technical information from most of these categories was readily available from BTPR staff members who were specialists in each area. The key factors in the efficient use of this information were the coordination of work programs between disciplines and the interactive skills of the team members. In the final analysis, the development of competent technical alternatives requiring inputs from many disciplines, relied as much on my management and communication skills as on my skills as a designer.

Communication and interpersonal skills were even more critical in interfacing with the participatory process. There was no staff expert on the social and political context of each study area; no single voice represented "the community." The establishment and maintenance of dialogue with a broad spectrum of concerned individuals, organized groups, governmental agencies and elected officials was probably the most difficult (and frustrating!) task encountered by the BTPR staff. But it was only through this dialogue that alternatives responding to community-perceived needs and values could evolve. These notions are explored further in the CONCLUDING OBSERVATIONS.

The I-95 Relocated episode has described what was -- or at least seemed to be -- an almost casebook example of successful problem solving in a highly complex task environment. Everything seemed to work "according to Hoyle" (pre-1769). True, I would like to have seen greater community debate generated by the six alternatives I developed, but in general all aspects of the technical, participatory and decision-making processes had gone smoothly. This assessment may be confirmed by comparing it to another episode from the same general task environment, namely, the Harbor Crossing.

The purpose of this episode is to gain additional insights into my problem solving behavior by analyzing the consequences of taking the same planning/design approach that seemed so successful for I-95 Relocated and applying it to the Harbor Crossing study area (see Figure 4). The episode begins by comparing specifics of the Harbor Crossing task environment to the I-95 Relocated task environment, highlighting similarities and some of the differences that led to a very different sequence of alternative development. The Phase I development of initial alternatives, a series of expressway Basic Choices, was accomplished along with the determination of Basic Choices for I-95 Relocated, I-95 North and the other North Shore Corridor facilities. However, due principally to persistent pressure from the community of East Boston, it became apparent during Phase II that the range of alternatives being examined was not broad enough. The result was a redefinition of the problem and the development of a second major alternative, a special-purpose "bus only" crossing.

Following still more community dissatisfaction, the problem was redefined a second time and a third alternative was developed based on maximum use of transit and a region-wide strategy of diverting some of the Logan Airport enplanement growth to suburban airports and to high speed rail.

In summarizing the development of these three radically different solutions for the Harbor Crossing, this episode illustrates how differences in task environment -- and the architect's perceptions of those differences -- affected his problem solving behavior. The episode also illustrates the role of problem definition -- the process through which they are defined as well as how they are expressed -- in the conceptualization of alternatives.

The analysis of problem solving behavior in the I-95 Relocated episode has described in considerable detail both the BTPR/I-95 task environment and the particular attributes of the architect that define his relationship to that task environment. Phase I of the Harbor Crossing episode ran roughly parallel with I-95 Relocated, but about one month behind. Thus, the use of information by the architect -- the application of sketch planning and reconnaissance techniques to develop conceptual frameworks and explore flow systems-adapted space relationships -- was essentially the same for both episodes. Hence, the principal differences in problem solving behavior between these two episodes may be seen in the architect's choice of information and task objectives. In the chapter on METHODOLOGY, two sets of choice-influencing factors were identified: the external "givens" of the task environment and the internal attributes of the individual problem solver. In this case, of course, the problem solver is the same; thus, specific differences in the task environment -- elements of the social, political and spatial context plus process management factors -- must account for the choices which differentiate problem solving behavior between the two episodes.

Context Differences

The local community for I-95 Relocated was the city of Revere. All of the alternatives developed for this facility lay almost completely within the political and geographic confines of this one city. The Harbor Crossing, by contrast, had four "local communities," two of whom -- East Boston and

Massport* -- were bitter adversaries in a classic power struggle of little-guy-community versus big-guy-agency. The other two communities are downtown Boston and South Boston. All four of these communities are fiercely independent, although South Boston, situated in the major aircraft approach pattern to the airport, tends to side with East Boston against Massport on issues regarding the airport. Management of a productive participatory process under these circumstances was all but impossible. In contrast to the I-95 Relocated episode, the BTPR staff was always seen as working for "the other guys."

The community of Revere and the next larger relevant scales for I-95 Relocated -- the Inner North Shore subarea and the North Shore subregional scales -- were all located within the same Phase I area of analysis: the BTPR North Shore Corridor. For the Harbor Crossing, on the other hand, two of the local communities -- downtown Boston and South Boston -- were not even included in the North Shore Corridor. In addition, the next larger scale, the metropolitan core area, included communities in all three BTPR Corridors (see Figure 4). Two additional scales were not even perceived (by me, at least) as being relevant to the development of Harbor Crossing alternatives until well into Phase II. These were the greater metropolitan region -- all three BTPR Corridors plus communities beyond Route 128 -- and the U.S. Northeast Corridor. During Phase I, my mental maps and conceptual frameworks at these scales were woefully inadequate for the task of conceptualization of the alternatives that were eventually developed. In

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*The Massachusetts Port Authority (Massport) operates Logan International Airport, which abuts the community of East Boston and is physically separated from downtown Boston by Boston Harbor (see Figure 40).

fact, at the outset of Phase II, I had only a very vague mental map of South Boston, certainly nothing approaching the data-rich frameworks I had developed for Revere, East Boston and the other North Shore communities.

As suggested in the foregoing paragraphs, the socio-political contexts were also quite different for the two episodes. Revere citizens for the most part seemed content to let the mayor and other city officials make decisions relating to land use and transportation. East Boston, by contrast, is a community which prides itself on community control of all land use planning decisions affecting their community. They are a citizenry politicized by a long history of unbroken promises made by Massport and numerous city and state administrations with regard to airport expansion (at community expense). They eventually discovered that they had to take care of themselves; no one else was going to do it for them. From this perspective, it is understandable that East Boston found it difficult to trust and interact constructively with the BTPR, a process which had as its basic technical goal providing sufficient new access to the airport to meet its projected growth through the year 1990.

A last difference in problem contexts between the two episodes has to do with constraints. Prior to the commencement of the BTPR, the Governor had gone on record against a second jetport to serve the region. The implication was that all future airport growth would be accommodated at Logan International. Two additional constraints were imposed by the Governor at the end of Phase I in an apparent move to placate East Boston: first, that all Harbor Crossing alignments would go primarily through airport property, and second, that there would be no residential takings in East Boston for any alignment through the airport that would connect to I-95

Relocated in Revere. A much more serious (and ironic) implication of these constraints, however, is that by ruling out any alignment through the community, the BTPR staff was effectively cut off from productive dialogue with the community. The only group left to work with on the north end of crossing alternatives was Massport.

In sum, the Harbor Crossing task environment was too narrowly defined in several dimensions: geographically, in terms of the various scales which were relevant to the eventual solutions; technically, in terms of problem definition, appropriate problem solving strategies and the range of possible solutions to be considered; and finally, politically, in terms of the regional characteristics of air travel use and benefits: it was not simply an East Boston versus Massport issue.

Process Management Differences

As fundamental as the context differences between the two episodes were, there were equally telling differences in the management and coordination of the BTPR technical and participatory processes. At the outset of the BTPR, the Harbor Crossing analysis was assigned to a separate Core Area team corresponding to the North Shore Corridor Team. During Phase I, in order to avoid overlap problems among the corridors and to improve process efficiency, the tasks assigned to this team were absorbed by the other three corridor teams. Responsibility for the Harbor Crossing was split mid-harbor between the North Shore and the Southwest Corridor teams. Since the principal issues to be resolved were ostensibly on the East Boston/Airport side, the sketch plan development of Phase I Basic Choices and alignment options was done by the North Shore team. Early in Phase II, South Boston and the downtown core -- particularly the Central Artery and Sumner-Callahan tunnels -- were integrated into the Harbor Crossing effort. As a consequence, many of the Phase I tasks of inventory and problem/issue definition in these neighborhoods had to be accomplished as part of the Phase II Work Program.

The responsibility for design development and technical coordination for the Harbor Crossing was shared by two architects, the North Shore team manager and myself. (For purposes of this episode, the "architect" generally refers to the author, but may refer to either or both persons.) Technical coordination was not as clearly defined for this facility as it was for I-95 Relocated, partly because the two architects were only "part-time" -- each had other primary responsibilities -- and partly because the Harbor Crossing was thought of as essentially an engineering problem by the BTPR study manager and the engineers who developed their own work program and priorities. During Phase II, once the I-95 R report was completed, I assumed a larger share of the Harbor Crossing technical coordination and synthesis. The other architect, however, retained control of the participatory process interface with East Boston and Massport.

As described earlier, management of a productive dialogue with four very disparate communities was extremely difficult, particularly with the Phase I problem definition and the constraints set by the Governor. In East Boston, the BTPR was perceived as serving the interests of Massport and regional growth advocates. Massport, however, greatly resented the Governor's restriction to study only alignments that, of necessity, would cross operational airport areas; their cooperation with the BTPR staff was perfunctory if not reluctant. Add to this context the overlapping efforts of several BTPR staff coordinators, and it is little wonder that after a year of "shuttle diplomacy" between Massport and East Boston, the architects felt more than a little like the sparrow that flew into the tie-breaking game of the Olympic badminton finals.

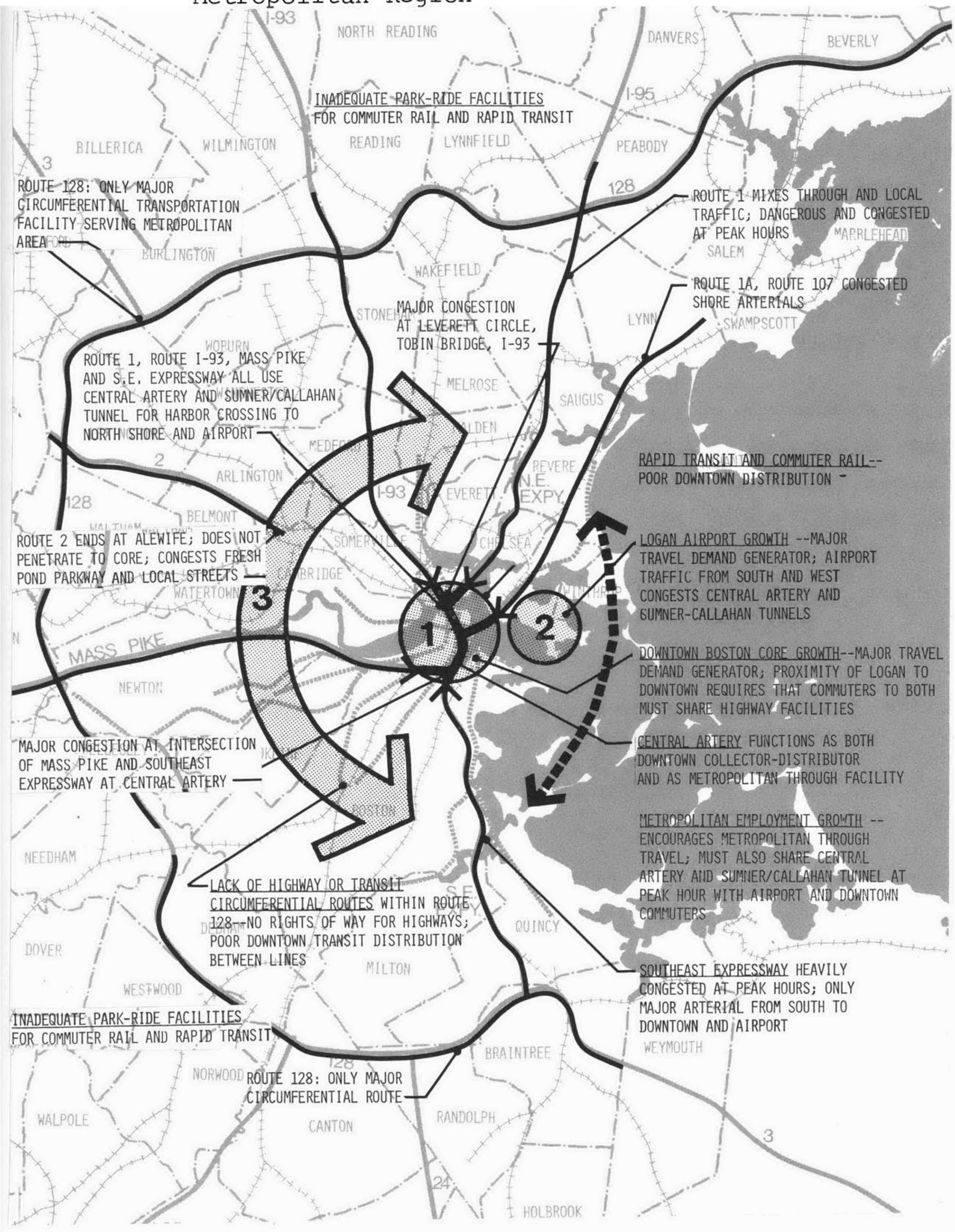
The conceptualization of Basic Choices for the Harbor Crossing was included in the North Shore Phase I effort described in the previous chapter. The elements of the task environment described for I-95 Relocated -- the BTPR context, technical objectives, staff organization, participatory process and the principal study products -- apply for the Harbor Crossing as well. Thus, the following subsections summarize only those features of the Harbor Crossing problem definition and selection of Basic Choices not included in the I-95 Relocated episode.

Problem Definition

The Harbor Crossing was seen as the key link in the metropolitan region's expressway system. It would connect the Massachusetts Turnpike, Southeast Expressway and the proposed I-95 South on the south side of the harbor with the Northeast Expressway, the proposed I-95 Relocated and possibly I-93 on the north. The relationship of these facilities is shown in Figure 4.

The major transportation problems addressed by the Harbor Crossing stem from the fact that the two principal regional traffic generators -- the downtown Boston core and Logan Airport -- are geographically adjacent to each other, separated only by the Boston Harbor. Thus, as indicated in Figure 39, a new Harbor Crossing would relieve serious congestion in downtown Boston by providing bypass relief for metropolitan through traffic and improved regional access to Logan Airport. The lack of circumferential highway or transit routes within Route 128 coupled with the decision to drop

Figure 39: Major Transportation Problems, Downtown Metropolitan Region



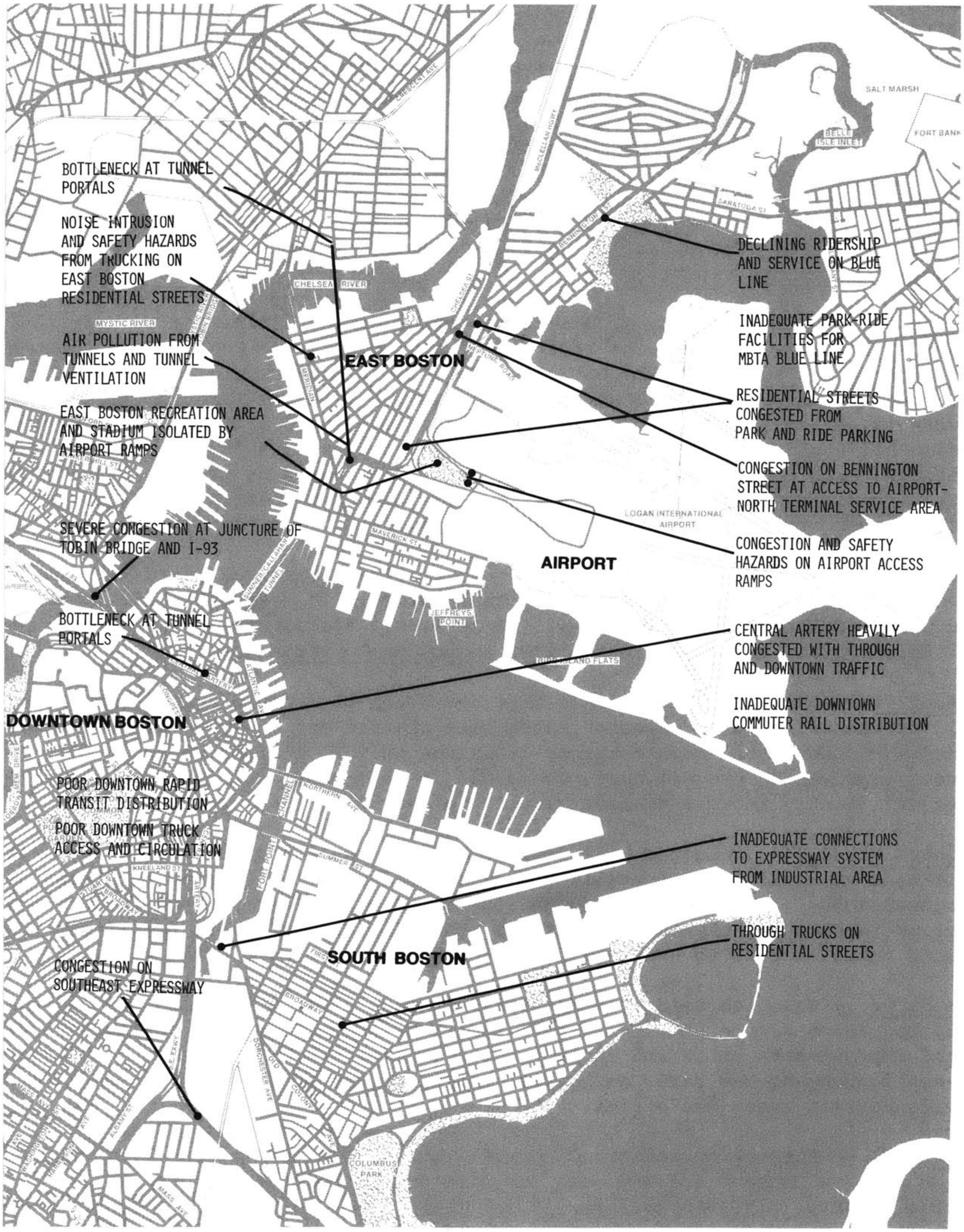
the Cambridge-Somerville portion of the Inner Belt, put even greater emphasis on the proposed Harbor Crossing as the only means to provide vehicular relief for the congested Boston core.

Although the Harbor Crossing was seen as a critical link in the system, there was no special emphasis placed on the analysis of this facility in Phase I. In fact, it received less conceptual analysis than any other of the major facilities under study. This was due largely to the perception of the Harbor Crossing as primarily an engineering problem. There had been several previous studies relating to this facility, including the detailed plan proposed by the Turnpike Authority in 1968. The only unknowns at this point, it was reasoned, were the portal locations, the engineering of the tunnel itself and the details of its connections to the other expressway facilities.

The Phase I approach to the Harbor Crossing was essentially the same as for I-95 Relocated. A preliminary survey of major subarea issues had been conducted for East Boston by the other inexperienced architect assigned to the Inner North Shore subarea. A number of community-perceived transportation, economic and community development issues were identified. But the overriding issue was how to stop airport expansion. The principal local transportation issues appearing in the final report are illustrated in Figure 40.

Basic Choices

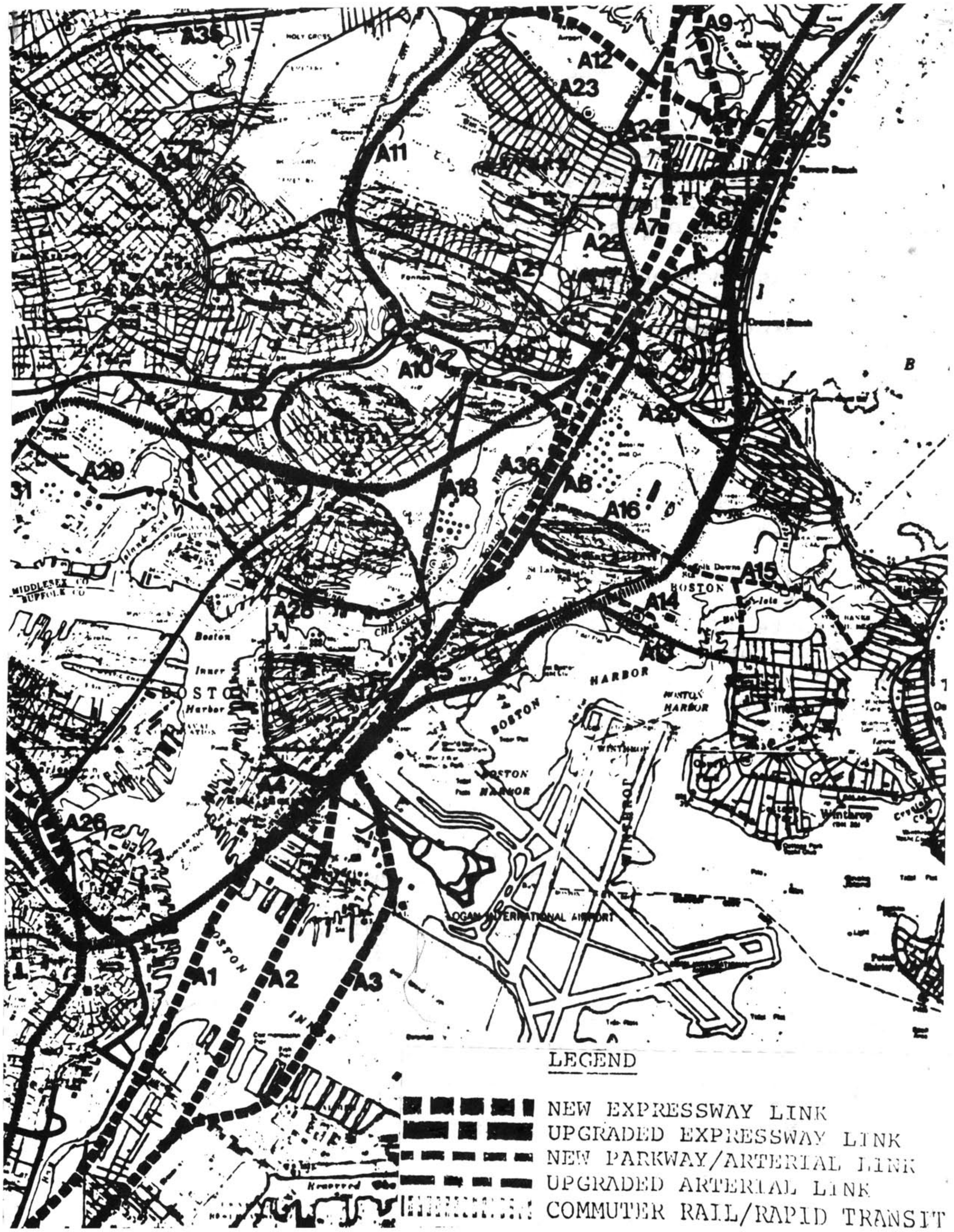
As noted in the I-95 Relocated episode, where regional facilities could be derived by adapting potential solutions first developed at the community-scale -- as was the case in Revere -- the alternatives thus


BOTTLENECK AT TUNNEL PORTALS
NOISE INTRUSION AND SAFETY HAZARDS FROM TRUCKING ON EAST BOSTON RESIDENTIAL STREETS
AIR POLLUTION FROM TUNNELS AND TUNNEL VENTILATION
EAST BOSTON RECREATION AREA AND STADIUM ISOLATED BY AIRPORT RAMPS
SEVERE CONGESTION AT JUNCTURE OF TOBIN BRIDGE AND I-93
BOTTLENECK AT TUNNEL PORTALS
POOR DOWNTOWN RAPID TRANSIT DISTRIBUTION
POOR DOWNTOWN TRUCK ACCESS AND CIRCULATION
CONGESTION ON SOUTHEAST EXPRESSWAY
DECLINING RIDERSHIP AND SERVICE ON BLUE LINE
INADEQUATE PARK-RIDE FACILITIES FOR MBTA BLUE LINE
RESIDENTIAL STREETS CONGESTED FROM PARK AND RIDE PARKING
CONGESTION ON BENNINGTON STREET AT ACCESS TO AIRPORT-NORTH TERMINAL SERVICE AREA
CONGESTION AND SAFETY HAZARDS ON AIRPORT ACCESS RAMPS
CENTRAL ARTERY HEAVILY CONGESTED WITH THROUGH AND DOWNTOWN TRAFFIC
INADEQUATE DOWNTOWN COMMUTER RAIL DISTRIBUTION
INADEQUATE CONNECTIONS TO EXPRESSWAY SYSTEM FROM INDUSTRIAL AREA
THROUGH TRUCKS ON RESIDENTIAL STREETS
EAST BOSTON
AIRPORT
DOWNTOWN BOSTON
SOUTH BOSTON
LOGAN INTERNATIONAL AIRPORT
CHELSEA RIVER
MYSTIC RIVER
SALT MARSH
BELLE ISLE INLET
FORT BANK
SARATOGA ST
MAVERICK ST
JEFFRIES POINT
COLUMBUS PARK
SUMMER ST
BROADWAY
NORTHERN AVE

developed would probably meet with relatively little community resistance. But, as I finally came to accept, the only community-scale solutions East Boston was interested in were those that would stop Massport's plans to expand the airport. Even the severe rush-hour congestion at the Sumner tunnel portal was viewed as an "asset" if it would impede implementation of these plans. In addition, there really were no existing local facilities or corridors that could be adapted to meet airport growth projections. The survey of existing East Boston transportation resources had suggested a number of improvements that might be made to improve the capacity and operational efficiency of the existing Sumner-Callahan tunnels and airport access roads, but these were a drop in the bucket compared to projected Harbor Crossing demand estimates.

As a consequence, the Phase I Basic Choices for the Harbor Crossing focused on alternative locations for a new cross-harbor tunnel. Three alignments were studied in Phase I. These are shown as links A1, A2, and A3 on Figure 41. Link A1 is the pre-BTPR proposal, which would utilize an existing rail right-of-way in East Boston and would require some takings of East Boston residences. Link A2 envisioned tunneling under the Jeffray's Point area of East Boston, thereby eliminating any residential takings. And link A3 would cut across airport property to the core at Bird Island Flats, thus avoiding the residential community entirely. On the South Boston side, these alignments would use either the Fort Point Channel or industrial waterfront and rail yards.

The Phase I Basic Choices presented for community review and the Governor's decisions were (1) three alternative alignments for a new expressway crossing, (2) the integration of transit into a new vehicular crossway, or (3) no new crossing.


A35
A12
A23
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A7
A8
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A21
A10
A19
A20
A32
A29
A25
CHELSEA
A18
A36
A6
A16
A15
A14
A13
A28
A4
A26
A1
A2
A3
BOSTON
HARBOR
LOGAN INTERNATIONAL AIRPORT
Winthrop
MIDDLESEX CO
SUFFOLK CO
LEGEND
NEW EXPRESSWAY LINK
UPGRADED EXPRESSWAY LINK
NEW PARKWAY/ARTERIAL LINK
UPGRADED ARTERIAL LINK
COMMUTER RAIL/RAPID TRANSIT

Decisions

The Governor's Phase I statement recognized the importance of the Harbor Crossing as the key regional facility under study. Consequently, his Phase I decisions with respect to this facility gave priority to the expressway options for Phase II design development. Implicit in this decision was a reaffirmation of the Governor's position that Logan International would be the only major jetport serving future metropolitan needs. Thus, the accelerating growth of air travel and air cargo -- easily the largest factor in projected cross-harbor travel demand -- was accepted as a principal design parameter or "given."

As a conciliatory gesture toward East Boston, the Governor eliminated the pre-BTPR alignment from further study on the basis of probable business and residential dislocation in East Boston, noting that "East Boston has already paid an excessive price for the convenience of motorists and air travelers." On the basis of Phase I sketch plans of alternative alignments, the Governor further stated that, ". . . all Harbor Crossing alternatives carried into Phase II will pass through Logan Airport property, to the east of the originally proposed alignment, and would not require the taking of any homes in East Boston."[62]

The Phase II development of alternatives was characterized by an increasing appreciation for the fundamental mismatch between the regionally-determined functional requirements of an expressway harbor crossing and fundamental community-perceived issues and objectives. The BTPR response to this situation was to make every effort to locate and design each expressway alternative so as to (1) minimize or eliminate any adverse impacts on the local communities, and (2) capitalize on every possible joint development opportunity to improve local access and enhance community development objectives. This was the strategy that was working so well in Revere. . . . .

In the I-95 Relocated episode, the initial conceptual effort made was to explore various alternatives that might solve locally-perceived issues. In Revere, these were local planning problems or development issues that had some transportation or access-related component. In East Boston, the major locally-perceived problems were centered around airport expansion into the community. The BTPR saw this as a "political" problem, not a transportation problem. It was some time before the failure of the initial BTPR strategy and persistent pressure from the community "forced" a redefinition or translation of the political problem into a transportation problem. And for most community leaders, when that translation finally came, it was a case of too little, too late.

Alternative 1

Newell and Simon (1972) have noted that the problem solver starts with a problem space that imbeds the initial situation and the final goal in the most "directly obvious" space available to him.[63] This is precisely what I did. The initial situation accepted the Phase I findings and constraints; the image of the final goal was an expressway crossing (or choice of several) that was somehow acceptable to both Massport and East Boston (hope burneth eternal).

The sketch planning and data gathering techniques described for I-95 Relocated were employed in a very similar mannr for the Harbor Crossing. Since information on East Boston was readily available in LTM conceptual frameworks and EM graphics developed in Phase I, I began sketch plan explorations of alignments on the north side of the harbor first. At the same time, I spent a great deal of time reconnoitering South Boston and the Central Artery area of downtown, mentally mapping areas for potential alignments to explore via sketch planning on aerial base maps.

On the north side, East Boston vetoed any alignment under the Jeffrey's Point neighborhood (alignment A2 in Figure 41), partly on the grounds that the BTPR could not guarantee that this alignment would not be a cut-and-cover construction operation resulting in takings of East Boston residences. A more subtle argument was that this alignment would become the new "psychological boundary" between the airport and the community, thus giving Massport the green light to gobble up that portion of the Jeffrey's Point neighborhood to the east of this alignment.

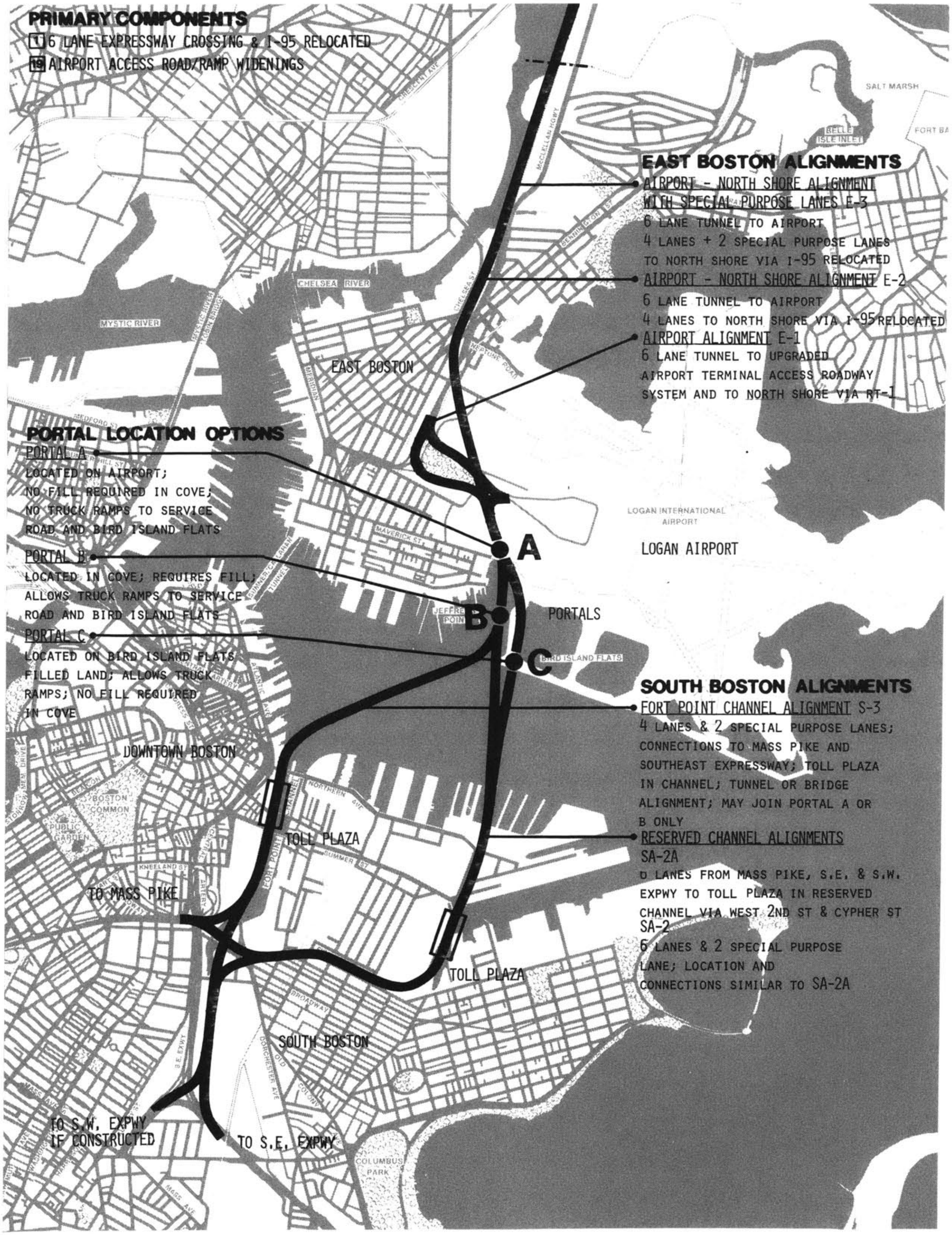
Next, I developed seven sketch plan alternatives to alignment A3 crossing airport property. Through weekly meetings with Massport, these alternatives were winnowed down to three that were then subjected to preliminary engineering and schematic joint development design. Extensive efforts were made to integrate ideas that might appeal to East Boston, e.g., a new community marina in the core at Jeffrey's Point, improved access to the stadium, presently isolated by the airport access ramps, and even a proposal to depress the elevated portion of Route C-1 to enable at-grade pedestrian and local street reonnections of the Jeffrey's Point and Eagle Hill neighborhoods. Community response to these proposals was baffling at the time. The elevated portion of C-1, for example, was perceived as the only real barrier to airport expansion in that direction. Removal of that barrier was the last thing East Bostonians wanted to see!

The South Boston alignments turned out to be even more complex than those through the airport. What at first appeared to be underutilized industrialized areas and abandoned rail yards turned out to be covered with a patchwork of public and private development plans to create a new-town-in-town. Extensive sketch planning informed by countless meetings with city agencies, planners and private developers resulted in the selection of two final alignments in South Boston.

The final expressway alignments selected for detailed engineering, joint development and evaluation are illustrated in Figure 42. To satisfy the requirements for transit, each alternative included an option which would provide space for future transit connections from South Station direct to the airport.

The preliminary "no build" alternative was a collection of highway improvements to the Central Artery, the existing tunnel approaches, the airport access road and Route C-1 in East Boston. Improvements were also proposed for the MBTA Blue Line serving East Boston and the airport. In addition, special provisions were proposed for bus-limousine service to

Figure 42: Program Package 1: New Expressway Harbor Crossing



the airport. These included the possibility of reserved lanes in existing expressways and head-of-the-line provisions at the existing tunnel portals.

The range of alternatives at this point was very similar to the range produced for I-95 Relocated. There were several expressway combinations of four and six lanes with and without special purpose bus lanes. There were three alignment options through the airport with three portal location options, and three alignment options in South Boston. The no-build alternative was a combination of transit and existing highway network improvements.

In sharp contrast, the participatory process interaction between the BTPR staff and the Harbor Crossing communities was markedly different from that in the I-95R episode. Community reviews were very difficult. The Governor's constraints to keep the alternatives out of East Boston had reduced the technical team interface with the community to little more than informing them of progress with Massport on the development of alternatives through airport property. The obvious disparity between community-perceived issues and the expressway alternatives was a clear indication of the need for much <u>greater</u> efforts at dialogue; instead, bereft of much of the motivation for dialogue, there was less. What dialogue there was, however, was crucial to the eventual outcome.

The technical team's strategy in meeting with East Boston was to empathize with the community's struggle with Massport, "We know you don't want a new harbor crossing but we've got to design it, so help us locate it to minimize community impacts and/or facilitate community development objectives." The community's strategy was to take a hard line, insisting on no new crossing and threatening to "lie down in front of the first bulldozer."

The only "good" alignment on airport property was one that would go through the proposed South Terminal expansion site. They wanted nothing to do with joint development "frills," nor with improvements to the existing highways that would improve access to the airport. We were beginning to get the picture.

Alternative 2

In situations where a number of issues are being taken into account in making design decisions, inevitably the ones that can be most clearly expressed carry the greatest weight and are best reflected in the form.[64] The main problem with inputs from East Boston was that while they were most certainly loud -- "No new tunnel!" -- they did not point to a clear or viable no-build alternative. Suggestions from East Boston, for example, included a ferry system to the airport from Massport-owned property in South Boston or relocation of the airport to a man-made island "somewhere out in the harbor."

The factors that were clear were those that reinforced the dominant idea of an expressway crossing, e.g. the projected 1980 Harbor Crossing trip demands ("clearly" expressed in Figure 43), and the formidable design issues of flow system-adapted space relationships for each of the expressway alignments under study. Figure 44 illustrates some of these issues for one of the South Boston alignments.

Through continued public review, however, it became increasingly clear that the range of alternatives being examined was not broad enough. Many participants in the study felt that the absolute no-build alternative, which made little impact on identified transportation problems, was diverting attention from important issues. Others felt that alternative assumptions

Figure 43: Origins and Destinations of Third Harbor Crossing Users 1980

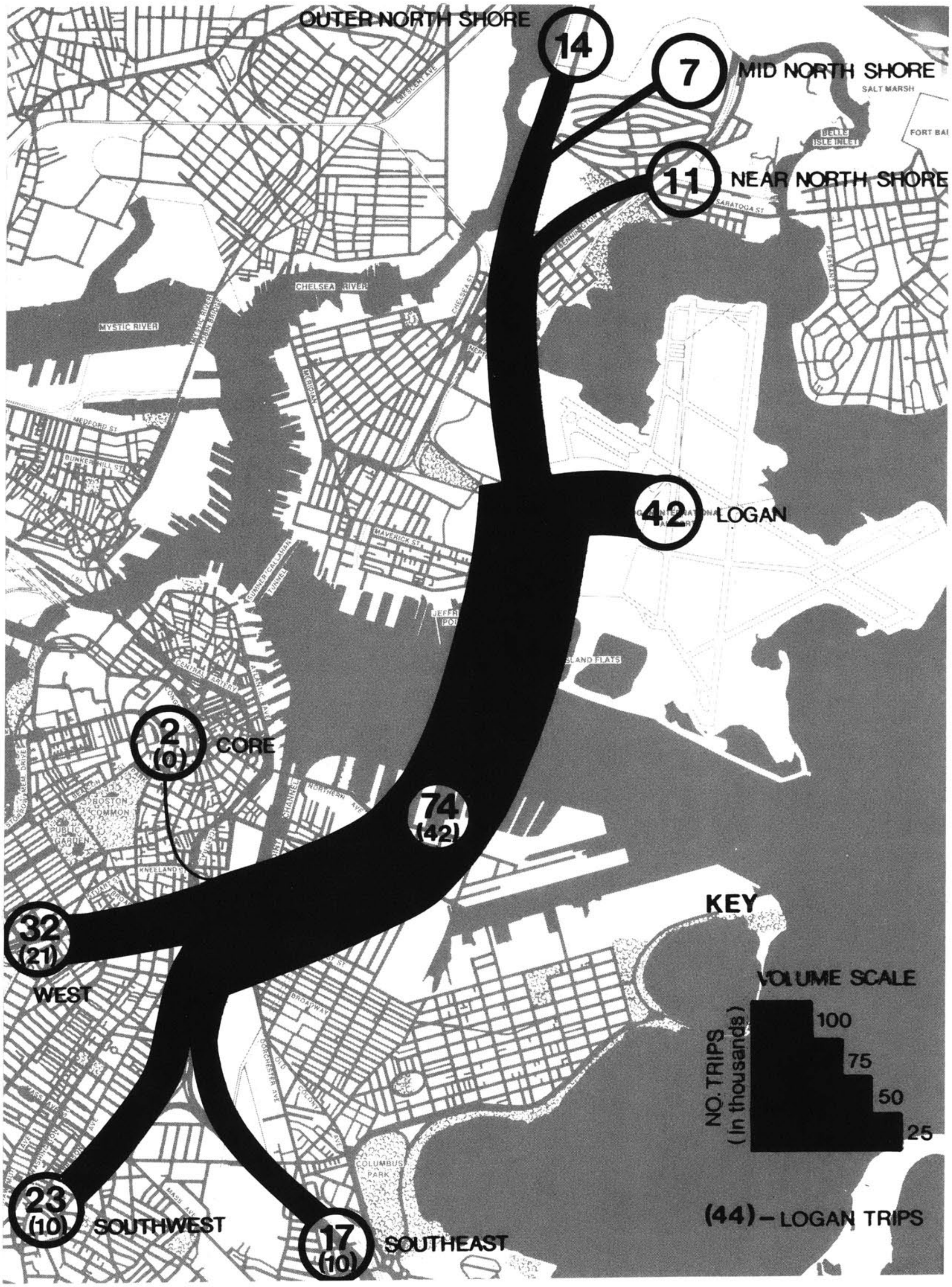
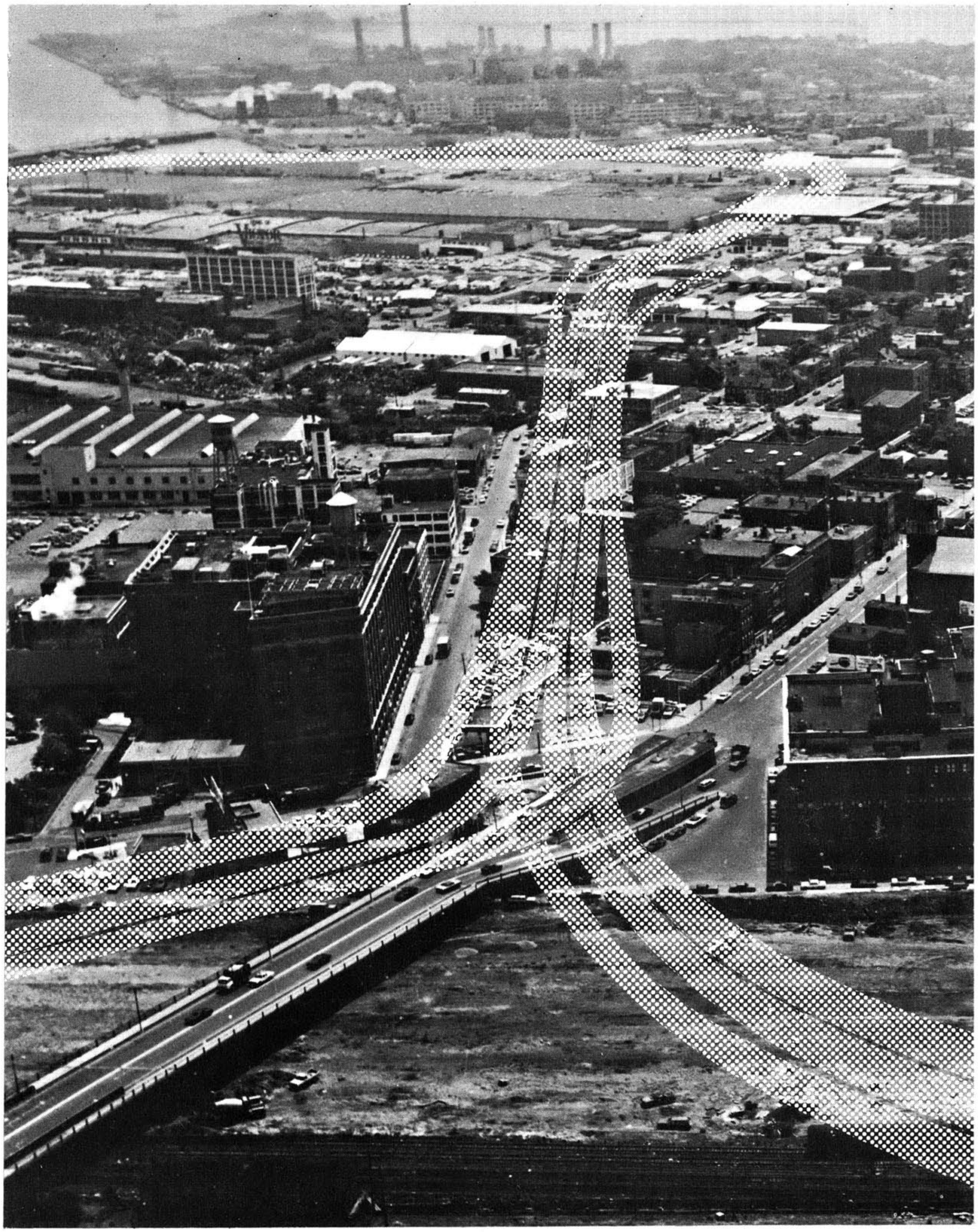


Figure 44: South Boston - Reserved Channel Alignment



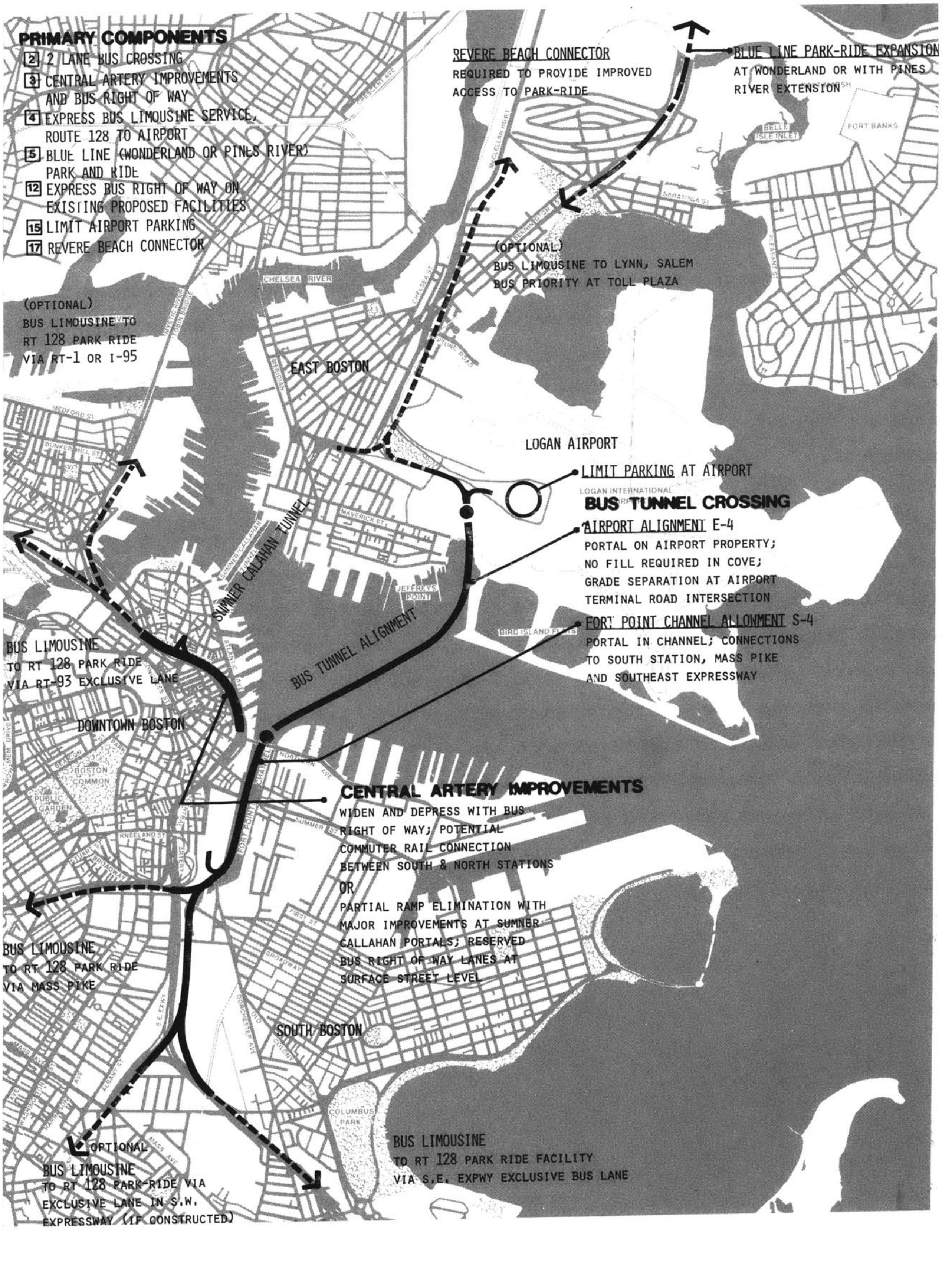
regarding regional and core growth ought to be tested. Further, many participants felt that attention should be given to the desirability of discouraging further growth in automobile travel demand rather than accommodating it.

In response to these concerns, additional efforts were made to explore possible transit alternatives. The results reinforced a preliminary determination that for the airport-destined component of cross-habor demand, a bus-limousine system offered the only significant alternative to the private automobile. And in order to be effective, such a system needed to offer perceivable convenience, reliability and time advantages over the automobile. The time advantage offered by head-of-the-line privileges at the existing tunnel portals was insignificant except possibly at rush hours. The notion of a special-purpose tunnel for buses and limousines was proposed.

The second alternative, the "Exclusive Bus Harbor Crossing," shown in Figure 45, responded to a new definition of the basic problem. The expressway alternatives had accepted the projected Harbor Crossing demands in terms of vehicle-trips. The bus-only crossing accepted the projected demands, but in terms of person-trips vis-a-vis vehicle-trips. The idea was to get the same number of people across in fewer vehicles. A fully utilized bus tunnel could handle <u>more people</u> than a four lane general purpose tunnel. A program package of supporting elements were identified that would optimize the feasibility of a region-wide bus-limousine system designed to reduce the number of cross-harbor vehicle trips to the airport.

At last, a viable no-build/no-new expressway crossing that made maximum use of transit. An alternative everyone could support. Well, almost everybody. . .

Figure 45: Program Package 2: Exclusive Bus Harbor Crossing



Alternative 3

East Boston was still adamant. Alternative 2 was still a harbor crossing, and while it might be called an "exclusive bus-only" crossing, there could be no binding guarantees that it wouldn't become a general-purpose facility serving the airport at some point in the future. Community leaders repeated their demands, "No build means no new crossing. And that's not just filling potholes in the existing tunnels. We want a real solution!"

It was at this point that my basic orientation (toward the participatory process) made the critical difference. My "covert" strategy all along had been to find the right combination of elements for each contending participant group, even (especially!) East Boston. After one particularly painful community meeting, I reassessed the entire effort to date, making a list of every idea that had surfaced that in any way affected the Harbor Crossing, even ideas that were "obviously" unfeasible. There were over forty items on the list. By personal analogy, I imagined myself as an East Boston resident looking at this list. What ideas would he choose? The only ideas that surfaced immediately from the list were the least feasible ones, e.g., recommission the old 10¢ ferry, make the tunnels free for East Boston, move the airport to an island in the harbor. etc.

I proceeded through the list again, this time classifying all ideas by mode type: highway, rapid transit, rail, ferry, air, etc. There was also a category for policies such as tunnel fees, parking, airport development, etc. Finally, I went through the list once more, assessing each idea in terms of its potential for "solving" the harbor crossing problem, by facilitating an increase in the number of cross-harbor vehicle-trips or person-trips (i.e., transit-trips). A number of the less feasible ideas such as moving the airport to a new location in the harbor were eliminated from the list. A few ideas that were technically feasible did not fit either of the categories. High speed rail to New York and short-haul air operations from suburban fields, for example, facilitated neither cross-harbor person-trips nor vehicle-trips. In fact, they potentially reduced the absolute number of harbor crossings. They accomplished this by diverting enplanements at Logan to other modes.

This, then, was the key to the translation of the "political problem" into a "transportation problem": there were technically feasible transportation strategies that could potentially reduce the projected growth of Logan Airport. At a hastily-organized staff/management review I presented a revised list of all of the options and ideas the BTPR had studied, grouped according to three dominant ideas relative to the airport growth component of cross-harbor demand: (1) meet projected enplanement growth by providing additional cross-harbor vehicular capacity, i.e., Alternative 1; (2) meet enplanement projections but reduce vehicular crossings by diverting Logan-bound passenger trips to transit, i.e., Alternative 2; and (3) reduce projected Logan enplanement growth by diverting would-be Logan trips to high-speed rail or flights originating at suburban airfields.

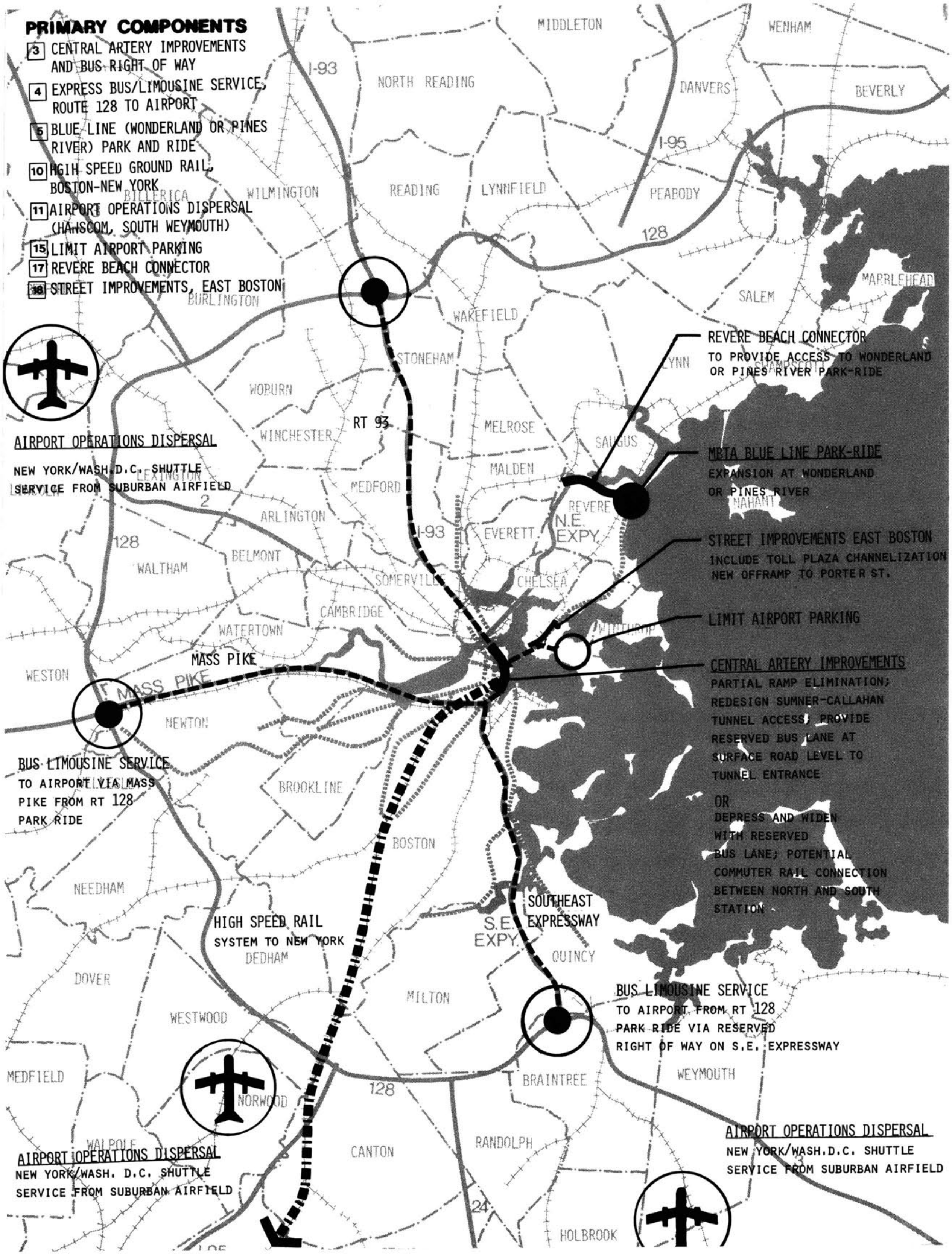
Both the second and third alternative would reduce the demand for additional harbor-crossing capacity but the third alternative would also reduce air operations at Logan and this is what the community of East Boston was most interested in.

Initial BTPR technical management response to the third alternative was skeptical. Several arguments were offered against this proposal. There was a strong feeling among many that the initial no-build alternative which proposed improvements to the Central Artery, Route C1, and the toll plaza and tunnel entrances would provide a better base condition by which to evaluate the expressway and bus-only tunnel alternatives. Others felt that the bus-only tunnel was really a transit alternative and qualified as a no (highway) build alternative. There was also concern that it was simply too late to develop a technically competent alternative based on diverting Logan enplanements. Would high-speed rail and dispersed air operations really reduce growth figures that much? Finally, there was the Governor's policy of no new airport. In this context wasn't a proposal to use suburban fields a "red herring"?

Various staff members provided counters to each argument. First, the Governor's policy could be construed as "no new jetport," which would not necessarily preclude the use of existing airfields. Second, both the Hanscom and South Weymouth airfields were presently handling jet aircraft of the size required for short-haul passenger service. Third, roughly one-quarter of all Logan enplanements were for Northeast Corridor destinations. In addition, the geographic centroid of all person-trips to Logan was located in Newton, which is actually closer to Hanscom than to Logan, particularly during rush hour. And finally, it was felt that the initiation of high speed rail service in the Boston-New York corridor before 1990 could offer a viable alternative to air travel in this corridor. On the basis of information already available, approval was given for a quick analysis of the new third alternative. Figure 46 illustrates the the principal elements of this alternative as it was presented in the final report.

In the meantime, two organizational improvements were made to the

Figure 46: Program Package 3: No New New Harbor Crossing



"laundry list" of improvements. First, a preliminary assessment was made to determine the compatibility of each idea with each of the three alternatives. Second, the element of time was interjected. Since the tunnel alternatives would require seven to ten years to construct, there was a need for a "short-term program" of interim improvements to the existing system. The principal elements of this program turned out to be those identified for the initial no-build alternative. Thus, it became clear that this was not a true no-build since most of the items would be implemented regardless of which major alternative was selected. The twenty final components for the Harbor Crossing study area are summarized in Figure 47 on the next two pages, together with the Short-term Program and three final Program Package alternatives.

As it turned out, further analysis of the use of suburban airfields and high-speed rail indicated that implementation of these strategies would not result in a dramatic reduction in projected harbor crossings. Thus, for the third "No New Crossing" alternative, these elements were combined with the bus-limousine system and other improvements to the existing highway and transit systems.

One of the more interesting conclusions that came out of relating all of these elements over time was that beyond 1990 the dispersal of air operations would be required regardless of which alternative was selected, even if an expressway crossing were built now. In other words, the real question for the Governor was, "Do we bite the bullet now or later?" In addition, by not building a new crossing, i.e., by selecting Alternative 3, more pressure would be put on earlier development of high-speed rail and rapid transit improvements such as elements six and seven.

Figure 47: Program Package Transportation Elements and Summary Description

KEY
- ■ PRIMARY COMPONENTS
- ○ SECONDARY/COMPATIBLE COMPONENTS
- * 1990+ PROGRAM TENTATIVE; INDICATES ANTICIPATED CHANGES FROM 1980-1990 PROGRAM

			SHORT TERM PROGRAM	PROGRAM PACKAGES: 1 NEW XWAY CROSSING		2 NEW BUS CROSSING		3 NO NEW CROSSING	
			1972-1980	1980-1990	* 1990+	80-90	* 1990+	80-90	* 1990+
ORGANIZING COMPONENTS	1	6-LANE EXPRESSWAY CROSSING + I-95 RELOCATED		■					
	2	2-LANE BUS CROSSING				■			
	3	CENTRAL ARTERY, IMPROVEMENTS & BUS RIGHT-OF-WAY	■	○		■		■	
	4	EXPRESS BUS/LIMOSINE SERVICE, ROUTE 128 TO AIRPORT	■	○	■	■		■	
RAPID TRANSIT	5	BLUE LINE (WONDERLAND OR PINES RIVER) PARK & RIDE		○		■		■	
	6	BLUE LINE-GREEN LINE INTERCONNECTION OR PRT SHUTTLE TO AIRPORT		○		○		○	■
	7	OTHER, RAPID TRANSIT EXTENSIONS/DOWNTOWN DISTRIBUTION IMPROVEMENTS	○	○		○	■	○	■
RAIL	8	COMMUTER RAIL - UPGRADE WITH PARK-RIDE	○	○		○	■	○	■
	9	COMMUTER RAIL EXTENSIONS/DOWNTOWN DISTRIBUTION IMPROVEMENTS		○		○	■	○	■
	10	HIGH SPEED GROUND RAIL, BOSTON TO NEW YORK CITY		○	■	○	■	■	
AIR	11	AIRPORT OPERATIONS DISPERSAL (HANSCOM, SOUTH WEYMOUTH)	○	○	■	○	■	■	
BUS	12	EXPRESS BUS RIGHT-OF-WAY ON EXISTING/PROPOSED FACILITIES	○	○	■	■		○	■
	13	DIAL-A-RIDE/SUBSCRIPTION SERVICE TO AIRPORT	○	○		○		○	
PARKING POLICY	14	INCREASE AIRPORT PARKING		○					
	15	LIMIT AIRPORT PARKING	■	○	■	■		■	
	16	LIMIT DOWNTOWN PARKING	○	○		○	■	○	■
HIGHWAY	17	REVERE BEACH CONNECTOR	○	○		■		■	
	18	STREET IMPROVEMENTS, EAST BOSTON	■	○		○		■	
	19	AIRPORT ACCESS ROAD/RAMP WIDENINGS	■	■		○		○	
	20	STREET IMPROVEMENTS, SOUTH BOSTON	○	○		○		○	

Program Package Transportation Elements Chart and Summary Description

SUMMARY DESCRIPTION OF TRANSPORTATION ELEMENTS

This section summarizes the principal features of transportation improvement elements 5 to 20, as listed on Figure 12. Elements 1 to 4 -- the organizing elements of the three Program Packages presented in this report -- are then described in detail in the following section.

Element 5 -- Provision of expanded park-ride facilities at the northern terminus of the Blue Line in Revere, at either Wonderland or the potential Pines River Extension station. These facilities were described in detail in Section IV of the BTPR North Shore report.

Element 6 -- Interconnection of Blue Line and Riverside Green Line transit routes would provide Green Line riders from the west of the Boston metropolitan area with direct access to the airport. This improvement would also give the Blue Line greatly increased distribution capability, thus attracting more riders. Conversely, Green Line riders would have direct access to all Blue Line destinations. All studies indicate that while the advantages of such a connection are great, the high costs involved must be justified in terms of overall improvements to the transit system, and not solely in terms of the connection's ability to reduce harbor crossing vehicular travel demand.

Alternatively, an Airport PRT shuttle could provide a personal rapid transit system either to replace the existing bus shuttle or, with a separate PRT tunnel, to join with a downtown circumferential PRT network. The downtown PRT circumferential is discussed in detail in the BTPR Southwest Corridor report.

Element 7 -- Other Red Line, Orange Line and Green Line rapid transit extensions would assist in reducing commuter automobile traffic and downtown Central Artery congestion; they would reduce harbor crossings only to a minor degree. Each transit improvement program must, therefore, be evaluated primarily on its ability to efficiently improve transit service to the downtown Boston Core.

Elements 8 and 9 -- Commuter Rail Improvements -- including attractive park-ride facilities -- would have generally the same effects as rapid transit extensions discussed above. The North and South Station terminal improvements include measures to improve the physical appearance and efficiency of these facilities, including better access to and from the downtown rapid transit network.

Element 10 -- The High Speed Ground Transportation program includes the planned early upgrading of the Boston/New York rail corridor, as well as the subsequent staged improvements up to and including a potential tracked air cushion vehicle between Boston and New York, as partial substitution for existing air shuttle service between these two cities.

Element 11 -- Airport operations dispersal includes the use of existing suburban fields such as Hanscom and Weymouth for some or all Boston/New York/Washington shuttle flights.

Element 12 -- Express bus right-of-way on existing and proposed facilities includes provision for express bus lanes on the Route I-93 inner city section; where needed along the Mass. Pike; two additional lanes, or exclusive use of existing lanes, on the Southeast Expressway; and provision for a bus-way at-grade adjacent to the Central Artery and leading to the Sumner/Callahan portals.

Element 13 -- A Dial-a-ride bus service to the airport would consist of a potential feeder to the express bus/limousine service, or a potential complementary service where needed.

Element 14 -- The planned Logan Airport expansion program for private vehicle parking would be required with the construction of a general purpose tunnel unless programs to restrain private autimobile use for airport access are implemented.

Element 15 -- Limited airport parking involves the implementation of policies to limit or discourage private automobile access to the airport, such as the construction of no further private parking, the increase in daily parking rates, etc.

Element 16 -- Limited downtown parking includes the implementation of policies discouraging further construction of downtown all-day parking facilities, the raising of all-day parking rates, complemented by low, short term shopping rates.

Element 17 -- The Revere Beach Connector is the proposed highway facility leading from Cutler Circle in Revere to the Revere Beach area. The Revere Beach Connector chould be constructed with direct ramps leading to the proposed Wonderland or Pines River Extension park-ride facilities (see Element 5, above). The Revere Beach Connector is discussed in Section IV of the BTPR North Shore report.

Element 18 -- Street improvements in East Boston include channelization of the Sumner/Callahan Toll Plaza to improve flow and reduce congestion; the addition of two toll plaza booths for better East Boston tunnel access; a new offramp from Route 1 to Porter Square for better access into East Boston; restripping and channelizing of the ramp from Route 1 to the Airport, the westward relocation of the Route 1 onramp from Neptune Road to Bennington Street; and the addition of a service road joining the north Airport service area with Route 1, allowing trucks to bypass the Neptune Road residential area.

Element 19 -- Airport access road/ramp widening includes improvements to the airport terminal roadway network for immediate relief of congestion under the short-term program. This consists primarily of eliminating the existing service road crossing, and widening existing ramps.

Element 20 -- Street improvements in South Boston consist of two alternative schemes for improving local circulation and removing trucks where possible from residential areas.

Problem Solving Analysis

In the I-95 Relocated episode the analysis of problem solving emphasized the sequence in which the development of alternatives took place. Very often in problem solving situations it is not just a matter of the order in which various parts are attended to but the choice of parts that are going to be attended to at all. In most situations if something is left out of consideration then it is very unlikely that it will ever come back in later on. Nor is there usually anything in what is being attended to that will indicate what has been left out. In the Harbor Crossing episode, however, the insistence of the community of East Boston was an ever-present prod to expand the choice of parts and ultimately to redefine the basic problem.

The importance of pattern reorganization was mentioned in the previous episode (see the last section of "Genesis of the Problem Space"). Failure to restructure and reorganize previously learned patterns to bring them into congruence with a new task environment was noted as a common problem in complex and changeable task environments like the BTPR.

In the Harbor Crossing episode, I began the development of alternatives using conceptual frameworks and problem definitions similar to those used with considerable success in I-95 Relocated. Negative response to initial alternatives from East Boston alerted me to incongruities between my previously learned approach and the concerns of the East Boston Community. My response was to redouble my efforts to find a crossing alternative acceptable to East Boston. When repeated efforts and new techniques met with repeated failure, I was faced with a choice of either ignoring East Boston as an obsessed, paranoid minority or changing my problem space to accommodate East Boston perceptions. I chose to do the latter because my basic orientation valued East Boston's position, even if I could not agree with or fully understand it.

Changes in the problem space occur constantly during problem solving. Usually, these are changes in LTM patterns and conceptual frameworks that are consistent with the problem solver's basic understanding or image of the task environment. The function of incoming messages is, in fact, to enable the problem solver to respond to changing demands of the task environment. The meaning of a particular message is the change which it produces in the problem space or image. There are four possibilities of message impact on the image: 1) no change; 2) clarification, such as in pattern recognition and the leveling and sharpening of patterns described in the previous episode; 3) simple addition, such as in the acquisition of new patterns; and 4) revolutionary change in the structure of the image.[65]

This fourth possibility is what I was being asked to do by the messages I was receiving from East Boston. Radical change seems to come about in sudden shifts after considerable effort has been expended either to reorganize existing patterns or to maintain the present organization in the face of mounting evidence of its inappropriateness to the current task environment. The image is highly resistant to messages which contradict previous experiences. Nevertheless, such restructuring is crucial to the best use of both task environment information as well as LTM patterns. This is because the sequence of arrival of information exerts such a powerful influence on the way patterns are used.

The principal external constraints to pattern restructuring in the Harbor Crossing episode have been mentioned previously, i.e., the absence of a productive interface with the community and the fact that the East Boston position was so remote from the initial problem definition and was expressed so stridently and uncompromisingly that it was too easily labeled "irrational" or "political." As a consequence, restructuring took place gradually in a series of shifts moving incrementally toward the East Boston viewpoint. Thus, the second alternative redefined the initial problem such that the major technical task was to identify and develop strategies that would reduce the number of vehicles going to the airport. In retrospect, how close this seems to reducing the number of people going to the airport. Yet the very satisfactoriness of this second alternative -- with its emphasis on transit strategies and reduction in cross-harbor vehicular demand -- for a time actually blocked progress toward the third alternative! It was De Bono's problem of "no problem," wherein the problem solver is blocked by the adequacy of the present arrangement. The trick was to realize (or accept) that additional improvements could be made and to define this realization as the (new) problem.

Bruner (1968) reports two principal blocks to the process of pattern restructuring. The first is the use of inappropriate conceptual frameworks, whereby the individual employs a set of pattern categories that are inappropriate for adequate prediction of the behavior of forces acting on the current task environment. The second principal block comes from inappropriate accessibility ordering whereby, due to the individual's fears or wishes or his problem solving habits, highly accessible pattern categories interfere with or block alternative categorizations (reorganizations) in less accessible conceptual frameworks. Bruner suggests that the mechanism most likely to mediate such interference is probably the broadening of pattern category acceptance limits when a high state of readiness to perceive prevails (such as during BTPR community reviews).

Bruner suggests two ways of dealing with failure to achieve a state of perceptual readiness that matches the probability of events (the likelihood that particular pattern categories will be needed during a problem-solving sequence): either by the relearning of categories and expectancies, or by constant close inspection of events and objects, i.e., by attention to cues which can facilitate a shift in perception. The exploration of a new feature may relate it to outcomes or goals that were very different from the goals which first suggested it. In the Harbor Crossing episode, for example, a jump in scale was suggested by examining the centroid of origins of Logan users. This information supported both the strategy of a region-wide bus-limousine service with satellite check-in locations at Route 128, as well as the feasibility of using suburban airfields. An even larger jump in scale was suggested by the inspection of destinations of Logan users. This data led to proposals to use high-speed rail and short-haul passenger operations from suburban fields to divert projected Logan enplanements.

Bruner also alludes to "the maintenance of a <u>flexibility</u> of (perceptual) readiness: an ability to permit one's hypotheses about what it is that is to be perceptually encountered to be easily infirmed by sensory input." This is analogous to my strategy of developing different conceptual frameworks to accommodate different perceptions, problem definitions, or criteria as demanded by the task environment.

Extensive efforts were required by all concerned with the Harbor Crossing to reorient perceptions, redefine basic problems and task objectives and eventually evolve the three alternatives produced for final evaluation and decision. This situation provides additional emphasis to the critical importance of problem definition. The very label "Harbor Crossing" provided such a powerful image of the solution that it is a wonder that any amount of effort could overcome such a "handicap." One wonders if similar efforts would have been required if, instead of defining the problem in terms of that solution image, it had been defined at the outset as "What physical improvements management programs and policy alternatives can be devised to resolve the underlying transportation problems in the Harbor Crossing study area?"

Community Response and Decisions

When the third alternative was finally ready for an East Boston community review, the meeting was boycotted. My feeling was that the BTPR had gone as far as possible -- albeit belatedly -- toward accommodating community objectives while remaining technically responsible to the economic and political realities of the study area task environment. All feasible ideas that could reduce projected Logan enplanement growth had been incorporated into the third alternative. For East Boston, it was "too little, too late" and instead of responding in a community review with the BTPR, they boycotted the meeting, saving their energy and emotions for the public hearing. In retrospect, probably no alternative short of relocating Logan Airport would have been supported by the majority of East Bostonians.

With respect to the Governor's final decisions, Alternative 3 was at a distinct disadvantage relative to the other two alternatives in the conspicuous absence of a dominant (new) form idea. It was a collection of several partial solutions, many of which would require extensive studies and coordination with a number of federal, state and local jurisdictions. At this stage of analysis the lack of technical certainty and feasibility of implementation of several of these ideas made this alternative a high-risk choice for the Governor. Nevertheless, the third alternative did serve to expose many of the trade-offs implicit in the Governor's eventual decision -- political and social trade-offs as well as technical.

In deciding on Alternative 2, the Exclusive Bus Tunnel, the Governor reconfirmed his pre-BTPR policy of no new airport to serve the region. But his decision combined a commitment to projected growth at Logan with a redirection toward transit as the principal mode which would accommodate that growth.

The analysis presented in this episode has illustrated some of the consequences of applying the problem solving "formula" described in the I-95R episode to a very different task environment. The adaptation of my design process to the Harbor Crossing context underscores first, the methodological importance of problem definition to the range of solutions explored by the technical process, and second, the relationship of the participatory process -- and my orientation to that process -- in the evolution of a strategy of problem redefinition and insight restructuring to develop the final alternatives. In the last analysis, the two critical factors in the determination of alternatives were the persistence of East Boston's demands, coupled with my motivation to meet those demands; all other context and management differences between the Harbor Crossing and I-95R episodes resulted primarily in delays in arriving at the eventual outcome.

This episode also illustrates that my <u>ability</u> to develop alternatives in the BTPR/Harbor Crossing context depended on the exercise of several basic design and management skills; the range and content of the alternatives actually developed depended not only on these skills but also on the interplay between my basic orientation and the factors and constraints of the task environment, most particularly the degree and quality of community input to the technical process.

Fundamental conclusions resulting from the analysis of the Harbor Crossing and I-95 Relocated episodes are summarized in the next chapter.


AFTER YEARS OF RELENTLESS STUDY,
LABORIOUS RESEARCH;
AND INNUMERABLE CALCULATIONS,.....
I HAVE HEREBY ASCERTAINED THAT,....
NO TWO SNOWFLAKES...
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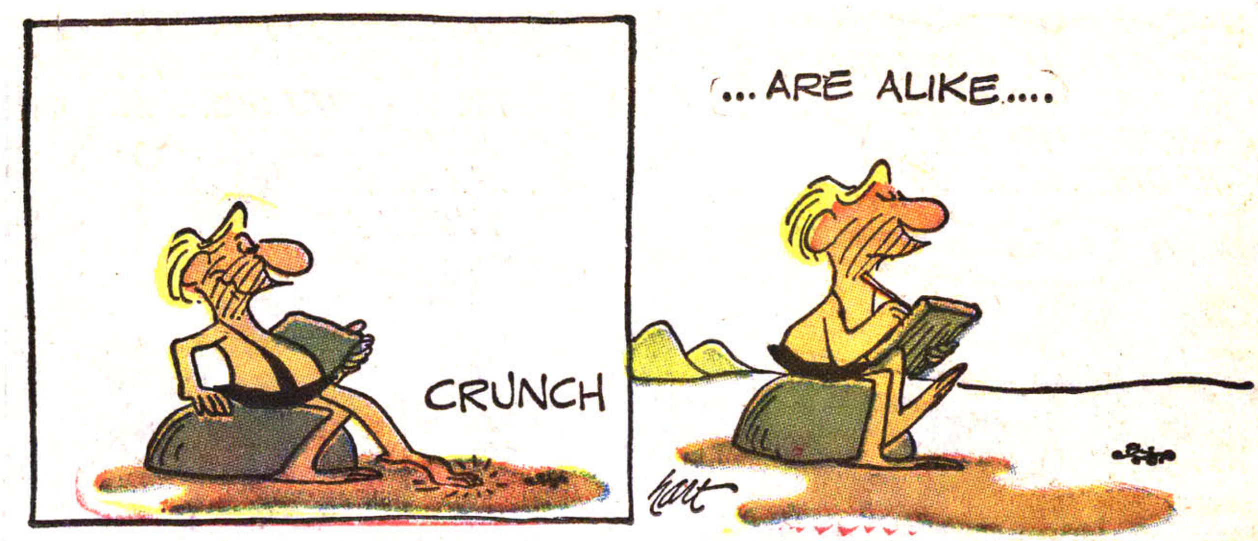
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...ARE ALIKE....
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A major objective in writing this thesis has been to document the evolution of my learning about design and design problem solving. The present thesis represents my current stage of evolution. Insights that formed the conclusions in previous drafts have been incorporated into the methodology and analysis of the present ("final") draft. In the nature of ongoing processes, the same fate undoubtedly awaits the contents of this chapter . . .

This thesis has presented an autobiographical odyssey into design behavior in a participatory transportation planning context. The analysis has alternated between figure-ground themes of task and task environment, choice and use of information and facts and values in problem solving -- themes of mutuality and interrelationship which, I believe, provide much of the interplay that makes designing the rich and creative behavior that we experience in "real life." This holistic approach was based on the methodological observation that it is in the linkages between elements that we may understand behavior; yet it is precisely these linkages that get "lost" in studies which analyze products and processes in isolation, disembodied from their behavioral contexts. In writing, as in visual perception, we can focus on only one element/figure at any given moment. It is in the shift of focus between elements/figures that we understand the "outline" of one as the "inline" of another and thus arrive at an understanding of their essential inseparability. Thus, the <u>first</u> conclusion of this thesis is that an holistic approach to the study of design behavior yields insights not possible with an analytic approach that deals with isolated fragments and neglects relationships. The observations in this chapter extend some of the insights -- drawn from the body of the thesis -- that resulted from this holistic approach.

A second conclusion is that the nature of design and designing is not as mysterious and unknowable as I had been led to believe (e.g., "I asked the brick what it liked and the brick said, 'I like an arch'" -- L. Kahn); certainly, much more is knowable than I had been taught and more than I had learned through my own (pre-thesis) experience. This, I believe, has been largely due to my limited understanding of the sensory and cognitive subprocesses that form the core of design as process. These subprocesses include the intricate counterpoint of divergent and convergent thinking modes, the interaction of various memory functions -- the LTM, STM, and EM suggested by Newell and Simon's IPS model -- and the use of perception and sketching during pattern acquisition, conceptual framework development and sketch designing, i.e., all of the concepts used to describe my problem solving process in the BTPR context (these are introduced in the METHODOLOGY chapter and developed in EPISODE ONE in the "Introduction" and "Genesis of the Problem Space"). An example of the kind of insights I derived from my explorations concerns the apparent polarities between the rational model and the insightful model of design problem solving. Rather than being inherently different (as, for example, are convergent and divergent thinking modes), the evidence from this thesis suggests a developmental link between the two and a possible explanation of how insight/inspiration may be "programmed" by experienced designers.

The developmental link is supported by the comparison of the experienced versus the inexperienced architect in EPISODE ONE and the advent of more insightful design behavior on my part in EPISODE TWO. My BTPR experience suggests that insght solutions are likely only for the designer who (a) has solved the particular type/class of problems previously and as a consequence has a well-developed LTM "library" of appropriate form-related patterns, and (b) whose understanding of the demands and constraints of the task environment is well organized by conceptual frameworks and "mental maps." I postulate that the conditions for developing insightful solutions are made possible by the designer's careful/intuitive juxtaposition of conceptual frameworks (probably at a preconscious level) to satisfy two conditions: first, that he maintain several ways of entering the problem space(s) to facilitate a full exploration of relationships via pattern manipulation (conceptual frameworks may be kept separate because of the way the mind works; see METHODOLOGY); and second, that he is able to control the informational inputs from the task environment, including the ability to abstract information in <u>intended</u> ways (inputs tend naturally to "distort" toward the closest LTM pattern/framework). The ability to control inputs and maintain different conceptual frameworks allows the designer to "suspend judgment" until the "right" moment. When this moment arrives, linkages are made between patterns residing in two (or more) different conceptual frameworks. This linkage or fusion of patterns results in the Gestaltic "Aha!" that is so characteristic of insightful behavior. As a footnote (hypothesis) to this explanation, the ability to consistently juxtapose conceptual frameworks in a manner so as to induce insightful design solutions is probably likely only after considerable (self-conscious) design experience.

A <u>third</u> conclusion is that an introspective approach to design analysis can be a powerful tool for "real" learning, i.e., for the self-knowledge that only first-hand discovery and awareness can bring. My experience suggests that it is only through the insightful analysis of one's own process that one moves beyond the "pseudo-knowledge" of belief systems developed from second-hand acceptance of this or that "authority." The implication for design education is that each student must acquire a method of finding out facts for himself lest he be "limited" for the rest of his life to facts the instructor relates. The student must learn for himself something of the true nature of design -- of the hidden processes by which inspiration works. This cannot be a matter of mere formula; the method must be centered in the student's own experience. When the student learns when and how to reinforce his own development (as I believe I finally have), he becomes independent.

At this point, I hasten to add, the instructor has succeeded. The instructor's role is to point out the road and facilitate appropriate experiences. Once the student has had that experience -- thoroughly and profoundly -- it is possible to point out what it is and why it has brought these results. What is needed then are instructors and critics who are not merely good designers themselves but -- more importantly for the learning process -- who understand how designers learn, who can explain and illustrate the basic relationships of convergent and divergent thinking and the "eyemindhand network," and who are concerned with the careful nurturing of fragile design skills in the (beginning) student. As a footnote, it seems to me that our most brilliant and creative designers may, in fact, be among our poorest teachers; often, those who seem to learn "naturally" are the least aware of what it takes (for others) to learn.

A fourth conclusion is that the evidence with respect to my use of information during design corroborates much of the basic research of Newell and Simon (1972), de Bono (1970), Arnheim (1969), Bruner (1956), and Lynch (1960 and 1971), among others. I have developed a model of design problem solving which makes the concepts proposed by these authors relevant to my BTPR experience. Figures 2, 5-13, 18, 21, and 26 illustrate the schematic organization and functioning of this model in the (formative and reorganizational) learning stages as well as in the ineractive and production stages of design problem solving. By clarifying concepts regarding the functional relationships between problem space and task environment, various memory resources and the role of perception and sketching in the development and use of patterns and conceptual frameworks, this model has provided the structural framework necessary for me to thoroughly explore the origins and development of my problem solving process as well as of the products -- i.e., the transportation alternatives -- of that process.

A fifth conclusion is that designing transportation alternatives in a participatory process context is, in many essential details, the same as designing a building or for that matter a better mousetrap in any other context. I believe that the fundamental mechanisms involved in the use of information by the mind are (as Newell and Simon have postulated) invariant across designers and design contexts. Thus, in the BTPR, the fundamental skills required to develop solutions -- i.e., to define the problem, analyze, ideate, evaluate and select -- are the same as for any other design problem. The differences lie in the relative emphasis of some skills over others. "Successful" designing in the BTPR context, for example, required much greater emphasis on communication, interpersonal interaction and management skills than my experience in architectural design has required.

A sixth conclusion is that personal values play a crucial role in design behavior and are ultimately reflected in the alternatives developed for evaluation and decision. The notion of basic orientation to describe the operation of values was introduced in the METHODOLOGY chapter to assist in the analysis of the choices and judgments made in the development of BTPR alternatives. Four basic orientations were identified: toward the technical process, toward the political process, toward the participatory process and toward personal advancement. At the scale of information processing during design episodes the functioning of these orientations are seen as operating through an Interpreter (the "I") -- interposed between STM and LTM -- which filters and prioritizes all informational inputs to the design process (see Figure 2 and accompanying description). Although my behavior exhibited elements of all four orientations at different stages during the BTPR, my basic orientation motivated the use of my technical, communication and management skills to serve participatory process objectives.

The development of the notion of orientations and the function of the Interpreter grew out of a gnawing sense that something was missing in problem solving models (e.g. Newell and Simon's) that assume motivations for the problem solver and claim that problem solving behavior can be explained by an analysis of "invariant cognitive subprocesses." As noted in the "Factors of Choice" section of the METHODOLOGY, part of choosing is rational and logical; but part is also intuitive, based on subjective knowledge and behaving in consonance with personal values and attitudes. The underlying criteria and standards by which my (covert as well as overt) chioces are made must ultimately rest on my own value systems and in a larger sense on the community and society in which they operate.

As suggested at the beginning of the thesis much of the material I had originally intended to put in this section dealt with the implications of my thesis for design education. I have many new (for me at least) ideas about what design is all about and how it should be taught/learned in an academic setting. I also have some thoughts about ways to facilitate the development of interactive skills and multidisciplinary learning. And I have some strong feelings about the role of education in fostering a "total vision" of evolving roles for the architect/planner. I've decided not to elaborate on these ideas here, partly because they are summarized in the third conclusion in the preceding subsection, and partly because I would like to subject them to the test of the classroom sometime further on down the road. . . .

However, one set of implications that I believe is entirely appropriate to include here concerns the design of future planning/design processes.

The Study Design for the BTPR completely revised the scope, organization and methodology of previous transportation planning processes in the Commonwealth of Massachusetts. A summary of this document is provided in the Appendix. (See also footnote 1.) This thesis describes the influence of many Study Design innovations -- e.g., the multi-valued orientation, the iterative three-phase technical process, the mechanisms of the participatory process, etc. -- on my choice and use of information in the development of alternatives.

Perhaps the most significant methodological result of these innovations -- one of critical import for my basic orientation toward the participatory process -- was that the BTPR technical team was not required to come up with a "recommended solution." This requirement is a standard feature of the technocratic transportation planning model which preceded the BTPR. The participatory process is commonly short-circuited by this model since the consultant is also responsible for the evaluation of his own alternatives. Not wishing to be derailed by public controversy in the closing stages of his technical process, the consultant desires minimum exposure to a public forum, just enough to satisfy mandatory legal requirements. He presents his preferred solution -- rationalized by "strawman alternatives" -- to the busy decision maker whose role in such a process is often reduced to rubber stamping his consultants' "expert" opinion.

In contrast to this (caricatured) technocratic model, the Study Design for the BTPR concentrated decision-making responsibility in the Governor's office, to be informed by an open, broadly-based participatory process. The single, "best" solution was not appropriate to the BTPR context. Instead, the role of BTPR alternatives was to clarify contending community values and focus debate on the objectives and tradeoffs implied by a range of options. The technical team was thus challenged to produce a range of several "best" solutions. Released from the blinding pre-eminence of professional values and biases perpetrated by the technocratic modal, the technical team had an incentive to be open to inputs from all shades and factions of the community spectrum.

This incentive should be an integral part of every planning/design process that deals with extensive increments/changes to our built environment. The architect/technical team must, of course, be responsible for the accuracy and thoroughness of technical information in such processes; in addition he must often be an advocate for unrepresented groups--children, the elderly, future generations--and minorities. But the evaluation of alternatives and final decisions, especially those with extensive social consequences, must remain the responsibility of the affected communities and their elected officials.

The analysis of the development of alternatives presented in the episodes suggests several recommendations for future processes. Most of these recommendations aim at securing an expanded "partnership" role for the community. All of them have direct implications for the relationship between the technical process, professional values and the architect/planning professional on the one hand and the participatory process, community values and the private citizen on the other.

1. The development of alternatives fully responsive to the participatory process must recognize the need for direct and <u>continuous dialogue</u> between the architect/planner (or whomever performs the role of technical synthesizer) and the full range of participant groups. The intended function of the BTPR community liaison staff as an intermediary or "filter" between the technical staff and the community, conflicts with this fundamental requirement. Dialogue, to be productive, must be based on the principle of "shared partial knowledge";[66] due to the obvious advantage accruing to "tenure," community participants know more details with respect to the problems and issues of the problem context than the architect/planner can hope to acquire; for his part the architect/planner (hopefully) knows more about possible solutions

and the (technical) process required to arrive at solutions which address the basic issues and at the same time incorporate the collective dreams and aspirations of the community.

2. The <u>definition of "community"</u> with respect to the participatory process should recognize that:

   - A different community exists for each problem context at each scale. Participants at the regional scale are more likely to include environmentalists, construction trade representatives and transit or auto lobbyists whose concerns are affected at that level; at the local neighborhood scale they are most likely to be homeowners, businessmen and others whose property or place of work or residence are threatened by a particular alignment.
   - The community at any given scale is not homogeneous. There is no single voice, no community "representative" who speaks for everyone. There are instead many viewpoints and many opinions representing a wide range of interests seeking equity through the participatory process. Children, the elderly and future generations must also be taken into account.
   - The community must be identified anew for each problem context and at several junctures during the process: participants as well as their perceptions change with the development of alternatives and the birth and waning of issues.

3. Greater emphasis must be placed on <u>problem definition</u>, especially at the local community scale. The thesis clearly pinpoints this step as the key to successful management of both the technical and participatory processes. The emphasis of community participation has historically been in the review and evaluation stages of the technical process. Only

recently has a larger role for citizen review of the generation and screening of initial alternatives emerged. But effective citizen input must begin before the range of alternatives to be considered has been determined: it must begin with defining the problems to be solved. If this is accomplished, the disparity between regional and local community perceptions of the problem will be clarified at this point. If they are compatible as was the case for I-95 Relocated, consensus on a solution optimizing problem definitions is possible. If they are incompatible -- as was the case for the Harbor Crossing -- the need to clarify differences and work toward a compromise solution will be indicated. If consensus on a solution or course of action is to be the (normative) goal of the process, it must begin with the definition of the problems and criteria which are to be used in developing potential solutions. There are several aspects of this step which should be spelled out in the Study Design of future processes:

- Problems to be addressed by the technical process must be the product of dialogue with local representatives, community groups and individual citizens. Consensus should be reached by the community that all reasonable perceptions/definitions of the problem have been identified. (If consensus cannot be reached at this stage, it is highly unlikely that it can be reached at the solution or evaluation stages.)
- Problems should be defined at each relevant scale. At the outset of the BTPR this would include at least 4 scales: the regional scale (for which the Study Design outlined the problems and range of alternatives), the subregional/"corridor" scale (North Shore, Northwest, Southwest and Core), the subarea scale (e.g., Inner N.S.,

Central N.S. and Outer N.S.) and the community scale (e.g., East Boston, Revere, Saugus, Lynn, Salem, etc.). Problems and issues at the local neighborhood scale become relevant as alternatives and specific alignments are developed. Generally there is considerable corroboration between the problems identified at each scale. This was the case for I-95 Relocated. But this cannot be assumed, as happens too often when a project begins with an emphasis on the regional scale. As the Harbor Crossing case illustrates, local community perceptions may be diametrically opposed to a regionally determined definition of the problem to be addressed. In general, this thesis argues that the major emphasis of problem definition in BTPR-type projects should be at the subarea and local community scales. This seems to be the largest scale at which most citizens and organized groups have legitimate and deeply held interests. As a consequence, it is also the scale which insures the most effective and broadly-based participation.

- The process should <u>allow for multiple definitions</u> of the problem. Not only may different definitions be appropriate for each scale but there may be several different definitions within a single scale. The problems and issues perceived by a local businessman who is concerned with maximizing his exposure to and access from transportation arteries is likely to be very different from the local resident who is much more concerned about privacy and the safety of local neighborhood streets. Perceptions of a local environmentalist is likely to produce yet another set of issues. To ignore any relevant viewpoint is to subvert the basic objectives of the participatory process. The existence of multiple problem definitions may well be a good measure of just how participatory a process really is: a plurality of viewpoints can only be sustained by continued incorporation of issues and potential solutions which may be supported by contending factions. Consensus in this context may mean that yes, all (contending) perceptions of problems and issues have in fact been identified.

- The problem definition must be problem-oriented rather than solution oriented. This may sound obvious, but all too often problems are stated in the language of solutions, often exposing the bias or preconceptions of the problem solver. The effect is to limit the range of alternative solutions which might otherwise be explored. As an example, a solution-oriented definition might read: "the existing capacity of local streets is inadequate." This definition immediately defines a limited set of possible solutions all of which would attempt to increase local street capacities. A problem-oriented definition of the same data might be stated: "too much through traffic on local streets." This definition allows consideration of solutions which could reduce through traffic -- e.g., through increased transit, diversion of through traffic to other arteries or a variety of traffic management techniques -- in addition to those which could increase local street capacities. Potential solutions will naturally surface during problem definition. They should be recorded on a separate list or as possible solutions to a particular problem. A solution which does not fit under an identified problem will often assist in defining a new problem.

- Problem definition should be seen as evolutionary. Issues which were initially perceived as key should be allowed to diminish in relative importance as response to the development of alternatives brings more pressing issues to the fore. The study process should recognize that many problems, e.g., those at the local neighborhood scale, usually surface in response to specific alignments and may be unknowable or irrelevant to early stages of the process.

4. The importance of scale integration in the development of alternatives must be recognized and facilitated. Analysis at each scale defines a set of participants, problems and issues relevant to the context it encompasses. The architect/planner may employ different conceptual frameworks to organize information at each scale as described in the thesis. Scales often overlap; work may occur at several scales concurrently. And while the thesis argues that the majority of technical work and participatory interface should occur at the community scale, the real challenge is the successful integration of problems and perceptions at all scales.

One of the "shortcomings" of the BTPR was the inability to redirect the transportation planning process of existing agencies resonsible for these functions, notably the State Department of Public Works and the Massachusetts Bay Transit Authority. Instead, the philosophy and essential elements of the BTPR process have been vested in a new Central Transportation Planning Staff (CTPS) which has co-opted many of the planning functions formerly directed by other agencies. The continuity of the BTPR spirit to some extent is assured by former BTPR staff members who now have key positions on the CTPS.

For all of its innovations, the BTPR was still a top-down process, and its nominal successor, the CTPS, will be hard-pressed to avoid the regional scale bias of previous planning bodies. The process described in this thesis demonstrates the viability of large-scale processes focused at the community scale; a process which can integrate inputs from a wide spectrum of participants and synthesize alternatives which respond to criteria and needs at several scales. From this perspective, the BTPR might be seen as an evolutionary step toward planning processes initiated by concerned citizens at the local community level. As yet we have no effective vehicle for this. One wonders if it will always require a crisis like I-95 and the Inner Belt to awaken professionals and citizenry to the possibilities and promise of a truly participatory process of urbanization.

A closing thought regarding analysis and the use of models: they add strong cement to the Western model of the world which reinforces the ego, the "I" that separates itself from the world. The brain's capacity for narrowed, attentive consciousness hand-in-hand with its power of recognition -- of knowing about knowing and thinking about thinking -- is the biological foundation to the illusion that the world is a collection of separate bits and pieces, things, events, causes and effects. The problem, of course, comes in relating the pieces (e.g., this thesis). We do this by creating myths or images used for making sense of the world. Thus, Western science and technology -- under the banner of Cartesian-Newtonian mechanicism -- postulated models of separable parts obeying logical laws in cause-and-effect series to explain the inner workings of man and nature (and design!). Under the self-evident assumption that one can describe only that which has boundaries, we have evolved a wonder-less view of life and the universe. Yet, the pendulum is now swinging back from the mechanistic/atomistic models and the philosophy of scientific empiricism toward more ecologic and holistic models.

The whole is greater than the sum of its parts if only for the fact that a scientific description of each part must take into account the order or pattern in which the parts are arranged at the next larger scale and of what they are doing. But even this is not enough. We must also ask, "In what surroundings (task environment) is it doing it?" If, for example, a description of the human body must include the description of what it, and all its "parts" are doing -- that is, of its behavior -- this behavior will be very different in different contexts.

It is not enough, therefore, to describe, define, and try to understand things or events by analysis alone, by taking them to pieces to find out how they are made. This tells us much but probably rather less than half the story. Our generation is becoming more and more aware that what things are, and what they are doing, depends on where and when they are doing it. If then the definition of a thing or process must include definition of its environment, we realize that any given thing goes with a given environment so intimately and inseparably that it is more and more difficult to draw a clear boundary between the thing and its surroundings . . . in each instance the "cause" of the behavior is the situation as a whole, the organism/ environment. Indeed, it may be best to drop the idea of causality and use instead the idea of relativity: the various features of a situation arise mutually or imply one another as back implies front and as chickens imply eggs -- and vice versa. Moreover, not all the features of a total situation have to appear at the same time: total situations are patterns in time as much as patterns in space.

We can never, never describe all the features of the total situation, not only because every situation is infinitely complex, but also because the total situation is the universe.

Thus, it would take me "forever" to tell you everything about my BTPR experience and about the insights evoked by my analysis. But I am much too interested in what is happening to me now. So I bring this thesis to a close with a syllogism adapted from Knots by R. D. Laing which sums up my best guess of my present relationship to the reader: . . .

The author thinks the author sees
  What he does not*
And that the reader sees what he
  Does not see.

The reader believes the author.
He now thinks he sees
  What the author thinks the author sees
And that the author sees it too.

They may now both be completely wrong.
  But then again . . .

---

* This is ambiguous. The author thinks he is seeing an illusion:; is he right or wrong? The author thinks he is not under an illusion; is he right or wrong? Try it anyway.

COMMONWEALTH OF MASSACHUSETTS

STUDY DESIGN
for a
BALANCED TRANSPORTATION DEVELOPMENT PROGRAM
for the
BOSTON METROPOLITAN REGION

Prepared for

GOVERNOR FRANCIS W. SARGENT

under the direction of the

STEERING GROUP

of the

BOSTON TRANSPORTATION PLANNING REVIEW

CONSULTANT: SYSTEM DESIGN CONCEPTS, INC.

NOVEMBER, 1970

THE COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE DEPARTMENT
STATE HOUSE • BOSTON 02133

FRANCIS W. SARGENT
GOVERNOR

December 1, 1970

Governor Francis W. Sargent
State House
Boston, Massachusetts

Dear Governor Sargent:

It is my great pleasure to transmit this study design for the Boston Transportation Planning Review to you. It is the product of intensive participation over the past four months by representatives of your office, ten other state agencies, nine localities, and a variety of private associations.

The study design process began during August with discussions of numerous memoranda from the participants expressing their priorities and proposals for the Planning Review. After several weeks, the consultant staff began to submit memoranda which sought to synthesize the various participant views and to pose difficult questions on which guidance would be required before an adequate study design could be drafted. At the end of September, the staff did produce a complete working draft. Following intensive discussion, a completely revised second draft was submitted to the participants in late October. Their suggestions for revision have, insofar as possible, been incorporated in the present version.

Needless to say, the participants are not unanimous in endorsing every aspect of this study design. Broad agreement on what the Planning Review should do, and how, does seem to have been achieved, however. And a basic confidence has been established that the Review will proceed without preconceptions, that it will openly and dispassionately evaluate all reasonable alternatives in the service of your quest for a Balanced Transportation Development Program.

As you know, the services of the study design consultant, System Design Concepts, Inc., have been financed by the Massachusetts Department of Public Works. The Commonwealth's study management effort has been financed cooperatively by the Governor's Office, the Massachusetts Bay Transportation Authority, and the Metropolitan District Commission.

During the course of the study design effort, contact has been maintained with representatives of Secretary Volpe's office, the Federal Highway Administration, and the Urban Mass Transportation Administration. A number of these officials have reviewed early drafts of the study design and their comments have been most helpful.

I look forward to working with you in the implementation of this study design. It promises, I believe, that the Boston Transportation Planning Review will provide you in timely fashion with the advice and analyses you have requested, and that it will provide a useful prototype for future comprehensive transportation planning in the Commonwealth.

Sincerely,

Alan Altshuler

Alan Altshuler, Director
Boston Transportation Planning Review

STEERING GROUP

of the Study Design for the
BOSTON TRANSPORTATION PLANNING REVIEW

(*) Alan A. Altshuler, Chairman
Office of the Governor

(Principal representatives only are listed; alternates and other members of delegations have been omitted from this list. Asterisk(*) denotes membership on Working Committee as well as Steering Group.)

Municipalities

Boston	(*) Robert H. Murphy
Brookline	John E. Woodward, Jr.
Cambridge	(*) Tunny Lee (James Morey, until 9/1/70)
Canton	Paul K. Lambert
Dedham	Paul F. Lawler
Milton	(*) Roger Nicholas
Needham	Henry D. Hersey
Newton	Michael Ferris
Somerville	Miss Carla Johnston

(Revere, Saugus, and Winthrop were also invited to participate in the Study Design phase, but decided to postpone intensive participation until the study itself is underway.)

State Agencies

Governor's Office	Guy D. Rosmarin
Mass Bay Transportation Authority	(*) Donald M. Graham
Mass. Dept. of Administration and Finance	Michael M. Bernard
Mass. Dept. of Community Affairs	George Thomson
Mass. Dept. of Natural Resources	Evans C. Hawes
Mass. Dept. of Public Works	(*) Leo F. DeMarsh
Mass. Port Authority	Thomas P. Callaghan
Mass. Turnpike Authority	Lawrence E. Ryan
Metropolitan Area Planning Council	(*) Paul E. McBride
Metropolitan District Commission	(*) Stephen Kaiser (Stephen Crosby until 10/1/70)

Private Groups (Total of 9 representatives to date)

Chambers of Commerce	
Cambridge	Malcolm F. Fryer, Jr.
Greater Boston	(*) William F. Chouinard
Conservation/Environmental Coalition	(*) Thomas S. Kohlsaat
(Charles River Watershed Assn.	Dr. Herbert M. Meyer
(Mass. Conservation Council	
(Mass. Forest and Park Assn.	
(Mystic River Basin Assn.	
(Neponset Conservation Assn.	
Greater Boston Committee on the Transportation Crisis	
Chairman	(*) Fr. John Hinckley (Fr. Thomas Corrigan until 9/1/70)
Operation STOP	(*) Charles Turner
Negotiating Staff	Dr. Arthur Katz
	Brad Yoneoka
	Stephen Zecker

Principal Observers

U.S. Federal Highway Administration	Philip Robinson
Joint Committee on Transportation, Mass. General Court	Miss Dawn-Marie Driscoll
League of Women Voters	
Boston	Mrs. Ila Cooper
Cambridge	Miss Deborah Lamb
Boston Society of Architects	Peter W. Roudebush

Consultant

System Design Concepts, Inc. — Lowell K. Bridwell, Joseph R. Stowers
Washington, D.C.,
in association with:
- Skidmore, Owings, & Merrill
- Marcou, O'Leary & Associates, Inc.
- E.S. Preston Associates, Inc.

Staff

Executive Secretary	John G. Wofford
Secretaries	Miss Bette W. Pounders
	Miss Stephanie G. Solomonoff

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INTRODUCTION AND SUMMARY

The Boston Transportation Planning Review has been established by Governor Francis W. Sargent to advise him on a number of major transportation controversies within that portion of the Boston metropolitan region bounded by Route 128. Governor Sargent has directed that these controversies be reviewed in concert, with careful attention to their interrelationships and to their impacts upon the full range of metropolitan values. To this end, he has also directed that the Planning Review process be open and broadly participatory, so as adequately to reflect the values, priorities, and proposals that the region's public agencies, private institutions, and voluntary associations may wish to contribute.

The controversies on which the Planning Review will focus concern the proposed construction of a number of new limited access expressways and rapid transit extensions, in particular:

The Inner Belt (I-695)

The Southwest Expressway (I-95 South)

The Southwest rapid transit extension

The Route 2 extension from Alewife to the Inner Belt

The Harvard-Alewife transit extension

Relocated I-95, including the Third Harbor Tunnel

The Planning Review is geared to take 18 months. Its aim is to advise the Governor and his Secretary of Transportation on whether and how to seek implementation of these projects, taking into account their feasibility and all their relevant impacts, together with those of alternative proposals that command substantial support within the region.

Where disagreement among the participants persists at the conclusion of the Planning Review, a well-developed set of alternatives will be presented to the Governor and Secretary, accompanied by a thorough analysis of the advantages and disadvantages of each.

This design for the Planning Review has been prepared in two parts.

Part I describes the Planning Review as a whole -- its purpose and orientation, its organization and participatory mechanisms, its work program, the criteria to be used in comparing alternatives, and the alternatives themselves.

Part II sets forth in detail the work elements to be accomplished, and includes more detailed budget and scheduling estimates.

A summary follows. It is divided into seven sections:

I. Study Plan for a Balanced Transportation Development Program

II. Overview of the Planning and Decision Making Process

III. Work Program and Study Process

IV. Criteria

V. Alternatives

VI. Study Elements

VII. Budget Summary by Study Element and Phase

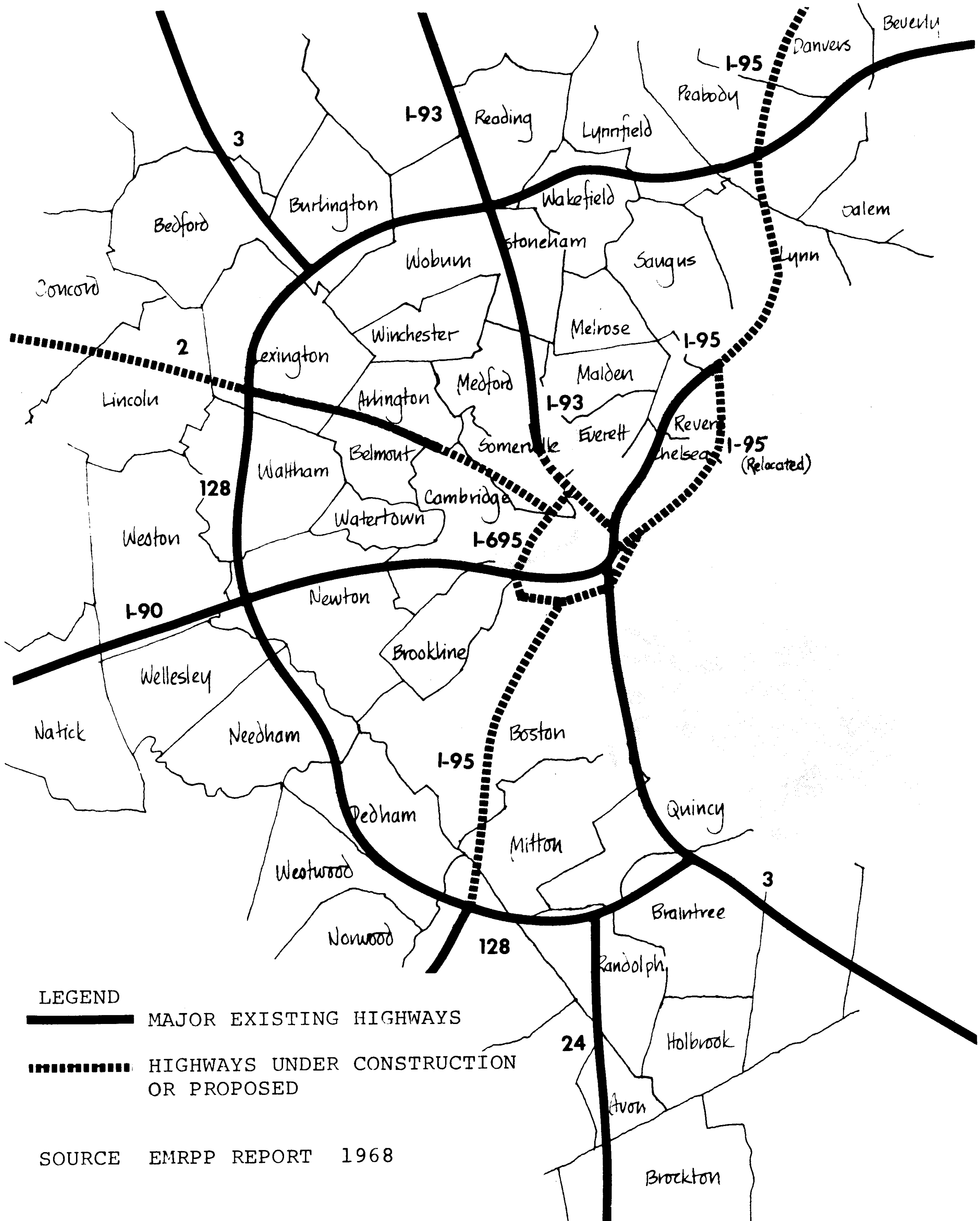

Figure V.1 RECOMMENDED HIGHWAY PLAN (EMRPP 1968)

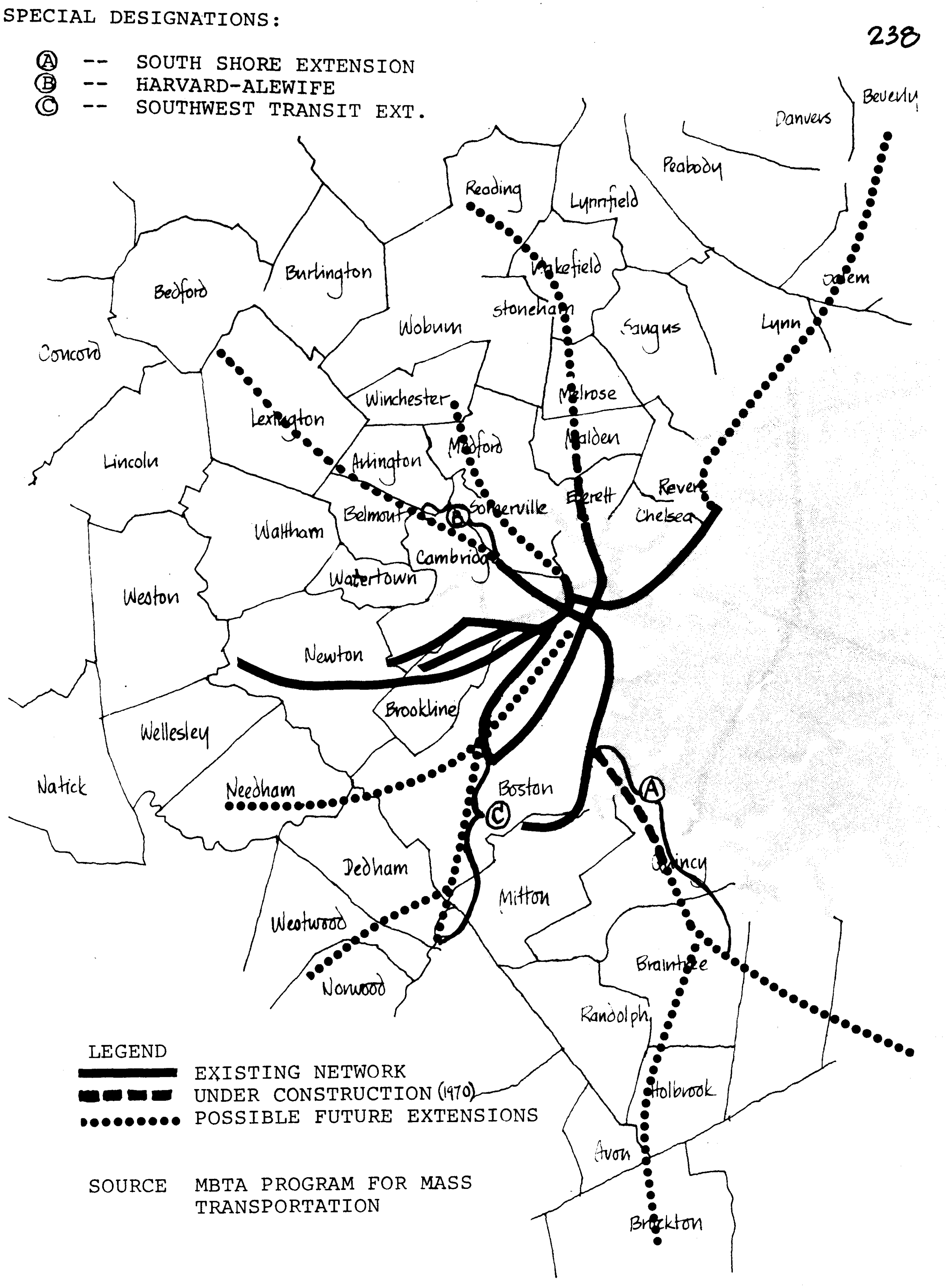

Figure V.2 RECOMMENDED TRANSIT PLAN (EMRPP 1968)

I. Study Plan for a Balanced Transportation Development Program.

This Study Plan is a response to the challenge and opportunity facing Massachusetts. In the words of Governor Sargent's Task Force on Transportation:

> "The Boston region is at a crossroads in transportation policy. Critical investment choices have to be made in the near future. Dissatisfaction with the existing transportation decision process, and with its products, is rife. And there is a widespread willingness to consider fundamental changes in the organization and philosophy of transportation decision making.
>
> "This willingness to consider fundamental change has been shaped by two major crises: on the one hand, the fiscal crisis of public transportation; on the other, growing resistance to the deleterious by-products of private transportation -- most notably, those of the new urban expressways that have been planned to accommodate the private car.
>
> "Both crises have reached a new peak of intensity at a time when fundamental reorganization of the state government is already under way. In April 1971, nearly all state agencies are to be brought within ten Executive Offices, all headed by gubernatorial appointees who will collectively constitute a Governor's Cabinet. One of these new offices will be the Executive Office of Transportation and Construction. Its Secretary will have an opportunity for multi-modal policy leadership that no state official has ever had previously.
>
> "...If (this opportunity) is exploited effectively, we believe the current transportation crises will be viewed in future years as having laid the groundwork for an era of great and genuine transportation progress." 1/

The study plan which follows has been designed fully to exploit this opportunity. The objective is to use transportation decisions and other closely related actions to preserve and enhance the natural and man-made environment; to improve the quality, vitality and integrity of neighborhoods; to retain and increase needed jobs in inner city areas; to reverse the deteriorating housing market conditions of older communities which have been impacted by previous transportation decisions; to improve the mobility of all

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1/ Governor's Task Force on Transportation, "Report to Governor Sargent, Part II," June 1970, p. 1.

citizens; and to speed the flow of goods so necessary to the metropolitan economy.

The Study Plan builds upon the significant advances which have been made in past transportation planning activities in the Boston metropolitan area, and fully recognizes both the letter and the spirit of dynamic new policies and programs which offer the opportunity to bring about more comprehensive urban transportation planning.

When viewed from today's perspective, previous planning has a number of shortcomings which require correction.

The most recent and most comprehensive transportation planning effort was the Eastern Massachusetts Regional Planning Project (EMRPP), a cooperative effort of the principal state agencies concerned with transportation and all Boston area municipalities through the Metropolitan Area Planning Council. It led the nation in the development of some of its advanced planning techniques. It closely integrated highway and transit planning for the first time. Its adopted comprehensive set of goals, objectives and policies formally recognized the drastic changes taking place in public attitudes and the new policy orientation of Federal, State, and local governments giving increasing emphasis to social, economic and environmental values and impacts.

However, the EMRPP accepted as committed the prior highway and transit plans for the area inside of Route 128 -- a highway plan developed immediately after World War II and a transit plan whose origins lay in the 1959 to 1962 period -- and gave primary emphasis to suburban-downtown service improvements and extensions.

Since the framework for the EMRPP was established in the early 1960's, a number of questions and controversies regarding the environmental and social impacts of these older designs have been raised. A serious housing crisis has developed. Tax losses, noise, air pollution, and traffic in neighborhoods have all become major concerns of core area communities.

Many potentially promising new approaches to the solution of these problems have developed and need to be examined in this study. Changes in the patterns of the region's development, and increased understanding of the functioning and the role of transportation, have led to a need to reexamine certain features of prior plans. Many other reasons can be given.

Most importantly, public attitudes and public policy, particularly regarding the environment, employment, taxes, housing, social disruption, and mobility for all citizens, have changed drastically while transportation plans, especially for the core of the region, have remained virtually unchanged.

In response to expressed dissatisfaction over these conditions, Governor Sargent appointed a Task Force in 1969 to begin a fundamental reexamination of the Commonwealth's transportation plans and policies. Acting on its recommendations, he announced in February 1970 that he was making major changes in transportation policy.

Design work and land acquisition were suspended on certain highway segments within Route 128. A reexamination of plans for the region within Route 128 was required, for both transit and highways. A new planning process was to be initiated, aimed at a balanced transportation development program -- a process which would plan for the future based upon recently established and newly emerging policies of both the Commonwealth and the Federal Government. The study design period has been the beginning of this new process.

Planning is to incorporate a genuine integration of social, environmental, economic and transportation criteria. Assumptions, options and conclusions are to be surfaced for public discussion and debate. The process is to be led from the Governor's Office, pending establishment of the Executive Office of Transportation and Construction, to insure decisiveness and adherence to the new policies.

Although the study plan covers an 18 month period, it is seen as the beginning of a new format for continuing, cooperative, comprehensive urban transportation planning.

II. Overview of the Planning and Decision Making Process.

The Study Design period (August-November, 1970) has been a testing and refinement period for the planning and decision making process outlined below. Its key characteristics are:

1. The process is participatory but decisive. Only through an open and broadly based participatory process can broad public consent or consensus for major decisions be obtained; but the role of this process should be to inform rather than supersede the regular governmental process. Decisiveness is facilitated by concentrating authority in the Governor. Deadlines will be set and adhered to.

2. It is multi-valued in orientation. As much attention

will be given to the by-products of transportation, and to its potential as a catalyst for community improvement, as to the transportation effects. All plans will be developed, and all decisions will be made, based on a balanced set of criteria representing the values of all concerned groups.

3. It is multi-modal. All facilities and services for intrametropolitan travel will be treated as part of a single system, each component to be planned in a manner most effectively utilizing its special characteristics in combination with other elements. Local service ("coverage") transit; bus rapid transit; new systems components and service concepts; operational and regulatory measures; and new terminal options will be included as well as the more conventional foci of transportation planning, major line haul highway and transit investments.

4. Equity requires full compensation to all who are affected negatively by transportation projects, taking due account of the impacts of other recent public works projects on the neighborhoods and families concerned. The Planning Review will endeavor to develop programs and designs that leave no one worse off in the wake of transportation projects than beforehand.

5. Decisions will be made on "program packages." The components of each program package will include a wide range of transportation elements (e.g., expressways, rapid transit, arterial improvements, parking policy, local circulation and feeder transit), and also a wide range of complementary elements designed to alleviate negative impacts and exploit opportunities to improve the quality of life in impacted communities (e.g., economic development, replacement housing, improved community facilities). The analysis of each program package will include detailed consideration of the administrative and legal mechanisms required for its implementation.

6. The process will be concerned with both short and long-term plans. The integration of short and long-term planning can infuse immediate decisions with concern for the full range of their unintended by-products and long-term implications. It can as well keep long range planning more attuned to considerations of political feasibility and responsive to changing community values.

7. Staged decision-making. A major consequence of the integration of short and long-term planning is the need to reach decisions on the implementation of some projects during the course of the Planning Review, rather than to leave all decisions to the end. Similarly, program package analyses will include

consideration of alternative strategies for staging implementation of the component elements (e.g., expressways, transit extensions, local street and parking improvements, replacement housing).

8. <u>An iterative process</u>. Articulation of alternatives will go through several cycles at various levels of generality, gradually reducing the number of alternatives under consideration and, where appropriate, recombining elements into new program package alternatives. The aim is to encourage the flexible exploitation of emerging study results and insights throughout the Planning Review to develop improved alternatives.

The Governor will assume responsibility for all important decisions within the jurisdiction of the executive branch. However, he encourages action at other levels through the cooperative, participatory mechanisms established for this planning process. He anticipates following, insofar as he is able, consensus recommendations of the Boston Transportation Planning Review participants. This commitment creates an incentive to reach agreement in order to substantially influence decisions. It also places a burden on private group, state, regional and municipal representatives to accurately represent the interests and positions of the people for whom they are speaking.

The planning and decision process also is designed to serve as a working prototype for future urban transportation planning in the Commonwealth, in accord with recent Federal directives and the model elaborated in the second report of the Governor's Task Force on Transportation (June 1970).

The study plan itself is a reflection and a result of the participatory planning process. It is the product of intensive involvement by representatives of the following:

... Governor Sargent and 9 local elected chief executives

... state and local public agencies

... private institutions and associations

... professionals from a broad range of disciplines

The organizational structure for developing this study plan consisted of two major committees -- the Steering Group and the Working Committee. The latter, in effect, was the executive committee of the former, and was created at the suggestion of the Steering Group to work intensively with the chairman and the consultant staff. All meetings were open.

Both groups were chaired by Alan Altshuler, whom Governor Sargent has designated to serve as Director of the Boston Transportation Planning Review -- working out of the Governor's Office and reporting directly to the Governor.

Neither the Steering Group nor the Working Committee decided anything by vote. Where they achieved consensus (most frequently, on the limits of a range), the chairman and consultant staff abided by it. Where disagreement persisted, the emphasis was on full discussion to inform the chairman's decision. It was agreed that, on major issues, appeals might be taken from the chairman's decision to the Governor.

This general structure, and these basic groundrules, are intended to characterize the whole Boston Transportation Planning Review, except that the Governor's role will largely be delegated to the Secretary of Transportation after that office comes into operation on April 30, 1971. An active effort will be made, however, to enlarge the Steering Group membership by attracting the participation of a still wider range of interests, most notably committees of the General Court, localities less obviously affected by the Boston Transportation Planning Review than those already involved, and private groups.

All activities of the Boston Transportation Planning Review will be structured to comply fully with Federal and State statutory and administrative requirements. The Steering Group and Working Committee will serve in an advisory capacity.

The process will be closely coordinated with the North Shore Planning Review (a parallel study of highway and transit options, including I-95, for communities on the north shore of the Boston region) and the Governor's Intercity Transportation Task Force (studying V/STOL, high speed ground transportation, jetport policy, etc.).

Special arrangements are being made to assure responsible, effective, informed participation by all vitally interested groups. In addition to the mechanism provided by the Steering Group and Working Committee, these special arrangements include:

1. Community liaison -- a program of briefings, workshops and public meetings, involving officials and private groups, designed to provide two-way information flow.

2. Technical assistance -- expert staff will be made available to private groups and municipalities, on the basis of need, to translate ideas into concrete proposals and to estimate impacts of alternatives on their interests.

3. The iterative process should increase the effectiveness of participation by permitting many alternatives to be examined in sketch plan form, decreasing the time required for each plan-making cycle, and permitting feedback from participants to shape reformulation of plans and designs in later phases.

The Governor's representative will serve as chairman of the Steering Group and Working Committee and as study manager. In the latter capacity he will, in close consultation with the Steering Group and Working Committee, direct the study staff in the conduct of all work including technical assistance. Staff may include consultants under contract and personnel assigned by agencies, municipalities or other qualified local organizations.

The study plan recognizes that legislative action may be required to implement recommendations. Representatives of the Joint Legislative Committee on Transportation will be encouraged to participate. Draft legislation will be developed in close consultation with appropriate elected officials and committees.

Since program packages are likely to require action by several units of government, implementation will be given special attention throughout and special efforts will be made to seek coordination with all appropriate key officials.

III. Work Program and Study Process.

Since formation of the Steering Group and Working Committee, a substantial start on the study has been made through an intensive effort by participants.

During August a consensus began to emerge on the general scope and outline of the study process. Numerous position papers and value statements prepared by participants were developed into a comprehensive set of criteria, which, after several rounds of drafting, debating and revising, have been included in Section IV. These are to be used to guide staff in designing and evaluating all alternative program packages.

Beginning in August and continuing throughout the Study Design period, intensive effort was devoted to definition of the alternatives to be studied. The current status of that effort is reported in Section V. These, like the criteria of Section IV, are subject to refinement and redefinition in early portions of the full study. Consensus has already been reached that considerably increased attention should be given to traffic operations

("TOPICS") improvements and local service ("coverage") transit in the core cities and towns.

The general methodology for the study evolved slowly throughout the study design phase. Experience in the conduct of the Steering Group and Working Committee business necessitated an evolution of the groundrules for participatory aspects which have been incorporated in this study design. The nature of the alternatives and the key issues to be addressed dictated the use of analytical methods which are capable of dealing both with questions of broad regional system efficiency and with highly localized issues of mobility, community impact and operation of individual elements of the transportation system. These requirements fit well with the desire to plan an iterative process to accommodate needs of the participatory process and the desire to stage decisions throughout the study period.

The definition of criteria and alternatives to be studied led directly to identification of most of the particular studies needed. Some Study Elements (or portions thereof) were called for by participants concerned with the feasibility of implementing program packages as intended, and others by participants who identified particular opportunities to improve local conditions or solve problems as part of possible program packages in a corridor. Drafts of Study Elements went through substantial revision as a result of participants' reviews.

A last phase in the development of the study design was the allocation of budget to Study Elements. After full discussion in which all viewpoints were aired, consensus emerged on most of the budget elements. The final budget was determined by Governor's Office decision, seeking insofar as possible to accommodate the various viewpoints expressed.

The participatory aspects of the study plan place special demands on the work program.

Study Element #2, described in Part Two, will provide technical assistance by professional study staff to municipalities and interested private groups to assist them in developing proposals, and in gauging the potential impact of proposals upon their values and interests. This technical assistance will be allocated on the basis of need to groups seeking it, and will be under the supervision of the Study Director, working in close consultation with the Steering Group and Working Committee.

Study Element #2 also provides for a series of workshops. Workshops will be held in communities which would be directly affected by proposed transportation projects and perhaps elsewhere as the need is determined. Early workshops will be devoted to describing the process, developing minimum, maximum and desirable standards to guide the study, and developing initial sketch plans. As sketch plans are developed, workshops will be devoted to discussion of them. In later phases of the process involving more detailed plans, a similar sequence of workshops will be conducted. Effective communications will be important in this process.

Monthly progress reports of the study management will be circulated among all interested groups to keep them informed and to notify them of planned public meetings, hearings, workshops, or forthcoming decisions. Meetings to discuss work with study staff will be held at the request of interested groups to the extent feasible.

Most of the Study Elements described in Part Two will involve important communications and interaction with participants and interested groups, including conduct of special surveys, the use of local area committees and special advisory committees. Results of all design and technical evaluation work will be distributed for review.

Public meetings will be held at all critical points in the study process when important decisions are to be made. These will be well-publicized meetings, held at convenient locations and open to the general public.

Three study phases are planned, each a complete cycle of plan design, evaluation and selection. These are preceded by the Study Design phase, completed with the submission of this document, and the pre-contract phase, during which preparation for the full study will be accomplished.

This pre-contract phase will involve:

1. Further organizing by private interests and others to participate effectively in the study.

2. Introductory workshops to contact and involve all groups who wish to participate actively.

3. Additional work on refinement of criteria.

4. Initial development of minimum, maximum and desired standards for selected criteria, including goals for land development.

5. Initial efforts to develop design inputs by participants.

6. Refinement of alternatives.

7. The selection of contractors.

8. The allocation of technical assistance among participants for Phase I work.

9. Providing public information on the study.

10. Making any necessary adjustments in the framework for participation to accommodate representation of new interests.

11. Establishment of subcommittees and advisory committees to handle various Study Elements or sub-regional portions of the study.

Phase I of the actual study begins after obtaining all necessary approvals of the Study Design and the employment of major contractors for the work. It is a highly compressed four month period of sketch planning in which a large number of alternatives will be designed in highly preliminary form and subjected to similarly tentative evaluations. Alternatives will include those identified in Section V, with possible revisions made early in Phase I.

The pre-contract functions of refining criteria, developing minimum, maximum and desirable standards, developing design inputs by participants, and conducting workshops and public meetings will continue with the aid of full study staff.

At the end of this period, attempts will be made to reach consensus on implementation of components of alternative transportation systems; elimination of some alternative systems, locations, or designs from further consideration; and selection or modification of sketch plans for further study in Phase II.

Special methods and short-cut estimating techniques will be used to make possible the work planned for Phase I.

Phase II work is the major, more thorough period of designing and evaluating a more limited number of alternatives. Some functions can begin before Phase I ends in the third month. Thirteen months are scheduled for this Phase. All of the functions of Phase I are repeated in more depth. Greater effort will be made during the later part of this Phase to reach consensus on implementation of recommended transportation and transportation related programs, or decisions to carry projects forward into final design.

A final period, Phase III, lasting from the twelfth to the eighteenth month, is reserved for design and evaluation of compromise alternatives which may result from previous plan-making cycles. Many previous studies have had to go through this type of phase inadequately because time and resources for this negotiation and resolution process had not been budgeted. It can be critical to the reaching of consensus. Essentially the same functions are scheduled as for Phase II, except that refinement of criteria and standards is not expected to be required.

IV. Criteria.

The criteria to be used in the design and evaluation of the alternative program packages have been developed from a series of position papers and value statements prepared by the participating groups which have been fully discussed in Steering Group and Working Committee sessions.

The importance of the criteria, and the need for a comprehensive listing, as a method for making explicit the values of the participants, is emphasized in the introduction to a memorandum submitted by the municipalities:

> "We agree with the statement . . . that 'values' are manifested, in one way or another, in nearly every aspect of a transportation study. This memorandum is an attempt to make explicit our values as they appear, in particular in (the) design and evaluation criteria . . . Past transportation studies have often failed to allocate sufficient resources to conduct an adequate assessment of the socio-economic effects of proposed transportation facilities. We have a very strong interest in seeing that the current Restudy does not repeat this deficiency."

Although the comprehensive list of criteria reflects the concerns and values of participants, the list is not final. Other criteria may need to be added if new concerns arise or if the existing criteria do not adequately reflect the range of values to be assessed.

In the framework of the study, the emphasis will not be on assigning formal weights to the criteria, but rather on using them as input to the design of program packages and the subsequent evaluation of alternatives.

Early in the study process, staff work will concenrate on defining, with the help of the Working Committee, the actual measures which will be applied to the criteria during the evaluation procedures. In addition, standards or levels of performance will be set for values that should not be violated, e.g., levels of air or noise pollution, or desirable values to serve as design objectives, e.g., land use goals.

It is recognized that the volume of information that will be produced on each alternative will be considerable,and a central responsibility of the study staff will be to develop procedures for synthesizing the material into comprehensible form.

The list of criteria includes diverse measures which include monetary values, quantitative non-monetary values, and qualitative assessments. Thus, it will not be possible to rely on a single overall criterion for evaluating and ranking alternatives. It is also recognized that the Working Committee is unlikely to be able to agree on relative weights to assign to the various criteria.

Accordingly the information will be synthesized and presented in a number of different formats, including, but not limited to:

1. A formal benefit cost evaluation, in which the differences among each pair of alternatives for which monetary values can be reasonably computed, will be presented.

2. Summary measures of evaluation by major category of type of impact. These measures will be partly monetary, partly ordinal ranking scales, and partly qualitative assessments.

3. Summary comparisons of impacts on all major categories of socio-economic groups affected by alternatives.

4. Visual portrayals of all designs at regional and corridor scales. Joint development designs and transportation facilities will be described by architectural sketches and preliminary designs.

The following table lists, in summary fashion, the preliminary range of criteria developed during the study design process. The right hand column of the table lists the Study Elements (summarized in Part Two) within which:

1. The work of developing the measures or standards for each criterion will be carried out.

2. The performance of each alternative program package will be described in relation to the complete list of criteria.

PRIMARY RELATIONSHIP OF CRITERIA TO STUDY ELEMENTS

Criteria	Study Element
1. ECONOMY	
A. Costs of Highway, Transit & Traffic Engineering Improvements	
(1) Property Costs	SE#12 Replacement Housing etc.; SE#13 Business Relocation etc.; SE#5 Joint Development; SE #10 Environmental Studies
(2) Construction Costs	SE#4 Transportation System Design
(3) Auxilliary Facilities	SE#5 Joint Development etc.
(4) Replacement Facilities	SE#5 Joint Development etc.; SE#12 Replacement Housing; SE#13 Business Relocation ; SE#10 Environmental Studies
(5) Moving Expenses	SE#12 Replacement Housing etc.; SE#13 Business Relocation
(6) Business Relocation	SE#13 Business Relocation & Employment
(7) Construction for Non-Relocated Property	SE#5 Joint Development etc.
(8) Loss of Value	SE#5 Joint Development; SE#10 Environmental Studies
(9) Change in Tax Base	SE#5 Joint Development; SE#13 Business Relocation etc.
(10) Cost of Compensation During Construction	SE#12 Replacement Housing etc.; SE#13 Business Relocation etc.
(11) Operating Costs of Cities and Towns	SE#5 Joint Development etc.
(12) Changes in Rent Levels	SE#12 Replacement Housing etc.; SE#13 Business Relocation
(13) Continuing Services	SE#5 Joint Development etc.; SE#11 Regional Economy
(14) Relocation Programs	SE#12 Replacement Housing etc.; SE#13 Business Relocation; SE #10 Environmental Studies
(15) a. Costs on Public Agencies b. Costs on Public Groups	SE#6 Land Use & Travel Forecasting
(16) Capital Costs for New Equipment	SE#4 Transportation System Design
(17) Capital Costs of Additional Private Vehicles	SE#4 Transportation System Design
(18) Aggregate Costs vs. Available Resources	SE#11 Regional Economy
B. Operating Costs	
(1) Net Change in Car/Truck Operating Costs	SE#6 Land Use & Travel Forecasting
(2) Net Change in Transit Operating Costs	SE#6 Land Use & Travel Forecasting
C. Total Costs	
(1) Net Change in Total Operating Costs	SE#4 Transportation System Design; SE#6 Land Use & Travel Forecasting
2. TRANSPORTATION SERVICE	
A. Net Change in Travel Times	SE#6 Land Use and Travel Forecasting
B. (1) Frequency of Service, etc. -- Peak Hour	SE#4 Transportation System Design
(2) Frequency of Service, etc. -- Non-Peak Hour	SE#4 Transportation System Design
C. Access to Employment, etc.	SE#6 Land Use & Travel Forecasting; SE#7 Special Mobility Studies
D. Reliability	SE#6 Land Use & Travel Forecasting; SE#7 Special Mobility Studies
E. Convenience, etc., to User	SE#4 Transportation System Design
F. Waiting Times, etc.	SE#6 Land Use & Travel Forecasting
G. Integration and Coordination	SE#4 Transportation System Design
H. Clarity and Informativeness	SE#4 Transportation System Design
I. Ease of Boarding	SE#4 Transportation System Design
J. Net Change in Travel Times to Non-Users	SE#5 Joint Development etc.; SE#4 Transportation System Design
K. Privacy	SE#4 Transportation System Design
L. Change in Travel Time During Construction	SE#11 Regional Economy; SE#6 Land Use & Travel
M. Service to Unmet Transportation Needs	SE#7 Special Mobility Studies
N. Ease and Convenience of Handling Packages	SE#4 Transportation System Design
O. Convenience for Goods Movement	SE#4 Transportation System Design
P. Effects on Local Street System	SE#4 Transportation System Design
3. SAFETY	
A. Changes in Injuries, etc.	SE#6 Land Use & Travel Forecasting
B. Property Damage	SE#6 Land Use & Travel Forecasting
C. Protection During Demolition	SE#5 Joint Development; SE#14 Neighborhood Cohesion
D. Safety During Construction	SE#5 Joint Development; SE#14 Neighborhood Cohesion
E. Convenience During Construction	SE#4 Transportation System Design; SE#5 Joint Development
F. Meteorological Effects on User Safety	SE#4 Transportation System Design
4. COMMUNITY QUALITY	
A. Noise Levels	SE #10 Environmental Studies
B. Air Pollution	SE #10 Environmental Studies
C. Visual, Psychologial Barrier	SE #10 Environmental Studies
D. Neighborhood Disruption (1-4)**	SE #10 Environmental Studies
E. Social and Cultural Impacts (1-8)	SE#11 Regional Economy; SE#12 Replacement Housing; SE#13 Business Relocation; SE#14 Neighborhood Cohesion
F. Development Opportunities (1-3)	SE#5 Joint Development
G. Effect on Community Strength & Growth (1-3)	SE#5 Joint Development
H. Visual Characteristics (1-6)	SE#5 Joint Development; SE#10 Environmental & Conservation Studies
I. Effects on Natural Features (1-6)	SE#10 Environmental & Conservation Studies
5. ACCEPTIBILITY AND ADAPTABILITY	
A. Coordination	SE#4 Transportation System Design
B. Adaptability to Social/Environmental Programs	SE#5 Joint Development;SE#10 Environmental Studies
C. New Technology	SE#8 Technological Planning
D. Changing Travel Desires	SE#6 Land Use & Travel Forecasting
E. Future Options & Irreversible Change	SE#4 Transportation System Design; SE#7 Special Mobility Studies; SE#6 Land Use & Travel Forecasting
F. Feasibility of Implementation (1-3)	SE#9 Administrative & Legislative Studies
6. DISTRIBUTIONAL EFFECTS	
A. Effect on Selected Groups (1-6)	SE#10 Environmental Studies; SE#12 Replacement Housing; SE#11 Regional Economy
B. Land Use Distributional Effects (1-2)	SE#5 Joint Development; SE#6 Land Use & Travel Forecasting ; SE #10 Environmental Studies
7. SHORT AND LONG TERM EFFECTS ON THE REGIONAL ECONOMY	
A. Positive or Negative Impacts on Federal Aid Funds	SE#11 Regional Economy
B. Positive or Negative Impacts on Alternative Program Packages	SE#11 Regional Economy; SE#10 Environmental Studies

* This table identifies primary responsibility for the generation of data & the measurement of performance, etc. There will be many areas of overlap & a clear need for continuous coordination. A major coordination role will be performed in Study Element 5 - Joint Development & the Development of Alternative Program Packages.

** Numbers in parentheses indicate sub-criteria, omitted here for simplicity.

V. Alternatives.

The final selection and refinement of the alternative program packages for the first phase evaluation will be a primary task during the early months of the study.

During the study design process, a wide range of alternatives has been described and reviewed by the Working Committee and the Steering Group. Although this process has reduced the number of alternatives to be evaluated, it is recognized that during the study, new alternatives or fresh combinations of alternatives may be generated.

Each defined program package will contain a set of transportation impact elements whose implementation will be tied inextricably to the implementation of the transportation elements. These elements will be designed to:

1. Integrate the transportation facility with the needs of, and maintain the integrity of affected communities.

2. Ensure that the transportation proposals are consistent with comprehensive regional planning goals and with local objectives and development priorities.

3. Offset the negative impacts of transportation facilities.

4. Capitalize on realistic opportunities to attract private development of the type most desired from each affected community's perspective.

5. Take advantage of opportunities which may be provided by the introduction of transportation improvements to help solve pre-existing problems identified by the communities.

A minimum standard will be that transportation program funds will be expected to assume responsibility for elements in (3) above. An objective in the design of these program elements will be to seek maximum feasible assistance from transportation programs in all of the above types of actions. Elements may include the provision or improvement of social and community services as well as physical facilities. Specific elements to be included cannot be identified accurately until completion of the relevant study activities, although it is known that substantial housing and joint development efforts will be required for alternatives involving new expressways in high density areas.

Consistent with the establishment of minimum levels of service or performance for transportation components, minimum standards will also be set for the design and implementation of transportation impact elements of program packages. For example, procedures will be established to insure that replacement or relocation facilities are in place before the demolition of existing property.

Some transportation elements are common to all the program packages. Each alternative includes highway improvement and transit improvements. Variations in the alternative program packages occur in their emphasis on particular goals, including both transportation service goals and the related consequences. For example, arterial improvements are of some priority in every program package alternative. Some arterial improvement programs may emphasize taking through traffic off residential streets, or providing special improvements for transit vehicles.

Transportation System Elements which will be described will include expressways, arterial streets, transit elements, "mode mixers" (transfer points), and operational improvements.

In addition special attention will be given, where appropriate, to the interface between metropolitan and inter-regional transportation systems, such as the airport and possible high speed ground links.

The preliminary proposals are grouped into three broad alternatives. The main features of each alternative are summarized below. It is important that they are not seen as auto vs. transit, but rather as mixtures of different elements emphasizing different design philosophies or "themes".

The "themes" of each alternative are at present described by combinations of a number of generalized goals, e.g., (a) provide mobility for core area non-drivers, (b) provide highway mobility for suburban to downtown links, (c) stress minimal disruption to core area communities, (d) provide suburban to downtown transit mobility, (e) stress design to alleviate damaging impacts, or (f) provide for lateral or circumferential highway mobility.

It is envisaged that certain proposals will be eliminated as the study progresses and at the same time expressway, arterial, and transit elements that are common to all networks can be identified, approved and released for design and construction.

Alternative A

This alternative stresses highway mobility, particularly improvements in radial travel, with full compensation for any disruption through sensitive design and through the transportation impact elements of this program package. Some stress is also put on transit improvements, although it is recognized that demand for transit may be less than in other alternatives. This alternative is the most detailed in its present description of transportation elements, since it draws heavily upon existing and committed projects.

This alternative involves the greatest expressway construction. The expressways are basically the system described in the Eastern Massachusetts Regional Planning Project Summary Report, "Recommended Highway and Transit Plan", 1968.

There are several variations within this alternative which are sub-options to the EMRPP Plan. It should be recognized that others may be generated during the study process. The presently defined range is as follows:

1. EMRPP network with no Harbor Crossing and subset alternative substituting the Western Corridor circumferential for the Inner Belt.

2. EMRPP network including the Harbor Crossing with the Western Corridor circumferential substituted for the Inner Belt.

3. EMRPP network with no Inner Belt or Western Corridor circumferential, and

    (a) a study for the termination of Route 2 at Dewey and Almay Circle (with particular attention to the effect on local arterials, especially Alewife Brook Parkway and Fresh Pond Parkway).

    (b) a study for an alternative bringing Route 2 into the vicinity of Sullivan Square and making a connection with I-93/I-695.

4. All network tests to include:

    (a) a subset study for the presence or absence of the South End By-pass.

    (b) a subset study for the effect of making the Third Harbor Crossing a toll or a free facility.

The transit elements of this alternative will be drawn from the current MBTA Master Plan, but sub-options for extensions will include:

1. Bus lanes or buses on freeways, or separate busways, including some emphasis on transfer facilities and integration of service.

2. Dual propulsion transit vehicles which can operate on both rails and highways; or other new types of systems.

3. A subset study of the impacts of continuation or discontinuation of the various commuter rail lines serving the Boston area, with consideration also of effects of possible improvements to those services.

In addition, all sub-options tested will include a subset study of coverage intensive transit service improvements for the inner areas of the region. Transit coverage is described more fully in Alternative B but includes considerations for improving the use of existing facilities and new service through either traditional or innovative systems.

Alternative B

This alternative stresses the prevention of disruption in dense inner city neighborhoods through the restriction of expressway construction and the provision of mobility by transit. The relative emphasis between suburban line haul extensions and inner area coverage intensive service can be varied as a set of sub-options. The provision of increased highway mobility through arterial improvements and traffic operation improvements for either radial or lateral mobility can also be varied within this alternative as another major sub-option.

No new expressways will be constructed, e.g., no Inner Belt, Southwest Expressway, Route 2 Extension, Third Harbor Tunnel or relocated I-95 North.

Sub-options for arterial improvements cover a wide range running from heavy emphasis on improving operational characteristics for transit vehicles to substantial improvements designed to aid auto commutation into the inner city.

This alternative implies, by the restriction of expressway construction in the inner city, a much greater emphasis on transit than the other alternatives. Thus, without competing expressways to provide access to the inner city and the downtown, greater demand might result for some or all of the transit extensions described under Alternative A.

An alternative or supplement to a fixed rail extension in any given corridor might be a commuter bus service utilizing

(a) an existing radial highway; (b) a specially constructed busway; or (c) a reserved lane on an existing expressway.

Improvement of the non-line-haul aspects of transit service has been established as a major goal of the study and will be of central emphasis in this alternative. In order to provide adequate, attractive service to a range of potential users, a high level of "frequency" and "coverage" are considered vital. Coverage is emphasized because of the interrelationship of transit service and land use. Urban sub-areas which are capable of supporting this kind of service have certain characteristics: high residential density; relatively close proximity to other activity centers; and low auto ownership rates. In some areas, low income is correlated with this pattern, in others the existence of a well-served transit corridor results in significant increases in land use density and property rents. In short, the patronage base for this improved service is not confined to the poor, the handicapped, and the elderly, but represents a potentially very broad cross-section of urban citizens.

A variety of mechanisms to provide the service will be investigated, including but not limited to:

1. A Guaranteed Service Concept -- where a variety of different modes would provide a specified level of service at a guaranteed price, employing fixed route services, and demand activated vehicles.

2. An Increased Community Accessibility Concept -- involving changes in the service to critical social services and activity centers through the operation of jitney-type local operations, multi-fare taxi rides, and so forth. Major public investment would still be channeled into improvements of bus operations on arterial streets through routed service into downtown and network connections stressed as critical for inner city service.

3. An Improved Feeder Concept -- which would rely chiefly on improving the operation of existing bus service by modifications to the fare schedules, improving transfer facilities, utilizing new equipment, and so forth.

4. Feeder to Line-Haul Concept -- which would concentrate on developing bus services as a feeder to the proposed line-haul transit improvements.

Alternative C

This alternative stresses the provision of both highway mobility and transit mobility. Sub-options in regard to transit mobility range from relatively heavy emphasis on suburban to downtown commuter service, to a heavy emphasis on the kind of improvement in inner city service described in Alternative B. The major point is that some expressways may be reduced in scale from the EMRPP system and the expressway system may not include all the links within the EMRPP system.

This alternative contemplates an intermediate level of expressway construction between A and B. In some or all cases, the scale of the proposed highways might be reduced from eight to six or even four lanes. Both full and partial networks will be defined and tested.

1. Network to include all EMRPP links, but some or all of them at a reduced scale, e.g., reduced scale Inner Belt, Southwest Expressway, I-95 relocated through East Boston, and Route 2 extension.

2. Reduced scale EMRPP network with the Western Corridor circumferential substituted for the Inner Belt. The possibility of merging the Western Corridor circumferential into the Massachusetts Turnpike extension at Brighton and converting the remainder of the Turnpike into a free road through refinancing would be a subset study.

3. A set of networks with reduced scale links and interface with the transit system, e.g.,

   (a) A reduced scale Southwest Expressway might run from Route 128 to Forest Hills with a mode mixer (e.g., "park-and-ride") to provide efficient transfers to transit for downtown traffic.

   (b) Route 2 to terminate at the end of the proposed MBTA Extension from Harvard Square to Alewife Brook.

4. A reduced scale inner city distribution system utilizing the Boston portion of the Inner Belt and either the Western Corridor circumferential or the Cambridge Inner Belt, but with no more radial expressway connections, e.g., no Route 2, no Southwest Expressway, no I-95/Harbor Tunnel.

The relative emphasis between transit extensions and coverage-intensive service is a sub-option as in other alternatives.

The same transit extension sub-options listed in Alternative A exist in C. The same transit coverage and transit extension sub-options listed in Alternative B also exist in C.

VI. Study Elements

All work of the study is covered by 14 Study Elements organized by categories of work to be performed.

It should be emphasized that these elements form an integrated whole and should not be thought of as tasks which can be performed separately by organizations working in isolation from one another.

The summary budget recommended for the 18 month study period is shown on the attached table. Estimated costs of the study are shown (in the first three columns) by Study Element, for each of the three study phases. In addition to these costs, ranges of costs are shown for each Study Element for the later two phases (second-to-last column). The total cost of each phase of the study is shown in the bottom rows of the table: Phase I--$839,000; Phase II--$1,902,000 (range $1,700,000 to $2,100,000); Phase III--$759,000 ($550,000 to $950,000). Total cost of the study is estimated at $3,500,000.

The reason for showing ranges of costs for later phases is that the precise scope of that work must depend on results of early work -- decisions on selection and elimination of alternatives, the specific nature of program packages being designed, and the relative emphasis that needs to be placed on various criteria in order to facilitate decisions and address concerns responsively.

Descriptions of each of the Study Elements follows:

General Study Elements -- Those Study Elements dealing primarily with study management, mechanisms for participation, and the general process for evaluating alternatives, rather than with specific technical aspects of design, evaluation and implementation of alternatives.

1. Study Management -- to provide immediate staff for the Steering Group and Working Committee, to provide the major creative effort in formulation of alternative program packages in response to values and priorities of participants, to oversee and coordinate the work of all other staff performing other Study Elements, and to handle arrangements for all public meetings, workshops and major communications.

2. Community Liaison and Technical Assistance -- to provide adequate communication and interaction mechanisms for the continuance of the participatory planning process throughout the study; and to provide substantive technical assistance to those participants who lack sufficient resources to play an effective part in the study.

3. Use of Design and Evaluation Criteria -- to refine the criteria used for design and evaluation in each study phase; to develop minimum and desirable standards for selected criteria, including land development goals; and to synthesize all evaluation measures in the form of overall benefit-cost comparisons and other summary comparisons to assist the Steering Group, Working Committee and other participants in performing their evaluations and arriving at recommendations for implementation.

Transportation Elements -- Those Study Elements dealing primarily with the design and evaluation of transportation components and systems and the joint development work necessary to integrate other facilities and services with transportation components.

4. Transportation System Design -- to design each of the transportation system components (expressways, arterials, rapid transit lines, terminals, local service coverage transit system improvements, various operational and TOPICS-type improvements), in coordination with all other study elements involved in the design work, and to provide information on those criteria dealing with transportation service and costs.

5. Joint Development and the Development of Alternative Program Packages -- to identify and relate transportation impact components of the alternatives, to integrate them with the Transportation System Design elements, and to design the total program packages in appropriate detail for evaluation.

6. Land Use and Travel Forecasting -- to forecast the effects of the alternative transportation systems on regional patterns of land use and intensity of development; to forecast travel on all parts of the system, taking into account competition among modes, effects of congestion, fares, tolls and parking fees; to provide information on the achievement of those criteria dealing with operating costs, service levels and land development goals; and to provide information on transportation user effects by type of group.

7. Special Mobility Studies -- to assess needs and develop recommendations to meet previously unmet or latent transport needs, with particular reference to especially disadvantaged groups, e.g., autoless households, the unemployed, the disabled, the elderly, and those too young to drive.

8. Technological Planning -- to identify those near-term innovations of high potential benefit to the Boston area for incorporation in the transportation system alternatives, and to provide information on longer term innovations which should be planned for, so that current system designs can accommodate them readily when they become available.

Implementation Element

9. Administrative and Legislative Studies -- to address the problems of implementation of program packages and the framework for continuing transportation planning, under the following functional headings:

    (a) Administrative cooperation and delivery systems.

    (b) Feasibility of implementation of alternative program packages.

    (c) The participatory process and the restudy.

    (d) An analysis of existing and proposed State & Federal regulations and legislation.

Transportation Impact Elements -- Study Elements dealing primarily with transportation impacts and the design and evaluation of aspects and components of alternative program packages which are complementary to transportation components.

10. Environmental and Conservation Studies -- to assess the impact of alternative program packages on ambient noise levels, air pollution, visual intrusions, and the positive and negative effects on natural features, eco-systems, open space, park plans, and symbolic and historical assets; and to integrate this impact information into the process of evaluating alternatives and in the process of locating and designing transportation facilities.

11. Effects of Alternatives on Regional Economy -- to assess the absolute and relative impacts that the alternatives can be expected to have on:

    (a) The costs, growth and effectiveness of operation of long-haul goods movement, including containerization.

    (b) The gross regional economy and its sectors.

    (c) The costs of doing business, producing goods and providing services.

(d) The ability of the region to compete with other regions in retaining and attracting firms or encouraging expansion within the region.

(e) Attracting tourists to the region.

(f) Affecting the size of Boston's economic hinterland and therefore the size of distributive industries and the volume of interregional trade.

12. Replacement Housing and Family Relocation -- to provide specific data on the number, type and special characteristics of families who would be relocated under each of the alternative program packages to be evaluated; to use this impact information in the evaluation of alternatives and in the design and redesign of alternatives; and to develop a replacement housing and relocation program as part of the recommended program packages.

13. Business Relocation and Employment -- to develop specific data on the number, type and special characteristics of business which might require relocation under each of the alternative program packages to be evaluated; to examine current procedures, agency responsibilities and legal requirements; to develop a replacement and relocation program for displaced businesses; to evaluate the comparative effects of alternative transportation systems in attracting needed job opportunities; and to use this information to aid in the transportation system design process.

14. Neighborhood Cohesion and Transportation Needs -- to identify and measure the degree of social interaction and neighborhood cohesion and the importance of neighborhood identity; to assess special local transportation problems, opportunities and needs; to assess the importance of existing and potential internal and external linkages; to analyze disruption problems which have occurred in the past during right-of-way acquisition, demolition and construction; to use this information to aid in the transportation system design process and in developing improved means for alleviating recognized problems; and to analyze, measure and evaluate the extent to which alternative program packages disrupt neighborhoods by severing or hindering linkages, inducing through traffic, etc. or the extent to which they improve cohesion and alleviate existing problems.

VII. Budget Summary by Study Element and Phase

A budget summary for all Study Elements follows.

Budget Summary by Study Element and by Phase

Showing Ranges of Cost Desired for Flexibility in Later Phases

Study Elements	COSTS BY PHASE (000's) I	II	III	Totals	Estimated Ranges II & III	Total
General Study Elements	$154	$387	$169	$710		
1. Study Management	60	170	100	330	$240-300	$300-360
2. Community Liaison & Technical Assistance	80	205	65	350	245-295	325-375
3. Use of Design & Evaluation Criteria	14	12	4	30	10-25	25-40
Transportation Elements	$495	$1170	$410	$2075		
4. Transportation System Design	170	505	85	760	430-790	600-960
5. Joint Development & the Development of Alternative Program Packages	70	280	150	500	380-630	450-700
6. Land Use & Travel Forecasting	215	325	160	700	485-700	700-915
7. Special Mobility Studies	28	43	4	75	30-90	60-120
8. Technological Planning	12	17	11	40	20-45	30-55
Implementation Element	$20	$35	$25	$80		
9. Administrative & Legislative Studies	20	35	25	80	45-85	65-105
Transportation Impact Elements	$170	$310	$155	$635		
10. Environmental & Conservation Studies	35	75	40	150	95-135	130-170
11. Effects of Alternatives on Regional Economy	20	40	20	80	50-70	70-90
12. Replacement Housing & Family Relocation	65	115	55	235	130-230	195-295
13. Business Relocation & Employment	40	60	30	130	70-150	110-190
14. Neighborhood Cohesion & Transportation Needs	10	20	10	40	20-40	30-50
TOTALS	$839	$1902	$759	$3500		
Range		$1700-2100	$550-950	$3100-3900		

[1]The reader is referred to three references which provide a broad perspective of the Boston context and BTPR experience (one written just prior to, and the others immediately after the BTPR):

Lupo, Alan, et al., (1971), Rites of Way, Boston: Little Brown and Co.

Gakenheimer, Ralph A., (1976), Transportation Planning as Response to Controversy: The Boston Case, Cambridge, Mass.: MIT Press.

Sloan, Alan, (1974), Citizen Participation in Transportation Planning: The Boston Experience, Cambridge, Mass.: Ballinger.

[2]Newell and Simon, (1972), p. 10.

[3]Weiss (1966), p. 198.

[4]Eberhard, (1970), pp. 364-365.

[5]One theme represents what I "know," the other what I "believe." The difference between what I know and what I believe is best described operationally: What I believe I will defend; what I know requires no defense. I know the sun will come up tomorrow; I know my mind uses divergent and convergent processes during problem solving. Similarly, I believe our constitutional democracy is the best form of government (yet devised); and I believe an orientation toward participatory processes is the best orientation for architects involved in planning processes with social consequences. (The Concluding Observations explore these notions in more detail.)

[6]Different authors use different terms in adapting the general model to a special class of design problems but they all have equivalent stages. A good summary of the many ways these models may be extended and diagrammed may be found in Koberg and Bagnall's The Universal Traveler. Perhaps the model closest to reality is the continuous spiral proposed by L. Bruce Archer in "An Overview of the Design Process" in Moore (1970).

[7]While it may seem a bit unfair to include feasibility of implementation as a model requirement, it points out the limitations of technocratic models. Urban planning has been a long time coming to the realization that problems with social consequences are rarely amenable to purely technical solutions. The Harbor Crossing episode, Chapter 3, illustrates this point rather well.

[8]"Convergent" and "divergent" are the terms used by Klausmeier and Goodwin (1975). Other authors have divided thinking along similar lines. Thus we have analytic vs. intuitive, classical vs. romantic, objective vs. subjective, etc. Perhaps the clearest description of the relationship between the two is provided by de Bono (1970) who uses the terms "vertical" and "lateral."

[9]Newell and Simon, (1972), pp. 808-809.

[10]*Ibid*., p. 11.

[11]Newell and Simon propose the notion of "compound" problem spaces to explain "the possibility of working abstractly," *ibid*., p. 827.

[12]Lockard, (1974), p. 72.

[13]DeBono, (1970), pp. 39-47, p. 58.

[14]Newell and Simon, (1972), p. 799.

[15]Arnheim, (1969), p. 14.

[16]*Ibid*., p. 115.

[17]Lockard, (1947), p. 106.

[18]Newell and Simon, (1972), p. 802.

[19]*Ibid*., p. 797.

[20]This is analogous to the difference between the beginner and expert typist. Unlike typing, however, sketching as employed in designing may be highly individualized, almost a personal shorthand, representing internal symbols which may be unique to the designer. This fact is evidenced in the apparent "crudeness" of the sketches of Corbusier and Saarinen among others.

[21]Lockard (1974) notes this problem. Unfortunately (for my purposes) he uses "concept formation" to mean "design conception" whereas I use it in Bruner's (1956) narrower sense of "category formation--the inventive act by which classes are constructed."

[22]Bruner, (1957), p. 127.

[23]Lynch-Rodwin, (1959), in Proshansky, (1970), p. 89.

[24]Lynch, (1960), pp. 47-48.

[25]The initial list is included in the Study Design Summary appended to the thesis, pp. S-15.

[26]"View from the road" is adapted from the book of the same title by Appleyard, Lynch and Myer, (1964).

[27]Lynch, (1960), p. 85.

[28]Newell and Simon, (1972), p. 8.

[29]*Ibid*., pp. 865-867.

[30]BTPR Study Design, p. S-8 (see thesis appendix).

[31]BTPR, Study Design, p. II-4.

[32]Alan M. Voorhees and Associates were the prime contractors in association with: Jason M. Cortell and Associates (ecology), David A. Crane and Partners (design), Frederic R. Harris, Inc. (engineering), Real Estate Research Corp. (economics), Skidmore, Owings and Merrill (design), Wallace, Floyd, Ellenzweig, Inc. (environmental design) and special consulting firms: Economics Research Associates (land economics), Environmental Research Technology (air pollution) and Environmental Systems Laboratories (noise).

[33]BTPR "Study Design" p. III-11; see pages III-10 to 11 and 4-5 to 4-9, for a detailed description of the sketch planning approach.

[34]Part two of the BTPR "Study Design" describes in considerable detail the specific tasks and products required for each of 14 Study Elements in each phase of the BTPR.

[35]The differentiation between "experienced" and "inexperienced" as used in this thesis refers to previous professional experience in transportation planning. The author, in the sense used here, was an inexperienced architect.

[36]"Partnership," one of eight steps defined by Arnstein in "A Ladder of Citizen Participation" (AIPJ July 1969), involves a sharing of planning and decision making responsibilities between citizens and power holders. Power is redistributed through negotiation between both groups. In the BTPR, the locus of decision making power remained with the Governor. Technical decisions with respect to the development of alternatives, however, could be shared by the community with the architect and technical staff.

[37]The author was fresh from five years in the U.S. Navy and two years of graduate school at M.I.T.

[38]Gibson, (1968), p. 676.

[39]The physiological mechanics of this process are described in some detail by R. L. Gregory in Eye and Brain: The Psychology of Seeing.

[40]Gibson, (1968), p. 677.

[41]An excellent example of this is Lynch's (1971) short chapter "The Design of Streets and Ways" which in 15 pages of concise text and terse diagrams provides design rules of thumb, essential calculations and sufficient technical understanding to make good use of information from the BTPR highway engineers and traffic analysts.

[42]Miller, (1960), pp. 81-97.

[43]Newell and Simon, (1972), pp. 780-781.

[44]Arnheim, (1971), pp. 81-83.

[45]"Flow systems" and "adapted space" are the major organizing elements of Lynch and Rodwin's (1959) schema for a theory of urban form. This conceptual framework, used by the architect to organize form patterns, is described in the next section.

[46]Kalusmeier and Goodwin, (1966), p. 286.

[47]Yet, as Lynch (1971) points out, even these rules and standards are based on the characteristics of today's automobile and will change with it.

[48]It is hard to think of highway examples which combine all of these attributes -- e.g., I-280 south of San Francisco -- as anything less than modern technology elevated to a high art.

[49]Arnheim, (1971), p. 284.

[50]Hebb, (1949), Chapter 2.

[51]The careful juxtaposition of conceptual frameworks allowing the designer to maintain subtle but critical pattern differentiation until the "right" moment for synthesis may provide a rational explanation for the "suspension of judgement" characteristic of the insight or "inspirational" model of design problem solving.

[52]Beck, (1970), p. 135.

[53]Foz, (1972), M.I.T. Master's Thesis, pp. 75, 81.

[54]Beck, p. 137.

[55]Kilpatrick in Proshansky, (1970), p. 105.

[56]The BTPR had a special set of aerial photographs at 1:400 made on mylar reproducibles. These proved to be easily the single most effective graphic base for the architect, both for sketch planning and for communicating alternatives to others, especially community groups.

[57]Lynch, (1972), p. 155.

[58]Weinzapfel, (1971), M.I.T. Master's Thesis, pp. 35-36.

[59]Arnheim, (1971), p. 304.

[60]BTPR Study Design, see Summary in Appendix, pp. S-16 - S-22.

[61]Cartwright, (1973), pp. 179-187.

[62]Governor's press release #1/DC/72 of December 29, 1971.

[63]Newell and Simon, (1972), p. 94.

[64]Alexander, (1964), p. 69.

[65]Boulding, (1956), p. 27.

[66]Friere, (1970), p. 23.

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