PRIORITIZATION: A CRITICAL STUDY OF THE
"TIP PROGRAM" OF THE METROPOLITAN PLANNING ORGANIZATION
(MPO), OF THE BOSTON REGION

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PRIORITIZATION : A CRITICAL STUDY OF THE TRANSPORTATION IMPROVEMENT PROJECTS (TIP'S) PROGRAM OF THE METROPOLITAN PLANNING ORGANIZATION (MPO) OF THE BOSTON REGION

b y
OBUKOHWO A. URHIAFE

ABSTRACT

The Metropolitan Planning Organization (MPO) in Boston is investigated by examining legislatively derived Policy, rules, institutional and organizational arrangements and the Transportation Improvement Projects (TIP) document. Recent efforts to prioritize Transportation Improvement Projects (TIP) in the Boston Region is emphasized. Two difficulties which arise in this study are (a) problem definition and, (b) measurement. Furthermore, these are often indicated in the failure of most environmental programs at both formulation and implementation stages.

The unique multi-agency and multi-disciplinary character of the Boston MPO, both emphasizes the need to isolate the individual from the process while eliminating inter-agency conflict of roles. The large number of candidate projects competing for limited resources, the diversity of individual, institutional, and professional positions and the expense of procuring up-to-date data require an explicit and formalized procedure for decision-making to be put in place. Thereby assuring opportunity for public input, and resolution of conflicting viewpoints through problem redefinition. Efficiency and a high degree of consistency in decision making over time will be guarranteed. Decision-makers will more easily and clearly redefine, review and improve the explicit basis for their decisions in the best interest of society. Communities will only expend resources on projects whose priority status is known.

The study frame is the Metropolitan Area Planning Council (MAPC) region of metropolitan Boston comprising 101 communities. Selected cases of prioritization are evaluated based on their theoretical soundness, flexibility, results compared to other methods and ease of use. Criteria with comprehensive and measurable attributes defining the transportation planning policy goals for the Boston Region are selected. From an MAPC 'needs list' a small 'plate' of eleven (11) randomly selected candidate projects is discussed.

TO MY WIFE OLUSOLA, AND CHILDREN, OVIGWE AND EJIROGHENE

FOR

THEIR LOVE

Preface

I first discussed the prioritization of Transportation Improvement Projects (TIPs) with Ed Bates, Carol Blair and Daniel Fortier of the Metropolitan Area Planning Council (MAPC). As vital aspects of environmental decision-making, TIPs deserve priority attention for three reasons. They are capital investment items. They affect land, air, water, sonic, aesthetic and other qualities of the environment; and hence people. They provide opportunity for multidisciplinary cooperation in environmental planning, design and management- practice and research. My thanks go to them for their encouragement and support !

To Dr. John Ehrenfeld of the Center for Technology and Policy, MIT, and Julian Beinart, Professor of Architecture, whose pedagogical concerns helped to redefine the problem, I am much obliged. To Professor Joseph Ferreira Jr, Director of the Computer Resource Laboratory of the School of Architecture and Planning and Mr Thomas Humphrey of the Center for Transportation Studies of the MIT who directed the research involved in this study, in addition to their advice for which I am thankful. To Dr Ray Rabindran and his wife Joan who made an extremely arduous task manageable through the use of their Mac^{se}; and to my wife Olusola and my son Ejiroghene Tolu Urhiafe who pitched in, in many more ways than one. To my colleague and friend Dilip Da Cunha for his very refreshing spirit of cooperation and willingness to help - an attitude that is in such short supply yet so badly needed by so many. To all of you I say Thank You Very Much !

This thesis was prepared under the supervision of Professor Ralph Gakenheimer who holds joint appointments in both Departments of Urban Studies and Planning and Civil Engineering. As chairman of the thesis committee he ensured its overall success . Nonetheless, I take full responsibility for all omissions and undetected errors in this work.

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PART ONE :

A FRAME OF REFERENCE

CHAPTER ONE

1. INTRODUCTION : A FRAME OF REFERENCE

Closing the Smuggler's Notch Conference of the American Association of State Highway and Transportation Officials (AASHTO) Tom Larson [1] remarked:

> " One of our underlying problems is that we don't have a complete understanding of what our product is. Our most visible product is the Interstate System, and we are in the midst of dealing with that now. But another issue is the process: how we talk about things is how we see them and how the public sees them. We used to sell the Interstate System on the fact that it is vital to national defence, and that worked. Now there seems to be a growing mismatch between expectations and delivery and people who have problems with what is delivered are more likely to litigate those problems. We have to articulate our product in new ways using new metaphors; then we will have a better chance of gaining support."

> " Any leader has to have a vision. Unfortunately, our vision normally is that we know we have to meet citizens' expectations, whatever they are. Then we spend time strategizing how to extract more money from the population so we can satisfy our view of their needs. There are some real problems with this vision. We need to sharpen it, and we need to have a lot of dialogue about it."

These remarks identify three problem areas: the lack of a "..complete understanding of PRODUCT", the PROCESS and the need to have a VISION". They emphasize the need for better problem definition which together with the need for a defined strategy for decision-making constitute the single most important task confronting both professionals and policy-makers in the public domain. The absence of formal techniques for the formulation of policy together with informed-and-explicit strategy for the choice of well articulated objectives have often prevented the effective implementation and comprehensive evaluation of environmental projects.

Formal strategies have proved useful in various sectors of decision-making ranging from transportation planning, land reclamation, facility siting, land use planning through water resources planning and development, wild life and natural resource management, to academic and manpower planning, R and D project design, evaluation and selection, and industrial production.

Although it is generally considered difficult to recommend a specific procedure to a precise plan evaluation problem, Voogd[2] suggests that it is nonetheless appropriate for planners to take an interest in and compare the merits of different formal procedures. This is because, studies[3] show that while as planning techniques they enhance objectivity and efficiency, there is a minimum of a 40 per cent chance that different techniques provide different results.

This study is structured into four parts. Part One provides a defined philosophical framework and planning context. It does not argue how a critical theory of planning may be not only empirical, interpretive, and normative in its content but practical as well. Part Two reviews the historical development and growth of the American Interstate Highway System including the policy instruments that have been employed to define the vision behind the system and the institutional arrangements that have translated that vision into reality. Part Three discusses the difficulties of resource allocation for transportation improvements from the perspective of criteria for choice of projects and the methods for applying these criteria. It also examines the error of cardinal use of ordinal data. Part four looks at the implications of technology transfer from the developed world to the developing.

Transportation decisions in the metropolitan Boston area are the responsibility of the Metropolitan Planning Organization [4](MPO). This is a group of six agencies charged with complementary responsibilities for plan/policy formulation as well as plan/project implementation. These agencies are the Executive Office of Transportation and Construction [5](EOTC), the Massachusetts Department of Public Works[6] (MDPW), the Massachusetts Bay Transport Authority [7](MBTA), the Massachusetts Bay Transport Authority Advisory Board [8](MBTAAB), the Metropolitan Area Planning Council [9](MAPC), and the Massachusetts Ports Authority [10](MPA).

As the regional planning agency (RPA), the MAPC also has responsibility for ensuring the effective participation in the planning process of the 101 communities that make up the region through the federally mandated comprehensive, continuing, and cooperative (3C) planning-process.[11] It is charged with developing a non-binding procedure for setting priorities for Transportation Improvement Projects (TIP's) [12] under the auspices of the MPO.

The TIP is both a process and a product! As a process, it is a program of phased improvement projects with annual, 2-5 year, and future "Elements". It has two sections categorized as Transit or Highway consistent with the transportation plan developed for the Boston region's highway and public transportation systems. This examination will focus on the Highway section of the TIP since the Transit section already has a well defined procedure for setting priorities for Transit improvements based on 14 policy guidelines.

As a product the TIP is a document developed and up-dated annually under the direction of the Metropolitan Planning Organization in compliance with the requirement of Title 23 of the Code of Federal Regulations, Chapter I, Part 450, Subpart B, effective August 1, 1983 and jointly established by the Federal Highway Administration[13] (FHA) and the Urban Mass Transportation Administration (UMTA).[14]

This study suggests alternative ways of organizing social data for the purpose of viewing social reality. The spectrum of attention thus includes both its typicalness as well as its uniqueness. It views the specific without precluding generalizations especially as they apply to the needs of a developing country such as Nigeria. However, one specific result of this study will be the enhancement of the TIP priority-setting process in the Boston MPO by making the status of listed projects remarkably explicit and predictable.

1.1.. towards policy goals, objectives, and action

Although professional planners, designers and managers daily discuss notions of policy goals and objectives only few attempt to define the ramifications of policy. However, a problem is tackled according to our perception of it. The way we perceive a problem determines the way we respond to it. Since this way is bounded by our world-view, the need for a holistic and well focused world-view is immensely important. A world-view is a system of beliefs and values.

One of the difficulties of defining policy is the multiplicity of schools of thought as to what public policy is. There are those who implicitly acknowledge the need to express public policy in more specific terms as goals and objectives in other to facilitate action for implementation through programs and projects.

Thus specific goals and objectives should be provided as bench-mark or reference points for evaluating the resulting programs and projects and for assessing the effectiveness of public policy.

O'Riordan[15] (1976,p.55) defines public policy as " the mechanism through which society's collective demands are monitored by the political system for conversion into action". Simon[16] (1957,p.12) goes further to define public policy to " include the creations of legislative bodies to deal with value-oriented ethical questions and those promulgated by management to deal with the rules, regulations and procedures by which formal organizations operate (Simon,1957, p.12). He thereby introduces into O'Riordan's definition a refinement by arguing that "Democratic institutions find their principal justification as a procedure for the articulation of value-judgements, many of which do involve factual questions".[17]

Thomas Dye[18] (1975,p.4) defines public policy as "whatever governments choose to do or not to do" He sees a difference, between government actions vis-a-vis specific government actions and overall programs of action towards a given goal. All government action must have a defined goal in order to be labelled policy. "Since all we can readily observe is what governments choose to do or not to do", he argues, "a realistic notion of public policy must include all actions of government" not just the expressed intentions of government as contained in formal statements by public officials.

Zube[19] (1984,p.2) defines public policy as " statements of normative social value"; with the idea of goals refering to desired end-states or ideals expressed as much as possible in terms of values inherent in these statements. He defines objectives as "specific actions or attainable conditions intended to further define the desired goals" . According to Zube, goals and objectives delineate policy settings or domain while standards and criteria identify the units of comparism or measurement used to substantiate the congruence of accomplishments with stated objectives. Furthermore, standards and criteria for some goals and objectives are defined in physical terms and derived by professionals or expert judgement from empirical evidence relating to cause-and-effect relationships.

For other goals and objectives, where such physical terms have not been developed and where cause-and-effect relationships are difficult if not impossible to identify in terms of measureable physical attributes, standards and criteria are expressed in more subjective terms relating to the perceptions, experiences, and expectations of users or participants. In this category, standards and criteria, or quality level thresholds change over time as new information becomes available to influence professional judgements and user-perceptions.

This study confronts a situation in which we must define our vision for society using both easily quantifiable and not-so-easily-quantifiable criteria. Herein lie the twin difficulties of criteria selection and measurement.

According to Simon, in a democratic society, the legislative arm of government (local, state, regional or national) is charged with responsibility for making the value judgements related to ethical questions. The task of policy implementation devolves on the executive branch of government which is free to take action and relate the decisions of congress to factual elements thereby realising the "vision" of society. This is the ultimate goal of governance. The inter-play of the factual and ethical issues have often led to inherent value judgements in the decisions of agency administrators as they define and select operational objectives to implement public policy.

Public Policy is formulated under varying conditions. Some policies are formulated in response to a situation of crisis. Others through consensus after negotiations between interest groups. Yet others in situations of indifference. The significance of the policy context is most evident in the allocation of resources required for giving substance to the action that necessarily follows decision-making in the public domain. The apparent ineffectiveness of public policy is the shifting emphasis of political theory. Hitherto, political economy had focussed on institutions and structures of government and with political behavior and processes.

Modern 'behavioral' school of political theory focuses its attention primarily on the processes and behaviors associated with government. It studys the sociological and psychological basis of individual and group behavior and the functioning of interest groups and political parties. It describes and explains various processes and behavior in the legislative, executive, and judicial arenas of government. Political theory describes and explains public policy as the causes and consequences of government activity; and policy analysis as the systematic identification of the causes and consequences of public policy including the systematic application of its findings to contemporary societal problems.

1.2 summary of issues and concerns in multicriteria evaluation for TIP's

The evaluation or rank ordering of alternative plans including transportation improvements involves much more than just technical issues. Environmental, political, as well as technical and economic factors must also be considered. Evaluation[20] is defined as "the process of analysing a number of plans or projects with a view to searching out their comparative advantages and disadvantages and the act of setting down the findings of such analysis in a logical framework".

Evaluation is not decision-making. It is highlighting the differences between alternatives and thus providing information for subsequent deliberation and action. This study does accept this point of view. Value judgements are made so frequently that it is sometimes difficult to identify evaluations as a distinct planning activity.

If we consider four common planning tasks: (1) identifying problems and goals ,(2) formulating alternative proposals, (3) forcasting impacts, and (4) evaluating alternatives, the delineation of problems and goals is no less a value judgement than the choice to analyse some proposals in details and not others. Even though value judgements are made implicitly throughout planning it is useful to distinguish the systematic consideration of impacts in ranking alternatives with the term evaluation. The techniques for ranking are commonly referred to as evaluation methods.

As planning proceeds, one of the four planning tasks listed above may be emphasized at some time. However, the four tasks are not carried out in a lock-step, sequential order. Determinations are continually made and revised regarding the nature of the planning problem, the alternatives to be considered and so on. We also observe that more than one set of values is relevant in choosing among alternative public sector proposals. Within democratic nations, it is commonly accepted that the values of all the individuals who may be affected by public decisions should be considered.

Adopting this perspective, evaluation thus includes the process of identifying different segments of the public and ascertaining their feeelings and opininons about alternative plans. Thus, in addition to techniques for organizing information to assist in ranking alternatives, evaluation methods include procedures for determining how individuals and groups value alternative public actions. Although there are literally hundreds of evaluation methods, there is little agreement among experts about which are the best. This study investigates some of the procedures most widely discussed in the public sector evaluation literature or commonly used in practice, or both.

It however does not present techniques for involving citizens in the planning process although it recognizes the important role that the public can play in evaluating alternatives. The simplest circumstance for ranking alternatives occurs when there is only one decision criterion and all impacts are measured in the same units. Suppose for example that the rule for choosing among alternative projects is the maximization of net economic benefits. In this case, the difference between total benefits and costs (in monetary terms as dollars) provides an index of a project's merit and a basis for project selection. Criteria may be measured in units as different as dollars and number of residences relocated. Such measures are "incommensurable". They are not readily compared or easily combined into a single index of a proposal's overall worth.

It is however convenient to view the ranking of alternative public actions in terms of the evaluative factors. These are the goals, objectives, concerns, and constraints that various decision makers and segments of the society consider important in ranking alternatives. Most significantly however, since plan ranking is strongly influenced by the choice of evaluative factors there is always controversy over who should define them. In public sector planning, there are three principal sources of evaluative factors: institutions, community interactions, and technical and scientific judgements.

Often, decisions on transportation facilities and services are made alone by the agencies directly responsible for their provision and these have become increasingly complex formal procedures for the participation in and review by non-experts. Impacts other than on transportation service may be at least as important as the direct effects of the transportation decision. Procedures and requirements for decision-making must be changed when dissatisfaction with the transportation system can be attributed to inadequate consideration of the views of affected parties who are outside the existing process. State policies are crucial in this respect to decision-making because of the importance of state government in creating the powers and constraints within which agencies act.

Also many transportation decisions appear to involve technical factors only, and transportation agencies make most of their decisions on the basis of only internal criteria that reflect the generally accepted technical standards and rules. This may be appropriate when the transportation need is clear-cut and there is a consensus in support of the agency's activities. However when they are not clear-cut as most of them often are, the critical policy question must be how to make such agencies responsive to the public and to the political process. In examining the programming and budget process we find that for some programs and agencies, the legislature decides the agency's actions by budgeting on a project-by-project basis, selecting from among those recommended by the agency.

In other cases, the legislature votes on a program of projects the agency intends or is committed to implementing. In still other cases, the legislature votes on a program budget with varying details about subprograms and area allocations, but not on projects. Although a project-by-project or list-of-projects action by the legislature might appear to be more subject to political considerations, as opposed to objective and rational factors, it may in fact not be so. Proposing a list of projects requires some accountability to the public. A governor or chief executive may wish to have the flexibility to trade projects for votes needed for some other issue and granting this may be inevitable because ultimately the elected officials are the true representatives of the people.

The Federal-Aid Highway Act of 1973 gives new powers to local governments over the programming of the Federal-Aid Urban System. But this is subject to state concurrence!

Parallel to the foregoing issues are other issues of scope and intensity of programming. Techniques for statewide programming and determination of priorities employed by various states do not really vary in terms of the models used, although the overall programming do have some differences. Progamming[21] is considered to be a very complex process which involves more than just assigning priorities to improvement projects. It is defined as "the process of integrating project priorities with fiscal plans to develop a strategy of project development sequences to be tentatively performed with a certain future time period". (Krecji cited by Humphrey,[22] 1974,p.91). Programming therefore, is the conversion of long-term general transportation system improvement plans into realistic short-term work programs. The focus of this study however is prioritization.

Programming must have the capacity to effectively address the following issues:
- multiple and conflicting policy objectives:- there are differences in objective at different levels, state, regional, local; and within a level there are differences through diversity of interest groups with varying objectives.

The role of planning and programming is to articulate the trade-offs among conflicting objectives as well as address distributional elements of a program in terms of equity among regions and socioeconomic groups;

- multiple impacts:- programs and individual projects have multiple attributes or impacts involving economic, environmental, and social concerns and the programming process must be able to cope with such multitude of impacts some of which are quantifiable, and some qualitative;

- interdependencies among projects:- the programming process must also be able to account for interdependencies. Project interdependency implies that building one project requires or eliminates the need for another while network dependencies arise from the interconnectedness of links in a network. Both lead to budget interdependencies simply because a dollar spent on one project means less resources available for other projects;

- organizational structure:- the fourth factor influencing the programming process is the complexity of organizational structure and a broader more participatory decision process. The fact is that many people are involved in helping to determine priorities through a participatory process. In addition, the planning and implementation (programming) functions are often the responsibility of different agencies.

Programming therefore must be structured and yet be flexible enough to allow many iterations and to integrate comments from people both within and outside the agency. It must be designed to be a cyclical, iterative and participatory process.

- contingencies:- in a dynamic and uncertain environment, programming decisions must recognize the inherent uncertainties associated with impact assessments; changes which occur in technology, in community values and social concerns, and in funding. In light of these uncertainties, programs must be flexible enough to respond to changing conditions without massive recycling of all projects and planning efforts.

A fundamental concern that must be confronted in this study is : why in the face of such much contribution and input as in the area of transportation planning is there still a need for a closer scrutiny of programming methods and procedures in the area of improvement projects? The reason is self-evident. There is the need for a more integrated approach. The backlog of improvements in each of several highway systems in the commonwealth and endless delays in scheduled dates for key documents to be ready and distributed are indicative of problems. The 1988 Fiscal Year TIP document is yet to be ready for review and final approval as an initial step before transmittal to the Federal Highway Administration. This is more than six months late!

Even more significantly, earlier documents have not satisfactorily addressed the five factors mentioned above. Environmental Impact statements are taking excessively long periods of time and costing enormous amounts of money to develop; but more importantly, they are probably occurring too late in the process. The overall result is that programming does not have much relevance to what is getting built.

1.3..programming methods

The programming methodology currently available to handle these factors are only being developed. Most procedures are either very subjective or nonexistent. Most states presently base their highway improvement priorities on sufficiency rating methods which usually ignore key factors until the end of the procedure when they are "stuck on'" ad hoc. According to studies by Humphrey[23] and Krecji, General Analytics and Comsis Corporation classify the priority setting procedures into 4 major categories: sufficiency ratings, quasi-economic analysis, benefit-cost, and macro or micro-economic theories. According to these researchers, there is a fifth category or "expert panel evaluation" called the pure judgement approach in which decisions have to be made on a periodic basis by a group of highly knowledgeable staff who have little quantitative input except funding constraints, what is in the pipeline and what can be built.

Sufficiency rating schemes evolved from procedures first proposed in 1939. They assign points to various road attributes (such as road condition, safety, and service) according to their comparism with a standard. Although the variables and point-weighting scheme vary from state to state the procedure is essentially the same. However, a few states are beginning to look beyond this procedure to include environmental and social factors.

California[24] has incorporated an approach which uses a sufficiency rating scheme in addition to a weighted sum of three direct measures of safety benefits, capacity adequacy, and time-delay savings index. Pennsylvania [25] apparently is the only state using a strict benefit-cost analysis. Massachusetts [26] is only in the process of implementing a similar benefit-cost procedure using the Highway User Investment Study - a computer package developed at the federal level for estimating benefit measures.

It is also a simplified programming procedure that accounts for different roadways according to their functional classification, budget limits, geographical area minimums, and overall total budget minimums. This procedure is being tested in a selected regional planning agency for its usefulness in a participatory framework.

California has also begun to incorporate budget constraints and multiple alternatives as well as contingency programs for any district as a hedge against the possibility that a key project in one program is not approved. The typical programming process of most highway or state transportation agencies during the past years may be characterized by 3 factors : (a) leaning towards fairly precise, definable indicies or priority measures of improvement and excluding the "non-quantifiable" socio-political criteria, (b) priority measures oriented towards the user without much consideration of indirect impacts, and (c) extremely low participation and understanding by the public and elected city and town officials as to the priority setting process.

In reviewing the priority-setting environment of the Metropolitan Planning Organization (MPO), this study proposes improvements in areas which correspond to the problem areas identified earlier:

(a)   incorporation of multiple mutually exclusive alternatives with a wide range of impacts;

(b)   expansion of the criteria for determining priorities to include social and environmental concerns;

(c)   incorporation of factors of uncertainty; and

(d)   development of a flexible, interactive, and participatory process.

PART TWO

INSTITUTIONAL ARRANGEMENTS

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2 : INTRODUCTION : INSTITUTIONAL ARRANGEMENTS

Political Economy defines an Institution[1] as a social process whereby people individually or groups of people interact with one another in a commonly understood typical and patterned way. More importantly, institutions occur in the context of organizations[2] which are either "formal" or "social". Formal organizations are "associations of persons grouped together around the pursuit of specific goals."[3] They enable their members to achieve more, collectively, than it would be possible for them to accomplish individually. Organizations strive to attain their objectives through the use of rules (designed to anticipate behavior, and to steer it in the desired direction), and a formal authority structure with clearly drawn lines of communication and responsibility.

Most organizations not only have boundaries which distinguish them from others and from their environments but which also help to identify who belongs and who does not. They have varying life spans with periodic replacement of personnel. The Boston Region Metropolitan Planning Organization (MPO)[4] is a formal organization in this respect. There are formal relationships among the various agencies that make up the MPO according to the formal agreements entered into by them.

The PROSPECTUS[5] clearly specifies what their different roles and responsibilities are in the context of formulating and implementing policies for transportation in the Metropolitan Boston Area. Where these formal channels of communication or hierarchy of relationships are not followed either on an interpersonal level or on an official level there are remedies which provide opportunity for redress without prejudice.

Thus is power relation among these agencies assured. There is also a definition of the limits of authority which may be exercised by these planning agencies in their relations with members of the public. These are defined by the state in the form of enabling statutes. It is from these enabling instruments that the agency derives its existence.

There are a third category of instruments by which the agencies construct and determine its strategy for intervention. All of these creations and constraints constitute a mode of intervention. This chapter reviews the formal statutory responsibilities of the various agencies that make up the Metropolitan Planning Organization (MPO).

2.1.1.an overview

Transportation planning in the Boston area is complex and unique both in its organizational structure and in its products. The structure involves a variety of public agencies and organizations as well as numerous private groups and interested citizens. The products include several state and federally required planning and programming documents as well as many more specific studies and reports.

The planning process reflects changing values and newly emerging fiscal opportunities. It represents the extraordinary diversity of this dense urban area, one of the oldest in the entire country.

.2.1.2..the Prospectus

The Prospectus is a document intended to serve as an introduction to the process. It explains the functions and roles of the actors in the process and describes the content and purpose of the different documents produced. It also serves as an introduction to the Unified Planning Work Program[6] (UPWP) one of the three documents. Together, the Prospectus and the Work Program serve as management tools for the provide a current overview of transportation planning in the region.

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The objective of the Prospectus and the Work Program is to provide the basic purpose context and the relationship of the TIP to the other elements of the transportation planning process (including the TIP) respectively. They also provide for the implementation of those programs consistent with the region's policy guidelines. The Prospectus, as well as the entire planning process, has been designed to conform with existing joint FHWA/UMTA regulations governing urban transportation planning. (See 23 CFR Part 450, Sub-part A, in 40 Federal Register No. 181, September 17, 1975). This Prospectus is the most recent version for the Boston Region replacing the 1979 - 1980 Prospectus.

2.1.3...the actors

The transportation planning effort is broadly conceived to integrate three levels of planning activity - systems or regional planning, corridor or sub-regional planning and project planning- so that the three types of analysis serve as complimentary aspects, all essential to the implementation of the regional transportation plan. This inherently interlocking nature of planning analysis is reflected in the organization of the work program and the variety of its products, the organization of the Central Transportation Planning Staff (CTPS) by the agencies, the role of the Joint Regional Transportation Committee (JRTC), and the close cooperation among the various planning agencies.

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The Boston Region Metropolitan Planning Organization (MPO) is unique and different from the MPO in virtually all other metropolitan areas in its composition. This is because most of these MPOs are single agency planning organizations (made of just the COG, the counterpart to the MAPC). This puts the Boston TIP in very specific context as it is prepared by an MPO made of eight agencies.

There are eight entities which figure most prominently in the Boston region's transportation planning effort. The group includes the following six agencies :

-     the Executive Office of Transportation and Construction (EOTC)
-     Massachusetts Department of Public Works (MDPW)
-     Massachusetts Bay Transportation Authority (MBTA)
-     Metropolitan Area Planning Council (MAPC)
-     Advisory Board to the MBTA (Advisory Board)
-     Massachusetts Port Authority (Massport)

On March 4, 1975, the first five agencies were designated as the Metropolitan Planning Organization (MPO) of the Boston Region by the then Governor Micheal S. Dukakis, in response to federal transportation planning requirements. By his letter of June 15, 1976, the Governor added the Massachusetts Port Authority to the MPO. To assist these agencies is the inter- disciplinary Central Transportation Planning Staff (CTPS) which serves as staff to the MPO.

The eighth participant is the Joint Regional Transportation Committee (JRTC), the transportation policy advisory group for the Boston region. As the Policy Advisory Group for the Boston Region MPO, its composition is to ensure compliance with the '3C' process. The JRTC, is composed of up to 58 members so as to facilitate discussion and decision-making. Its membership has been selected in order to be representative of the localities within the region, of state agencies with transportation and related responsibilities, and a wide range of recognized private associations concerned with transportation policy. All members are appointed by the Signatories as follows:

- Public Agencies : There are up to eighteen (18) representatives of public agencies. In addition to the six Signatories, who sit as non-voting, ex-officio members there are twelve others whoare appointed upon the recommendation of the Secretary of Transportation and Construction.

- Cities and Towns : There are twenty (20) municipal representatives, chosen so as to provide broad geographic representation of the region. These representatives are appointed upon the recommendation of the MAPC and the Advisory Board.

- Citizen Designees : There are twenty (20) citizen designees primarily representing private non-governmental organizations concerned with the transportation planning process. These designees may include private transportation providers.

Annually, a vice-chairperson is elected by the JRTC from among its members. The vice-chairperson becomes the chairperson the following year. The group also adopts by-laws and other procedures as are necessary to govern its internal operations, and appoints subcommittees to carry on the work of the organization. The JRTC does have defined responsibilities in the broader context of transportation planning of which the TIP is a part. How much impact it has on the TIP specifically is more likely to be based on informal power relations among individuals than on statutory guidelines. On the contributions of the JRTC, its current chairperson Carole Sonduck[7] has this to say:[8]

> "Citizen participation is exciting because it is a tangible expression of democracy. Through the JRTC, people can have an impact on the planning of transportation which will ultimately play a big part in how well their communities work. The day-to-day reality of living in a democracy is participating in the decision-making process, and providing guidance about what you and others in your community would like to see, to people who can do something about it"
>
> (MPO Transreport, Spring 1988, vol.IV No3 p.4)

The Prospectus, Unified Planning Work Program and related documents are prepared under the direction of a sub-signatory Committee (SSC) composed of the senior transportation planning personnel of each of the MPO agencies, with staff support from the agencies and from the CTPS. The Work Program itself is developed in consultation with officials and citizen groups representing a variety of interests.

Meetings are conducted on the sub-regional or municipal level in which affected communities and interested groups are invited to participate. The work program is submitted to JRTC for review and recommendation.

2.1.4..the Background

The existing planning process grows out of the region's recent experiences. It is , therefore, worth noting the key events in its evolution before examining the current process in detail. In this context, the first significant effort was the one that produced the "Whitton Plan in 1929". This plan laid out many of the highways that became subsequently controversial. This was followed by the "1948 Master Highway Plan".[9] The report was prepared in response to the burgeoning demands for new motor-cars and new roads. Hence while giving passing mention to the need for improved public transportation, this Plan reflected the most exclusive availability of federal funds for highway construction.

In the early and mid- 1960's the Bureau of Transportation and Development within the Massachusetts Department of Public Works joined with the Massachusetts Department of Commerce and Development and the Metropolitan Area Planning Council to carry out the Eastern Massachusetts Regional Planning Project (EMRPP).

The EMRPP "Recommended Highway and Transit Plan", published in 1969, included an extensive expressway network and substantial additions to the region's transit system. It also led to an extensive debate over a number of controversial transportation issues regarding the construction of certain expressways within Route 128, particularly the proposed "inner Belt" through Boston, Somerville, Cambridge and Brookline.

Due to this controversy and the resultant federal government order that the Inner Beltway be re-evaluated, it was decided to undertake a re-study of the transportation needs of the region within the circumferential Route 128. The study, known as the Boston Transportation Planning Review (BTPR), consisted of a droad multi-faceted analysis of metropolitan transportation alternatives focused on the corridors for which major new highways were being proposed.

The basic question was not simply where and how the expressways should be built, but also whether they should be built at all, and what transit alternatives should be considered. The planning process developed by the EMRPP in 1968, by the BTPR in 1971 - 73, and by the agencies since 1973 has been certified by the federal government as meeting its requirements for the comprehensive, cooperative and continuiing (3C) transportation planning process for the Boston region. The structure of this process is described is section III.

In response to the state law, the MBTA in 1966 prepared and submitted its program for Mass Transportation to the Advisory Board to the MBTA. The program listed several high priority "Action Projects" for implementation. One of these projects has completed in its entirety (Orange Line North of Haymarket) and several others have seen substantial progress. The program remained in effect until a new PMT was approved by the Advisory Board in December 1978.

The new PMT summarized the status of the 1966 Action Projects and presented a new long-range plan for the consrtruction, reconstruction and alteration of mass transportation facilities within the MBTA. The 1978 PMT also included a schedule for implementation of the plan along with estimates of costs and revenues of the planned improvements.

2.1.5..conclusion

This planning history is necessary to draw attention to the fact that the problem of choosing transportation system element priorities has a background of thinking and controversy that make the process more complicated than one might think especially when the TIP planning process is seen as a simple rational exercise.

2.2.. GOALS AND OBJECTIVES - BOSTON TRANSPORTATION PROGRAM

In defining the vision as well as the process (i.e., the statement of normative social value to society and the approach-process or measurable condition by which such normative societal value will measured when attained), the MPO for the Boston region stated explicitly :

2.2.1..Goal of Boston Transportation Planning Program :-

The overall goal of the Transportation planning program for the Boston region is to improve the region's transportation facilities and services in a manner which enhances the quality of life for the people who live, work, and travel here, now and in the future.

In specifying the objectives by which the goal will be attained and measured the plan took in consideration, the need for such a plan to be directly supportive of decision-making and action- i.e., the implementation of both capital intensive or capital projects as well as low-capital or maintenance solutions to the region's transportation problem. For the planning process to achieve the above overall goal the MPO has identified five objectives.

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2.2.2..Five Objectives (processes) for achieving the above Goal:

-To identify transportation problems and analyse possible solutions to them;

-To strike an appropriate balance between short-range and long-range considerations, so that beneficial incremental actions can be taken now with an adequate understanding of probable future consequences and possible future options

-To set project issues and decisions in a context which strikes a balance between regional, sub-regional and local considerations, and between transportation and non-transportation objectives and impacts;

-To assist implementing agencies in reaching and implementing policy and project decisions in timely social, fiscal, and economic impacts, and with adequate opportunity for participation by other agencies, by local agencies, by local governments, and by private citizens;

-To implement the requirements of Section 134 of the Federal-Aid Highway Legislation and Sections 3 (a) (2) and 5 (g) (1) of the Urban Mass Transportation Act of 1964, as amended, that there be a continuous, comprehensive and cooperative transportation planning process in each metropolitan area as a prerequisite to the flow of Federal Capital funds.

The MPO also identifies "procedural objectives" to complement certain more "substantive objectives" which the planning program is designed to meet.

.2.2.3...Objectives towards the Objectives of the Transportation Plan:

-To preserve the vitality of the regional core as an already densely developed focus for employment, residence, services, culture, and other activities; and

-To use transportation to assist in achieving certain land use objectives, at local, sub-regional, and regional levels within a framework of an overall comprehensive plan for the region.

This study holds the position that the definition of goals as a vision for society and objectives as the process whereby such a vision is achieved and evaluated suggests a hierarchical structure very much in the pattern of a decision-tree that becomes increasingly definite and concrete as the branches grow.

It is thus very nebulous, impalpable and qualitative at the root but grows into definite tasks at the leaves; with each branch easily and clearly discernible. It also helps at the goal formulation stage to break up the totality of the goal into smaller goals from which the task of choosing and measuring processes with suitable and appropriate attributes begins. This decomposition of goals into objectives leads to the specification of objectives through hierarchies. Specification[10] means subdividing an objective into lower-level objectives of more detail, thus clarifying the intended meaning of the more general objective. These lower-level objectives can also be thought of as the means to an end, the end being the higher-level objective. Thus by identifying the ends to be very precise objectives(the means), we can build the hierarchy up to higher levels.

2.3 RESPONSIBILITIES OF THE PARTICIPATING AGENCIES

2.3.1 METROPOLITAN PLANNING ORGANIZATION (MPO)

The transportation planning process for the Boston region is the responsibility of six agencies : EOTC, MDPW, MBTA, MAPC, the Advisory Board of the MBTA, and the Massport. Together they make up the Metropolitan Planning Organization (MPO). They each have defined statutory responsibilities according to the legislative instruments creating them.

2.3.2. Executive Office of Transportation and Construction (EOTC)

This is also known as the EOTC. This agency under Chapter 6A of the Massachusetts Genral Laws, has the statutory responsibility to conduct comprehensive planning for and to coordinate the activities and programs of the state transportation agencies, and under Chapter 161A, to prepare the capital investment program and plans of the MBTA in conjunction with other transportation programs and plans.

2.3.3   Massachusetts Department of Public Works (MDPW)

This agency has statutory responsibility to plan, design, construct and maintain highways and related facilities. Within the MDPW, the Bureau of Transportation Planning and Development, under Chapter 563 of the Acts of 1964, has the statutory responsibility also to serve as the principal source of transportation planning in the Commonwealth. Also, the MDPW Bureau of Project Development has been established to serve as the principal unit sheparding specific highway projects toward imlementation. The MDPW policy board consists of a Commissioner and four Associate Commissioners who are appointed by the Governor.

2.3.4   Massachusetts Bay Transportation Authority (MBTA)

This agency has statutory responsibility, under the provisions of Chapter 161A of the General Laws, to prepare the engineering and architectural designs for and to construct and operate transit development projects within the area constituting the Authority as well as to operate the public transportation system. Although the MBTA district is smaller(79 cities and towns) than the MAPC district (101 cities and towns), all MBTA member communities are within the MAPC district. The MBTA policy board consists of a Chairman and four Directors who are appointed by the Governor.

2.3.5 Metropolitan Area Planning Council (MAPC)

This is the Boston Metropolitan Clearinghouse under Section 204 of the Demonstration Cities and Metropolitan Development Act of 1966 and Title VI of the Intergovernmental Cooperation Act of 1968. It also has been designated an economic development district under Title IV of the Public Works and Economic Development Act of 1965, as amended. MAPC is responsible for regional land-use planning, including land-use components of transportation planning, and for providing technical assistance to its member communities. The MAPC is composed of the Chief Executive or his designee of the 101 cities and towns in the MAPC district, 21 gubernatorial appointees, and 12 ex officio members. It has statutory responsibility for comprehensive regional planning in the district under Chapter 40B of the General Laws.

2.3.6 The Advisory Board to the MBTA (AD. Bd)

This Board was established under the provisions of Chapter 161A of the General Laws. It is a regional body created primarily to review and approve the MBTA annual budget and the state-required program for Mass transportation. The Advisory Board consists of the Chief Executive Officer or designee of each of the 79 member municipalities. Each municipality has a weighted vote on the Advisory Board.

2.3.7 Massachusetts Port Authority (Massport)

This agency has the statutory responsibility, under Chapter 465 of the Acts of 1956, as amended, to plan, construct, own, and operate transportation and related facilities as may be necessary for the development and improvement of commerce in Boston and the surrounding metropolitan area. Among other facilities, Massport owns and operates the seaport, Logan International and Hanscom airports, and the Tobin bridge.

While the various agencies constituting the MPO bring to the Organization legal responsibilities for transportation planning, and the provision of transportation services or comprehensive regional planning, they at the same time represent state or local interests. On issues primarily affecting municipalities, the MPO is guided by the MAPC and the Advisory Board in their capacities as representatives of local governments in the region. As the MPO, these agencies oversee and direct the urban transportation planning process. This process includes developing and endorsing the various plans and programs required by federal regulations. These same six agencies are, as may be necessary or required, also refered to as the "signatories".

This name derives from their having jointly signed a Memorandum of Understanding, which is more fully described later. (see Appendix 2.1) In this Memorandum, the functions of the Signatories/MPO are outlined further as below:

The Signatories, acting as the MPO, shall jointly adopt an annual unified transportation planning work program for the Region, as well as transportation plans and programs as may be from time to time required of the MPO by the federal and state laws and regulations.

The Signatories, acting as the MPO, shall be the forum for cooperative decision-making by principal elected officials of general purpose local government in the Boston Region, and shall register with the federal government the views of "reponsible local officials" of the region where called for under federal law with respect to the initiation of certain transportation programs and project

In the resolution of basic regional transportation policy, the Signatories shall seek and consider the advice of the JRTC. In so doing, the Signatories shall provide the JRTC with information and analysis in the form of reports, briefings, and discussions concerning their plans, programs, and priorities so that JRTC can carry out their functions in timely fashion.

The Signatories shall contribute resources in the form of funds, staff, and other contributions, to support a unified inter-agency transportation staff, known as the Central Transportation Planning Staff (CTPS), to assist in carrying out the region's 3C process under the policy control of the Signatories.

In setting policy and work priorities for said staff, the Signatories shall be advised by the JRTC and,subject to overall work priorities, shall provide information and analysis to JRTC to assist the JRTC in advising on issues arising out of the '3C' process.

The MPO meets as necessary under the chairmanship of the Secretary of EOTC, either to conduct business or at the request of a member. Most routine MPO matters are resolved by the SSC (as is more fully decsribed below), although formal actions are still carried out by the Signatories. The Committee of Signatories, acting as the MPO, has usually but not always taken particular actions with the unanimous agreement of all parties. Its mode of operation has been to seek to develop a consensus position where possible, noting substantial areas of disagreement where complete agreement was not forthcoming.

In determining that the MPO has sufficient consensus to enable it to act, the chairman takes the following factors into account:

- the nature of the action by the MPO which is called for under federal regulations;

- the extent of agreement or disagreement among the signatory agencies or their representative;

- the distribution of views in the Joint Regional Transportation Committee;

- the seriousness of any time constraints on reaching a decision.

Any MPO member may request that specific objections of one or more members to any specific MPO action be recorded and transmitted along with the MPO action.

In general, management responsibility for each specific Unified Planning Work Program element is assigned to the agency with the statutory responsisbility for the subject matter of that work element. For example, a study that is predominantly highway oriented is under the management leadership of the MDPW; and one that is concerned primarily with land use planning is under the leadership of the MAPC; and one that is concerned primarily with airport facilities is under the leadership of the Massport. It is recognized that some study elements involve two or more agencies as essentially equal partners. In such instances, the assignment of manamgement leadership is made on the basis of the senior staff resources available within each agency for work on specific projects. There are also key responsibilities for coordination that belong to some joint committees.

2.4.1 Sub-Signatory Committee (SSC)

Day-to-day coordination among the agencies is provided by the designees of each of the signatories who meet regularly as the Sub-Signatory Committee (SSC). The SSC consists of a senior transportation planning person of each agency, with the EOTC designee serving as chairman.

The group's functions are to strive for the integration and full coordination of transportation and land use planning efforts, to ensure the timely and concerted allocation of staff and other respective agencies, and to review and approve professional staff for and provide general direction for the CTPS.

As the provision of guidance for the CTPS is one of the SSc's most prominent functions, the CTPS Director attends each bi-weekly meeting. Regular reports are made to the JRTC on progress with each Work Program element and to significant scheduling problems. There are other functions and responsibilities that the SSC undertakes for more effective inter-agency coordination.

2.4.2. Central Transportation Planning Staff (CTPS)

Certain tasks in the Unified Planning Work Program require work performed by the combination of various agency staff members and/or require such professional or technical disciplines that are currently not available in the agencies. Generally, these tasks are interdisciplinary in nature and are intended to provide a variety of services in support of normal agency work loads. These tasks are so identified in the Unified Planning Work Program. The signatory agencies therefore established, in May, 1974, the Central Transportation Planning Staff (CTPS).

The CTPS is under the administrative direction of the MAPC, the MPO agency which is the primary recipient of grants and contracts for comprehensive and transportation planning in the region.

The purpose of creating this Staff was to develop a permanent, integrated, multi-modal, systems planning and analysis capability, to reduce overlap and fill gaps in the work of transportation agencies in the metropolitan Boston region, and to increase inter-agency cooperation in the creation of a balanced, comprehensive, regional transportation plan. The CTPS conducts long-range transportation planning and analyzes major transportation policy issues, with the participation of the agencies. The CTPS also assists the agencies in developing particular transportation projects and programs.

2.4.2.1 Disciplinary Set-up of the CTPS

To fulfil its *raison d'etre* as an organ of the MPO, the CTPS has assembled a multi-disciplinary staff which has systems analysts, design and engineering planners, environmental experts, and community liaison specialists. The staff is headed by a Director who is also currently performs the functions of the MPO Executive Secretary. Under the latter title, his primary responsibility is to implement the policy directions to the CTPS. As the CTPS Director, he is responsible for the overall administration and supervision of the staff.

Working through the MAPC Executive Director, his functions also include ensuring that MAPC meets its program and contractual obligations related to CTPS work activities and fulfills its transportation responsibilities as the Boston-area regional planning agency. Also, representatives of the MDPW and EOTC are part of the CTPS.

Their role is to facilitate interaction between the CTPS and their respective agency as well as to perform various technical functions. Any other MPO member may maintain representatives at the CTPS for carrying out similar duties. While the individual agency representatives are selected by the respective agency, the MPO Executive Secretary is selected by the Committee of Signatories and the CTPS Director is selected jointly by the Committee of Signatories and the MAPC.

2.4.2.2. CTPS Responsibilities

The CTPS has responsibilities at three levels of planning (systems/ regional, subregional/ pre-project, and project) and in design and operations. The scope of these responsibilities is at its maximum level in systems planning and diminishes in each of the succeeding stages. The end of the project developemnt phase, namely the completion of the environmental impact process, signifies a substantial lessening of the CTPS role.

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The principal responsibilities in the systems planning stage also include the establishment and maintenance of a regional data-base and the production and revision of the transportation plan and program and related products. In order to avoid duplication of effort, agencies provide to the CTPS existing data and data analyses and continue to collect, provide and analyse such data as it is a continuing and regular agency function. The CTPS, in turn, provides such new data analyses as are required, and makes such data analyses available to the agencies.

Principal responsibilities at the sub-regional and pre-project planning stage include doing analyses of area-wide or sub-area transportation needs, as part of the basic decision on the need for a facility. The agencies and CTPS have reciprocal tesponsibilities for data collection and analyses as described.

Principal responsibilities at the project development stage include its full participation in a joint effort with the agencies on the location, basic design, and environmental analysis of a particular facility, service, or program. While the major responsibility rests with the agency, the CTPS works with the agencies to assure that the project plans are consistent with regional transportation planning requirements and that the process for involvement or other agencies, local governments, and private citizens is adequate.

Principal responsibilities in the final design stage rests with the agencies. The CTPS assures continuing compatibility of final design with previous and current transportation policy and planning decisions and related efforts in planning by providing a periodic general review of final design plans.

Principal responsibilities in operations planning rest with the agencies. The CTPS identifies the need for new services or operational facilities, works with the agencies in translating the general need into specific operational proposals, and serves as continuing liaison between the JRTC structure and on-going operations of the agencies. The operations effort looks at operations of the agencies to ensure that program decisions are made informed of foreseeable operational costs and potential problems.

The Central Transportation Planning Staff (CTPS) is also involved in the area of public participation as well. Within the CTPS, this role is carried out by the field staff whose task is to perform community assistance functions at all planning stages to ensure effective local input. The details of the CTPS roles and functions both at inter-agency level as well as in the realm of public participation may be found in the Prospectus. The work of the CTPS is organised under key staff groupings such as the systems planning group, the design/environmental/ operational planning group, the field staff group, the Central Artery group, the urban design and graphics group and the library resources unit.

2.5. THE JOINT REGIONAL TRANSPORTATION COMMITTEE (JRTC)

The JRTC is a special Committee established by the Signatories/MPO. It ensures the overall accomplishment of the objectives of the '3C' process for the Boston Region. Its composition is as discussed earlier. The specific functions of the JRTC are :

-To advise the signatories on matters of policy affecting the conduct of the '3C' transportation planning process for the Region;

-To advise the Signatories on such regional transportation documents as may from time to time be required by state or federal laws and regulations;

-To provide maximum participation in the transportation planning process by creating a forum bringing the Signatories together with other public agencies, representatives of cities and towns, and citizens concerned with the transportation planning process, thereby facilitating, where possible, the consistency, wherever possible, the constituency of transportation plans and programs for the Region with the policies, priorities, and plans of affected state and regional group agencies, local communities, private groups and individuals within the Region.

2.5.1. The organization of the JRTC

Membership on the JRTC shall be widely representative of the Region so as to ensure a balanced consideration of transportation issues. The JRTC shall be composed as follows, with all members to be appointed by the Signatories:

Up to eighteen (18) representatives of the public agencies. In addition to the six Signatories, sitting as non-voting ex officio members, the others shall be appointed upon the recommendation of the Secretary of the EOTC; and

Twenty (20) representatives from the cities and towns of the Region. These representatives shall be chosen so as to provide broad geographic representation of the Region. These municipality representatives shall be appointed upon the recommendation of the MAPC and the Advisory Board; and

Twenty (20) citizen designees, primarily representating private organizations concerned with the transportation planning process.

A chairperson and a vice chairperson shall be elected annually by the JRTC from among its membership. Consistent with the provisions of this Memorandum, JRTC shall adopt bye-laws and other procedures as may be necessary to govern its internal operations. The TIP is adopted formally by the MPO after it is reviewed and commented upon by the JRTC.

3.1 INTRODUCTION : TIP IN THE FEDERAL-AID HIGHWAY PROGRAM

The Transportation Improvement Program [1](TIP) is a staged, five-year program of capital improvements to the Boston metropolitan area's transit and highway transportation systems. The capital improvement projects in the TIP are consistent with the Transportation Plan. The TIP both as a process and a document is best understood and appreciated in the context of the overall transportation program especially the Federal-Aid Highway Program. This chapter attempts to bridge the description of participating agencies with the actual description of the TIP responsibilities. It does this within the framework of the federal-aid highway program. The Transportation Improvements Projects (TIP) Document carries this Declaration[2] on its front Page:

<u>CERTIFICATION OF "3C" TRANSPORTATION PLANNING PROCESS</u>
IN ACCORDANCE WITH THE FHWA/UMTA URBAN TRANSPORTATION PLANNING FINAL RULE, DATED JUNE 30, 1983, THE METROPOLITAN PLANNING ORGANIZATION (MPO) FOR THE BOSTON REGION HAS COMPLETED ITS REVIEW AND HEREBY CERTIFIES THAT THE CONDUCT OF THE 3C TRANSPORTATION PLANNING PROCESS COMPLIES WITH THE REQUIREMENTS OF CFR 450.114 (c) ; AND THAT SAID PROCESS INCLUDES ACTIVITIES TO SUPPORT THE DEVELOPMENT AND THE IMPLEMENTATION OF THIS TRANSPORTATION IMPROVEMENT PROGRAM (TIP), THE TRANSPORTATION PLAN, AND SUBSEQUENT PROJECT DEVELOPMENT ACTIVITIES , AS NECESSARY AND TO THE DEGREE APPRIOPRIATE.

- TIP FISCAL YEAR 1988, PAGE 1

3.2. BACKGROUND TO THE INTERSTATE SYSTEM

3.2.1. The Federal-Aid Highway Program

The federal-aid highway program in Massachusetts is a federally assisted and state administered program. The program currently consists of three separate federal-aid systems : the Primary system (which includes the Interstate), the Secondary system in the rural areas, and the Urban systems in the urban areas. Each of these separate systems was developed on the basis of functional classification which takes into account the various functions and uses of the roadways.

Functional classification is concerned with the three different types of routes: arterials, collectors, and local roads. Arterials and collectors vary in importance with regard to statewide or local significance. The federal-aid Primary system is composed of arterials with statewide significance, whose basic function is the movement of large numbers of people and vehicles by way of long distance travel corridors. The federal-aid Urban system is composed of rural collectors with statewide significance whose function is to serve urban areas and traffic generators of intra-county importance. The federal-aid Urban system is composed of urban arterial and collector routes which serve the more important travel needs of local communities, providing access to both neighborhoods and the federal-aid Primary system.

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The federal-aid network in Massachusetts is the result of a major re-examination of the travel corridors conducted in 1975. This effort was spear-headed by the Department's Bureau of Transportation and Development. It concluded major participation and input from other sections of the Department of Public Works, City and town officials, regional agencies, federal highway administration officials. The results of this re-examination were officially adopted with the realignment of the federal-aid systems effective July 1, 1976. Maps have been developed to depict this realigned federal-aid network, and includes revision to the systems approved since its adoption in 1976. Requests for revisions must meet functional classification criteria and be based upon the following FHWA requirements.

Federal-Aid System	Party Responsible for Designation
Primary (including Interstate)	Mass. Dept. of Public Works
Secondary	Mass. Dept. of Public Works and local officials in cooperation with each other.
Urban	Local officials with the concurrence of Mass. Dept. of Public Works.

Maintenance of the functional classification and of the federal-aid system networks is the responsibility of the Bureau of Transportation Planning and Development. Comments and suggestions may be forwarded to the BTPD.

3.3. THE TIP DOCUMENT

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.3.3.1.the vision of the TIP

The Transportation Improvement Projects Document originates under the aegis of enabling regulation by the Federal Highway Administration (FHWA) and the Urban Mass Transportation Administration (UMTA) which were themselves set at one point in the transportation timeline traced here in this study. The TIP is divided into distinct portions and the preliminary matter outlines the overall procedure to be adopted in the preparation of the TIP document. The joint regulations were promulgated on August 9, 1976 to implement the Office of Management and Budget (OMB) Revised Circular A-95 which established regulations for coordinating Federal and Federally assisted programs and projects with each other and with state, regional and local plans and programs.

Essentially, the legislative authority upon which A-95 rests remains Section 204 of the Demonstration Cities and Metropolitan Development Act of 1966 and Title IV of the Interdepartmental Cooperation Act of 1968. The A-95 Review Process is not based on the Environmental Policy Act but does serve as a means of securing state, regional and local inputs to Environmental Impact Statements (EIS) as required by Section 102 (2) (c) of that Act.

The definition of the A-95 Review Process was devised as a response to the acknowledged "need for coordination of planning and development activities within and among Federal, State, regional and local levels of government at each of which there may exist structural obstacles to such coordination". It calls for the elimination of duplication of effort and the prevention of the unilateral establishment of projects in conflict with one another. Underlying the entire process is the intention that all transportation related projects to be consistent with local, regional and state goals and objectives. While the dissemination of information concerning most programs and projects is necessary to this assurance of consistency, the A-95 Review Process is strictly applicable only to those projects that receive Federal funding assistance.

In a document of this nature with legal constructions and contractual powers there is the need for the elimination of doubt. This is done through the definition of the most used terms as below :

3.3.2. Definitions

As used in the A-95 Review Process :

"Applicant"- means-Any local or State Agency which applies for
Federal Transportation assistence, including but not
limited to cities, Metropolitan Planning Organizations (MPOs),
Transit Operators, State Highway agencies, and designated
recipients of the Urban Mass Transportation Administration
(UMTA) funds.

"Annual Element (TIP/AE)"- A regional list of transportation
improvement projects proposed by the MPO for
implementation of a program action (i.e., PE, ROW,
Construction) during the first program year.

"Capital Expenditure and Program Office(CEPO)"- That unit within the
Department's Bureau of Transportation Planning and
Development responsible for all FHWA programming
transactions including the formulation the statewide 105
Program of projects and the initiation of A-95 reviews and
assistance in TIP preparation.

"Department"- Massachusetts Department of Public Works. That
agency responsible for planning, programming, design,
construction and maintenance of highways. As the state
highway agency, it is also responsible for implementing '3C'
transportation planning and is a signatory and partner in the
'3C' transportation planning process within each region.

"Highway Planning and Research Program (HPR)"- The statewide
highway planning, research, and development effort described

in an annual two-part statement of proposed work and estimated cost

"Metropolitan Planning Organization (MPO)"- That organization in each region designated by the Governor as being responsible for carrying out the "3C Transportation Planning Process".

"Program and Process"- A period of 12 consecutive months beginning not later than October 1 (Federal Fiscal Year).

"Regional Planning Agency (RPA)"- That agency responsible for regional, comprehensive, transportation planning, the development of the TIP/AE; and for serving as the areawide clearing-house for A-95 reviews.

"Regional Transit Authority (RTA)"- That Authority responsible for developing, financing and contracting for the operation of Mass Transportation facilities and equipment on the regional level.

"State Clearinghouse"- The Office of State Planning (OSP).

"Statewide '105' Program"- An annual listing of projects, submitted to FHWA by the Department, that provides for phases of work which theDepartment expects to request Federal authoritization to proceed with during the program period.

"Transportation Improvement Program (TIP)"- A staged multi-year program of transportation improvements including an annual element. The program shall cover a period of not less than 3 years.

"Unified Planning Work Program"- The planning work program that identifies and describes all regional transportation and related planning activities to be undertaken within a two-year period.

.3.3.3. .defining the roles of the actors in the TIP

There are general roles and responsibilities which some of the actors in the TIP process must fulfil to ensure the overall success of the document. The A-95 Review Process also specifies what these roles must be concerning the FHWA and UMTA Discretionary and Formula Capital Projects. On the Transportation Improvement Program /Annual Element (TIP/AE), these are :

-The Department, RPA and the RTA shall maintain close consultation with each other during the development of the TIP/AE;

-The Department (through CEPO) shall annually provide to the RPA on or before June 1, a listing of all projects that the Department reasonably expects program action during the program period;

-The RPA shall annually submit to the Department (through CEPO), no later than July 1, a draft TIP/AE and specify those projects for which they desire further pertinent information;

-The Department (through CEPO) shall provide to the RTA such requested additional information on all federal and state funded highway and highway-related projects no later than August 1; the RPA shall request additional information for UMTA-funded projects from the appropriate RTA;

-The RPA shall annually submit to the Department (through CEPO) no later than september 1, the TIP/AE bearing the endorsement of the RPA and the RTA;

-In their role as a member of the MPO, RPA endorsement of the TIP/AE and amendments thereto shall satisfy the necessary Areawide A-95 review requirements;

-The MPO shall annually furnish the TIP/AE and amendments thereto to the State clearinghouse for review and comment. Concerning the Statewide "105" Program of Projects, these are :
-The Department (through CEPO) is responsible for the annual preparation of the proposed 105 program and for its circulation to clearinghouses for A-95 Review on or before August 1;
-The clearinghouse shall conduct an A-95 review on the proposed 105 program and submit comments to the Department (through CEPO) on or before September 1;

-The Department, based upon the endorsed regional TIP/AE's and comments received from clearinghouse A-95 review, shall finalize the 105 program and submit it to FHWA on or before October 1 of each year regarding its operation for urbanized areas.

For those areas of the country where the Metropolitan Planning Organization (MPO) serves as the areawide clearinghouse, endorsement of the transportation Improvement Program/Annual Element (TIP/AE) will meet the areawide clearinghouse review requirements of OMB circular NO. A-95, Part I, Para., 3 and 4 for each project in the AE.

While the above is not strictly applicable to Massachusetts since the RPA's, not the MPO's, serve as areawide clearinghouse, the flexibility allowed in reaching the common goal of project awareness and an efficient review process allows for the adoption of the new regulation, albeit with modification to fit the particular case. Therefore, since the Department, as the designated applicant for federal funding assistance for highway and highway-related projects, must work within imposed time constraints in making annual federal applications; and since, when viewed statewide, the review process is a major task, the endorsement of the TIP/AE by the RPA will satisfy the necessary areawide A-95 Review requirements. The adoption of this procedure is made possible by the fact that the areawide A-95 clearinghouse is the RPA and the RPA is a signatory to all MPO actions.

It is expected that clearinghouses will be able to perform complete A-95 reviews with the information contained in the TIP/AE for the majority of projects may require more information and further review at subsequent stages of development. Since large, major impact, capital projects must be implemented in stages, that is, engineering, right-of-way acquisition and construction, each successive stage is required to be reported in a TIP/AE and will, thereby automatically be subject to an A-95 review.

The Federal Highway Administration has agreed that this single endorsement action will satisfy Federal requirements for A-95 notification, construction and review. The procedures outlines in this document are in conformity with the minimums set forth in the joint FHWA/UMTA regulations (Federal Register, Volume 41, No. 154, August 9, 1976) that will satisfy Federal requirements for OMB Circular No. A-95 notification, consultation and review.

These procedures do not in any way impose limitations on the frquency of requests for additional information for projects at any stage of development by an A-95 clearinghouse. These procedures do not in any way impose limitations on the frequency of requests for additional information for projects at any stage of development by an A-95 clearinghouse.

The Transportation Improvement Program (TIP) is a staged, five-year program of capital improvements to the Boston metropolitan area's transit and highway transportation systems. The capital improvement projects in the TIP are consistent with the Transportation Plan. This Plan describes the Boston metropolitan area's long-range and region-wide policy for the development of its transit and highway transportation systems. The TIP is a set of short-range and specific capital projects that implement that policy. The Capital improvement projects in the TIP are expected to be candidates for federal-aid funding for their implementation at some time during the next five federal fiscal years.

The TIP is divided first into two main categories- transit and highways. The priority setting procedure for the transit section of the TIP is the responsibility of the Metropolitan Bay Transport Authority (MBTA). The highway section of the TIP is broken up into two sub-sections namely the Annual Element (TIP/AE) and Future Element (TIP/FE) where the future is either the five-federal-fiscal years or beyond. It is also desirable to further break down the Annual Element into capital projects or extensions to the system and maintenance projects for the replacement of an existing facility. Projects in the Annual Element of the TIP are expected to be ready for implementation funds during the federal fiscal year 1989, which extends from October 1, 1988 through September 30, 1989. Projects in the 2-5 Year Element of the TIP are likely to be ready for implementation funds during federal fiscal Years 1990 through 1993.

The TIP is developed and updated annually under the direction of the Boston region's Metropolitan Planning Organization (MPO) , in cooperation with state and local officials.

The MPO produces the TIP in compliance with the requirements of the Title 23 of the Code of Federal Regulations, Chapter I, Part 450, Subpart B, effective August 1, 1983. The Urban Mass Transportation Administration (UMTA) and the Federal Highway Administration (FHWA) jointly established these requirements for the production and content of the TIP. However, the content of this document actually exceeds the requirements of the federal regulations. The MPO has established this policy to allow the document to present a complete picture of the regional projects and their programming.

The federal regulations require that only projects that will be fundef by certain federal-aid transit and highway programs must appear in the TIP. However, the Boston region's Transportation Improvement Program includes all projects that the region has programmed for federal-aid funding during the 5-year period.

Furthermore, for some of the highway funding programs that must be present, the federal regulations allow the TIP to omit projects that either rehabilitate facilities or improve safety but do not increase traffic capacity.

3.3.4. ..a context for the TIP

In attempting to relate the TIP to its institutional and organizational context, this chapter attempts to answer four questions: What is defined as a transportation need and who does? How does that 'need' become translated into a worthwhile proposal or project? How does that project get into the TIP? What is its flow through the process?

3.3.5. The definition of 'need'

A transportation need is identified as any aspect of the network whose continued existence undermines the attainment of the stated goal of the MPO "to promote the good life" for all road-users in the metropolitan Boston Region. Thus, the first step in determining which TIP projects are the most critical is to establish what constitutes a deficiency in an existing condition. The literature on road project programming generally refers to four broad and overlapping categories of concern: physical condition, safety, capacity and access.

The physical condition of a facility may be assessed in terms of age and date (re)surfaced, pavement condition, certain geometric characteristics such as median and shoulder widths, and drainage. More than half of the projects in the major categories of recent TIPs have been for resurfacing.

Capacity deficiencies are identified as physical problems though difficult to remedy. The most obvious symptom of insufficient capacity is traffic congestion. Congestion may be measured and expressed in terms of volume/capacity ratios, levels of service, and vehicle delay. While seriously congested conditions exist at various locations throughout the Boston region, in many case the problem is addressed less cost-effectively by physical improvements than by transportation system management measures such as contra-flow lanes, ridesharing and flexible-time-to- work schedules.

Safety of a given intersection or road segment is a worthwhile objective, but it is difficult to measure for many reasons. The perception of safety is subjective on the one hand, and, on the other, varies with the hierarchical structure of the network from rural collectors up to the Interstate system. Since safety is the absence of hazard, various measures of safety include the number of fatalities per 10,000 registered vehicles, or, per 100,000,000 vehicle miles traveled, or, per 100,000 of the population.

Also, it takes a driver, his vehicle and the roadway for an accident to occur- three elements that must be addressed at different planning levels with varying degrees of effectiveness. Therefore, although the occurrence of an accident or two over a one-year period may make a location stand out from other locations, such an occurrence does not truly signify anything about the comparative safety of that location.

If the usefulness of plannning is measured by the actions arising therefrom, then the issue is: should action be stayed until 'safety' is better defined, or should accident rates remain crucial to the assessment and definition of a project's urgency or need?

Access as a general term in transportation improvement refers to the extension of the network through the construction of new roads. The need for access not already available can be expressed and measured either as congestion on existing facilities, land development generating new traffic or simply as traffic growth rate. Very few TIP projects outside the Interstate and Primary funding categories have to do with new facilities. For example the New Central Artery/Third Harbor Tunnel project is a capital project although it is an improvement on an existing facility. The maintenance of existing roadways including widening, provision of turning lanes, elevation, etc which require substantial amounts of resources are considered under pavement management programs.

Thus excessive delays, lack of turning lanes, malfunctioning of signal lights, accident-proneness, pot-holed pavements etc, are indicators of need. The degree to which different locations suffer from deficiencies in any of the above categories defines the 'need' for transportation improvement.

3.3.6. Project inception

However, not every need, real or imagined becomes a project. "The MAPC's Transportation Programs: A Guide for Community Officials in the Metropolitan Boston Region" is a publication which attempts to describe in detail how a perceived 'need' or proposed highway improvement becomes eligible for state or federal-aid funds which is the objective of the TIP. According to this guide, the funding process typically begins with a community's perception of a highway problem and an initial investigation by the MDPW district office. The community and the MDPW often decide after review and analysis, that some transportation problems can be solved entirely through state aid reimbursement funds or specialized state programs.

Other highway problems may require either 100 percent state funding or federal-aid funding for their solution. The MDPW's Project Review Committee(PRC) reviews the proposed improvement and formally approves it to establish its eligibility for these types of funding. It is the approval of the MDPW's Project Review Committee that grants official status to a proposal thereby translating it from a need into a project. "Approval" does not guarantee funding for construction. It expresses official (MDPW) support for the goals of the proposal, and MDPW's willingness to devote resources to developing the proposal into a final engineering design and make every effort to secure construction funding if project development is successful. It is however not clear exactly what this means in practice!

The MDPW determines which projects it considers to be priorities for construction funding and development work based on its limited resources. Each year, it reviews all projects it has approved for development and establishes its own 5-year capital program of federally-funded projects. Approved projects which the MDPW considers to be low priorities are not included in the program receive neither federal-aid funds nor resources for project development. as the only authorized recipient of federal-aid highway funds for the state, the MDPW is in a sense the MPO. But statutorily, the MAPC, as the Regional Planning Agency has responsibility to determine project priority. Hence the recent effort to develop an acceptable priority-setting procedure for the region. However, the MAPC only has a 'needs list' not a projects listing.

3.3.7. TIP Programming

The TIP includes only those proposed highway improvement projects approved by the MDPW for development as federal-aid projects. It programs the construction of any newly approved project which is not in the current MDPW 5-year capital program in a future category since such a project could not require federal-aid funds during the period of the TIP. It programs the construction activities of projects that are in the MDPW program in either its 2-5 year Element or the Annual Element based on the following guidelines:

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o   Percentage of design work complete by the beginning of the fiscal year.

o   The Estimated date that the project will be advertised for construction bids.

o   An updated Assessment of money available and need for the proposed improvement.

A project must have received Federal Highway Administration approval of its 75 percent design plans and have an estimated advertising date within the current Federal fiscal year before it may be considered for inclusion in the Annual Element. Projects which do not meet these requirements automatically fall into the 2-5 Year Element. There are exceptions to these rules.

o   Projects which meet these requirements may be placed in the 2-5 Year Element as a result of Federal-aid funding limitations, or other problems which are currently delaying the implementation of the project.

o   Projects which achieve 75 percent design during the course of the fiscal year may be added to the Annual Element by amendment, provided that sufficient funds are available.

o   Projects which advance quickly through design and approval and are ready for advertising during the fiscal year such as traffic signal updates or resurfacing projects.

o   Projects of high-priority whose implementation is expedient and desired during the current fiscal year. Assignment to the Annual Element in this instance, assumes a committment of sufficient resources to complete preliminary engineering and anticipates all necessary federal and local approvals.

3.3.8. funding

In theory, federal-aid funds may also support project activities besides construction. These include preliminary engineering and the right-of-way items of projects which are in the MDPW program in either its 2-5 year Element or Annual Element. The FHWA and MDPW refer to activities conducted during the development and design phases of the project as preliminary engineering. These include, environmental analysis, location reports, basic and final design. The implementation phase often requires right-of-way activity. This can include survey, appraisal, and relocation assistance, as well as the actual purchase of land for the transportation facility.

In practice, federal-aid funds are only for construction work and communities must undertake both the preliminary engineering as well as the right-of-way acquisition as an indication of their committment to the project. It is this conditionality that creates so much uncertainty with the rate at which projects advance through development to implementation.

Until a community achieves 75 percent design completion as well as acquire the right-of-way for any "approved" project, it does not receive any federal-aid funds. The implications of this conditionality in light of proposition $2^1/_2$ is best left to be imagined. It however does not enhance equity.

Although Federal regulations require that the TIP's Annual Element be reasonably consistent with the amount of federal funds expected to be available to the region during the current fiscal year, the over-subscription of the Boston Region TIP in recent years could also be seen as a programming strategy consistent with the vagaries of construction activity and declining levels of funding at federal and state levels. It allows the MPO to respond quickly and easily to the changing fortunes of projects in development phase.

The Regional FHWA approves this strategy and has established levels of over-subscriptions. In funding categories that are apportioned solely to the Boston metropolitan area, for example, the estimated cost of the TIP's Annual Element may be up to 200 percent of the total of federal and state funds expected to be available. In funding categories that are apportioned to the state as a whole, for example, the Interstate program, the total estimated cost of the TIP Annual Element may be up to 80 percent of the total of federal and state funds expected to be available. During the production of the TIP, agency staff determine a target figure for the total cost of each funding category's Annual Element.

For each federal-aid category, the MDPW's Capital Expenditure and Program Office provides both the amount of unused federal funds still available and the current fiscal year's apportionments of federal-aid funds. The sum of the two is the amount of federal funding expected to be available to the area within each category. Next, this figure is increased by the state share appropriate to the particular funding category to determine the total funding available. For example, the Federal-aid Urban Systems program will pay 75 percent of total project costs, state funds pay for the remaining 25 percent. The Federal-aid Interstate funding program will pay for 90 percent of total project costs, state funds pay for the remaining 10 percent. The target size of the Annual Element in each funding category is this figure multiplied by the appropriate "over-programming".

3.3.9. conclusion

The foregoing indicates that The MDPW sets _de facto_ priorities. This is not consistent with the certification of 3C process contained on the first page of the TIP document. Legitimate questions that must be confronted include the following: what is the procedure adopted by the MDPW? Why does the MDPW set priorities and not the MAPC whose statutory responsibility as the regional planning agency it is to set project priorities? The TIP flow is as depicted graphically in figure 3-3.

Actual project costs can also be lower than the estimate in the TIP. The federal funding agency may not agree to fund the entire project as it was conceived locally. This usually becomes known during the various reviews which occur during project development. Whenever either UMTA or FHWA determines that the project contains elements which fall outside of the intent of the funding program. They may deny requests to pay for them, thereby requiring the Commonwealth or the local community either to find an alternative source of money or to eliminate these elements.

3.3.9. funding categories

Justification for the various funding categories is not adequately documented but there is reason to believe that the various categories attempt to ensure a balanced distribution of funds among competing needs. However, this is neither rational nor justifiable as an analysis of the TIP for Fiscal Year 1985.

Table 3-2 shows the results of an analysis of the 1985 Fiscal Year TIP with emphasis on the Urban Systems funding category most adversely affected by the oversubscription of the TIP. Excluding the City of Boston, the records of the TIP for 1981 and 1985 show the degree to which the TIP has failed to indicate accurately which projects would actually move through the 'pipeline' from preliminary design to advertisement for construction. It is essentially arbitrary !

Only 28.9 percent of all the projects in 1981 TIP (and 42.7 percent of the projects in the 1981 Annual Element) had been advertised by 1985. At the same time 22 projects actually moved back from the 1981 Annual Element to the 1985 2-5 year Element . Also some projects fail to reach the 75 percent design stage after several years in the 2-5 Years The failure of the TIP to reflect the status of projects is particularly problematic in light of the oversubscription.

Funds may not be transfered between projects. The Urban System, Boston Urbanized Area Category as per the table shown indicates the cost of scheduled projects exceeds available funds by more than thirty-eight million dollars. This means that funds are not available for nearly half of the programmed projects. This discrepancy shows the importance of establishing project priorities. When the MDPW directs its district offices to work less on some projects and more on others, priorities are being set *de facto* . These priorities are however not made public nor is there the basis or process by which they are established.

This is not very safisfactory for a public agency which spends public funds to meet the needs of members of the public. This is all the more significant when considered from the viewpoint of the various communities for which these funds are meant.

Communities have indicated their dissatisfaction with a situation in which they are made to expend scarce funds on projects whose priority status is not known only to have the MDPW set such projects aside as being of low priority. In the face of fiscal austerity brought about by proposition 21/2 such misapplication of resources has far-reaching implications for the implementation of other projects. An explicit process for determining the priority status of a project would go a long way towards avoiding such fiscal uncertainty.

The absence of formal priority-setting process makes it difficult for communities to plan for future road improvements. It also raises the possibility that projects which, by virtue of the severity of the problems they address, should be undertaken with due haste, may be deferred in favor of lee urgent projects. The question now is: what distinguishes important projects? The purpose of setting priorities among projects is to determine which should be performed first.

Funding levels for the different categories are determined independently, so a project in one category may be funded when a more important project in another category may not. The relevant group of projects which should be compared, then, is those in the same funding category, for those projects in a real sense compete with each other.

But this categorical distinction is only for better control of the situation not that these categories are fundamentally different. It should be possible when situations demand to waive this categorical distinction since it is in essence very arbitrary.

The significant decision that must be made includes : (a) is it more efficient to prioritize all projects according to their respective categories or (b) to prioritize all projects according to those criteria that will in effect reduce these projects to the same denominator to make true comparism and competition possible in the best interest of optimal resource allocation for the good of society? The fact that some categories hardly have any projects and have adequate funds for their needs when some other categories have enough to meet only half of their needs reveals the need for flexiblility in the reallocation of available funds. What ever authority is responsible for any category should set priorities since resources are always insufficient.

The Interstate category, has only a few very large scale projects such as the proposed Central Artery depression or the reconstruction of the I-95/ Route 128 Interchange in Peabody. These are prioritized at the highest executive and political levels. While projects in the Urban Systems, Boston category is at the discretion of the City of Boston. There are certain categories, such as Pavement Marking, Railroad Crossings, etc which in most years contain only a handful of projects.

3.3.10   The   TIP   Prioritizing   Process
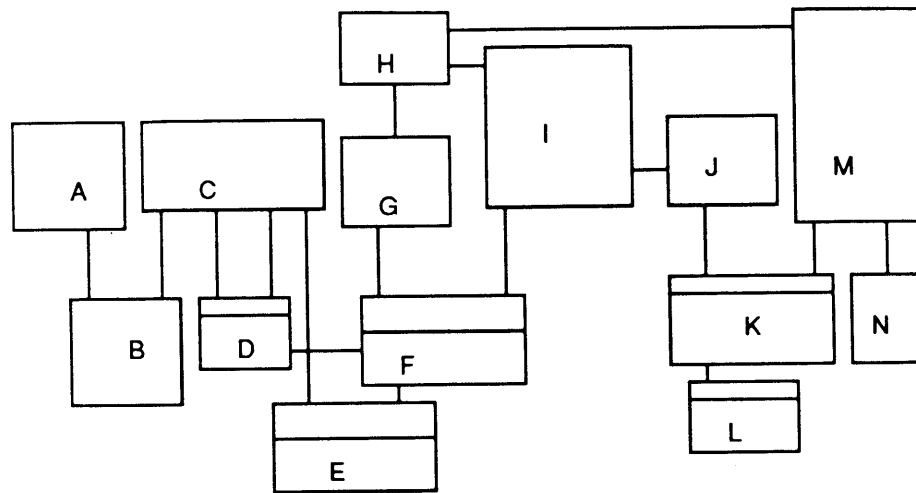
FIGURE 3-1
TIP PRIORITIZATION PROCESS

Figure 3-1 shows the TIP process with respect to the actors, activities and flow. Activities are either community activity or MDPW activity. The 'Element" is either "Future Element" (with low or medium priority), "2-5 Year Element" (medium or high priority) and "Annual Element" (means 75 percent design).

The Process begins at "A" where the community indicates an interest in a project and makes a formal request for submission requirements of the MDPW. Then at point "B" the MDPW District Office responds by providing the requirements. At "C", the community begins to develop data for the project and submits its report to the MDPW District Office at point "D". At "D", the MDPW District Office reviews report and either makes recommendation to MDPW Boston HQ at "F", or returns report to community for more data.

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If report is returned to "C" the community then sends report to the MAPC and JRTC at "E" to establish an initial priority for project before forwarding to the MDPW Head Office at "F". From the MDPW- HQ Boston, the report could return to the community at "G" if rejected by the MDPW, or goes to "I" if accepted in principle by the MDPW. At "G", the community either decides to revise proposal and develop more data by returning to point "C", or decides that no further action be taken on the proposal and proposal is forgotten at point "H".

The community could also decide to forget about the project at point "I" where the MDPW approves it with a low priority unacceptable to the community. But the community decides to continue at "I", knowing its project priority, it then initiates study and engineering to 25 percent design development and develop a Benefit/Cost Ratio for project at point "J". From "J", project returns to MDPW Review and FHWA at point "K" and from there to the MAPC/JRTC to review and revise project priority based on new data and Benefit/Cost Ratio before returning same to "K" From "K" proposal may still be rejected by community if its revised priority is too low from the point of view of the community, otherwise the project is further developed at "M" before being sent for final approval by MDPW and FHWA at point "N".

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4. INTRODUCTION : SELECTED CRITERIA

This chapter defines the attributes,[1] characteristics and the dimensions of those criteria that determine the relative importance of transportation improvements. As a decision problem, the selection of criteria depend on sets of attributes which are complete,[2] that is, they cover all the important aspects of the problem. These attributes should also be operational,[3] that is, it should be possible to use them meaningfully in analysis. They should be decomposable[4] so that aspects of the evaluation process may be further simplified by breaking it down into parts. However, they must be non-redundant[5] so that double-counting of impacts is avoided; yet minimal[6] so that the problem dimension is kept as small as possible.

Furthermore, the characteristics of the attributes in turn determine what relationship between them is meaningful as well as the level of computational complexity. [7] Computational complexity is concerned with both the algebraic complexity[8] which considers the minimum number of arithmetics needed to solve a given problem; and the analytical complexity[9] which addresses the questions of how much computation has to be performed to obtain a result given a level of accuracy; the vexing issue of cardinal treatment of ordinal data.[10]

In this study the concept of priority-setting has nothing to do with the amount of resources available either in terms of funds or personnel. It is only concerned with the relative importance of the criteria chosen as truly representative of the issues identified in transportation improvement. Programming as a further stage examines how selected projects using the above process may be implemented considering the funds available and what additional sources may be found. This approach has been adopted so as to isolate the priority-setting process from the budget allocation problem which is often complex enough without introducing additional sources of difficulty or uncertainty. Thus setting priorities is not necessarily saying what will be built but what may be built if the available level of funding allows.

Hitherto, different categories of projects have been created and set in stone. The result is that while some categories are oversubscribed others hardly have any candidate projects as an analysis of the 1985 TIP shows. Limited funds should not be allowed to sit idly when crucial needs have to be met. Hence the creation of categories would be counterproductive unless it is flexible enough to allow for circumstances in which rigid categorization militates against the judicious allocation of available funds. Lastly but by no means least, the selection of criteria requires attention to geographical location. This has two components viz: the rural - urban dicotomy and the maintenance - expansion dichotomy.

Rural - Urban dicotomy refers to the usual classification according to location of candidate project whether it is in a "rural" area or in an "urbanized" area. These differences are subsumed in issues of economic development, density of population and other factors, and any additional categorization results in redundancy. Concerning the expansion - maintenance conflict, it is true that in those older states in the Northeast US, with a major investment in physical infrastructure that is deteriorating rapidly, emphasis must necessarily be on maintenance; while in the The Sun Belt states on the West Coast US, currently experiencing rapid increases in population and economic development, major concerns will focus on system expansion. Federal emphasis must lay with per capita distribution being equitable. Since the only common denominator is the number of persons who need these facilities. The criteria most used may be broadly categorized as quantifiable or non-quantifiable.

4.1 Technical Quantifiable Factors: Although not exactly synonymous ,those factors that are technical are also factors that most easily lend themselves to measurement based on practical, scientific principles with little or no infusion of subjective likes and dislikes, Quantifiable factors that assist decision makers in establishing priorities include:-

-   Physical conditions of roadway(measures of pavement deterioration, such as road surface condition, pavement structure, condition of foundation, shoulders, and drainage, etc;

- Bridge condition, based on structural and functional condition;
- Geometric characteristics;
- Safety factors;
- Capacities and volumes;
- User costs;
- Energy implications;
- Cost of project;
- Cost of design alternatives (i.e. cost of reducing design standards within acceptable levels of safety).

One significant observation in reliance on 'hard' quantitative data as may be got from the above criteria, is that they are not as useful as we would like to believe. This is because they are difficult and expensive to gather even with total committment over long periods of time and they originate from highway needs studies, corridor and project studies and other planning procedures which may or may not be directly relevant to the present problem. Their only advantage is that they lend themselves very easily to statistical analysis. It cannot be too highly emphasized that technical studies however thorough are not a replacement for good judgment but only serve to provide additional information, confirmation of intuitive 'haunches' or as a point of departure for evaluation purposes.

4.2. Nontechnical. (Nonquantifiable) Factors : [12] Unlike technical factors which require specialized skills and lend themselves easily to precise scientific measurements, the following factors present more difficulty to decision-makers who prefer to consider them as nontechnical and nonquantifiable. These include:

- Political commitments;

- Commitments to other agencies;

- Equity

- Changes in administration; policy changes, and unforeseen contingencies; uncertainties, etc.

- Inflation, etc;

- Conflicts as between economic growth and environmental concerns;

- Public input as through hearings and political process;

- Local planning decisions, zoning policies, etc.

The degree of cooperation between the decision-maker or politician who is elected through the political process and the technician who is equipped with specialized skills determines the level of success in the implementation of public policy. While the politician ought to recognize that the expertise of the technician is required for the development of society, the technician on his part must also respond to the reality of the fact that it is the politician who has been duly elected and mandated to act in a decision-making capacity and the entire TIP program is one part of an overall mosaic of resource allocation.

On the converse, the administrator or political body, must recognize that to provide the best level of public service to the electorate it is their responsibility to listen to and work with the best technical advisors that are available to the community. This means recognizing and allowing for input through a systematic, objective evaluation of priorities according to pre-established criteria for efficient decision-making.

4.3. Selecting The Criteria: A survey of the Transportation Departments of fifty states[13] suggests that in twenty four states, citizen and community requests are the reasons for transportation improvements. Conversely, in only ten of the fifty states studied are the district engineer's recommendations the reason for undertaking such improvements (Table 4-1). Thus Table 4-1 ranks the thirteen principal reasons for transportation improvements according to their popularity among various transportation departments.

These broad categories[14] could be further decomposed into subcategories, such as social criteria with direct impact on users or indirect impact on non-users, physical criteria, financial/fiscal criteria, technological criteria, environmental criteria, etc. These sets of criteria have been further decomposed in the following tables. 4-2 to 4-7. The effective use of these sets of issues in the selection of criteria as well as the relationship between these criteria for the purpose of setting priorities is the crux of this study.

TABLE 4-1: REASONS FOR PROJECTS SELECTION (frequency of use of reason by DOT's for selection of candidate project for improvement)

Rank	Frequency Reported by the States	Item
1	24	Citizen and community requests
2	21	Sufficiency ratings
3	21	Fund source and availablity
4	17	Economic factors
5	17	Accident ratings or rates
6	16	Continuity of routes/improvements
7	15	Environmental impacts
8	15	Urban studies
9	14	Needs
10	12	Social effects
11	11	Project or program cost
12	11	Traffic volume
13	10	State district engineer's recommendation

This table suggests that the district engineer's recommendation is claimed to be the least used justification for undertaking road improvements while community and citizens' requests are claimed to have been most responsible for transportation improvements. Although this is as it should be it not true of all the MPOs surveyed.

TABLE 4-2

CRITERIA BASED ON USER AND SOCIAL NEEDS (Needs Parameter)

User Requirements	User+Nonuser+Operator (Requirements)
1) Improvement which serves most people based on: - Less Peak period volumes - More Off-peak volumes - Shorter Weekend travel	Improvement with least cost - capital cost - operating cost - land requirements - effects on property values
2) Less Travel time: - In-vehicle - Out of vehicle	Improvement which hastens most desirable development - social - economic
3) More Reliability	Improvement which provides greatest revenue - taxes - tolls - fares - user charges

TABLE 4-2 (continued)

CRITERIA BASED ON USER AND SOCIAL NEEDS (Needs Parameter)

User Requirements	User+Nonuser+Operator(Requirements)
4) Less Out of pocket costs	Versatility: can the improvement be utilized for other uses such as as goods movement
5) Greater Safety	Adaptability to deal with peak demand - changing land use - technology - travel trends

Table 4-2 combines consideration For Users on the left-hand side. For Society as a whole including users, non-users, and motor-vehicle operators of other categories, on the right-hand side. For users only transportation improvements must be assessed based on the listed considerations. For society as a whole including both users, non-users and operators of motor-vehicles on roads another set of impacts and more indirect considerations are more appropriate.

TABLE 4-3 : CRITERIA THAT EMPHASIZE PHYSICAL FACTORS AND CHARACTERISTICS OF A FACILITY (PHYSICAL FACTORS)

1.	Physical Condition		4.	Bridges
	sufficiency ratings			- condition rating
	deficiency ratings			- operationg rating
2.	Geometrics		5.	Safety
	pavement width			- accident totals
	shoulder width			- accident rates
3.	Alignment		6.	Capacity
	horizontal			- volume/capacity
	vertical			

Ranking requires the Decision-maker (DM) to rank the various criteria on the basis of their relative importance. The weights are usually standardized by dividing each by the sum of the original weights, that is, $w_i / \Sigma w_i$.

Rating requires the DM to assign weights judgementally on the basis of a pre-determined scale. For example, the DM may be asked to determine the relative importance of criteria i on a scale of 0 to 5.

TABLE :4-4

FISCAL CRITERIA (INCLUDING COSTS AND ECONOMIC BENEFITS) OF

AN IMPROVEMENT (FISCAL CRITERIA- FINANCIAL FEASIBILITY)

Economic Feasibility	System Implementation Funding	Operation Funding
1. Total Capital Costs	1. Total Capital Costs	1. Total Operating Cost
2. Annualized Capital Costs	2. Federal Share*	2. Fare, Toll Revenue
3. Annual Operating Costs	3. State Share* (undefined)	3. Subsidy/Tax Requirement
4. Annual System Local, Costs	4. Local Share* (undefined)	4. Federal, State, Funds Available for Subsidy
5. Annualized Benefits	5. Local Funds Available	5. Surplus/Deficit
6. Benefit-Cost Ratio	6. Surplus/Deficit	
7. Benefits		

* funding for the implementation of transportation improvements
   systems depends on the program category:
Federal-Aid Urban Systems: federal share 75%; State share 25%
Interstate program: Federal Share 90%; State Share 10%
Other programs: Federal Share 80%; state Share 20%.
Local share : Preliminary Engineering and Right-of-Way Acquisition

TABLE 4-4 (continued)

FISCAL CRITERIA (INCLUDING COSTS AND ECONOMIC BENEFITS)

OF AN IMPROVEMENT   (Fiscal criteria - Financial Feasibility)

_____

Annotation : This listing relates the key determinants of an improvement from its inception through its implementation to its operation from a fiscal and economic point of view. Economically, an improvement may be undertaken if it is feasible, that is, if there are funds available to implement it and operate it when commissioned. Funding for any transportation improvement comes from either the local, state or federal levels in varying proportions both for initial capital outlay as well as concurrent expenditure(maintenance).

Total Capital Costs: indicate the resources to implement an improvement.

Annualized Capital Costs: indicate the initial outlay amortized over economic life of system components and time value of money.

Annual Operating Costs: Indicate the continuing financial resources that must be committed to maintain and operate a system.

Annualized System Costs: Represent the total annual resource investment required for system implementation and operation considering time value of money.

Annualized Benefits: are gains to society from implementation of the improvement over the benefits of baseline alternatives. Those that can be qualified in dollar terms.

Benefit Costs Ratio: Ratio of marginal benefits and costs

Benefits Net of Costs: Reflect dollar amount by which benefits exceed the costs of an improvement

TABLE : 4-5   IMPACT CRITERIA TO MEASURE EFFECTS OF A
TRANSPORTATION IMPROVEMENT ON THE COMMUNITY AND ON THE
NATURAL ENVIRONMENT

Impact Criteria

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1.   Minimize Impact on Natural Environment

   (improve) Air Quality

   (improve) Water Quality

   (reduce)   Noise Levels

   (reduce)   Energy Use

   (improve)   Ecosystem Analysis

2.   Minimize Impact on Built Environment

   (minimize) Relocation

   (minimize) Neighborhood Disruption

   (maximize) Green Space

   (maximize) Safety

   (minimize) Construction Impacts

   (maximize) Conformity with Community Goals

3.   Impact on Overall Goals

   Evaluation here insures that all other criteria are consistent
   with national and regional goals and local policy, rather than
   specific plans.

TABLE : 4-6 TECHNOLOGICAL SUITABLILITY CRITERIA TO MEASURE RISK, FLEXIBILITY, AND DEPENDABILITY OF AN IMPROVEMENT

_____

Technological   Suitability

_____

1.   Maximize Quality of Highway Design

This criterion is essential since demand for improved transportation will be generated by increased standard of living. Since investment is limited, resources should be put into facilities which will have maximum utility.

2.   Maximize Flexibility of Construction Schedule

This indicates the capability of staging transportation improvements so that change in policy may be put into effect at some time in the future as new conditions may warrent. This prevents the development of systems that will be obsolete before they are complete.

3.   Minimize Uncertainty of Project Implementation

This criterion implies selection of an improvement that is directly related to the degree of development required to bring the system's performance to an acceptable level.

4.   Maximize Service Dependability of Facility

Indicates reliability and maintainability of a particular improvement. Can it be depended on by users?

5.   Minimize Procurement Risk

Assess the supplier's willingness to produce the necessary supplies at acceptable costs and required lead time.

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TABLE :4-7

PERFORMANCE CRITERIA TO MEASURE THE EFFICIENCY AND EFFECTIVENESS OF A TRANSPORTATION IMPROVEMENT

Urban   Transportation   Performance

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1.   Maximize Efficiency(Capacity Performance)

Improved Capacities for the link are divided into the link traffic volumes to determine the improved peak hour, peak direction v/c ratios for each year.

2.   Maximize Physical Efficiency

Percentage of highway pavement area in good condition versus the percentage in poor condition for both ride quality and pavement distress or cracking.

3.   Maximize Economic Efficiency

Assess the various improvements based on various cost elements per outputs   produced and consumed.

4.   Maximize   Relative Cost Effectiveness

The capacity benefit-to-cost ratio compares the relative cost effective of the capacity improvements selected for individual links. It is defined as the net decrease in link v/c ratio (weighted by link length) in the year of interest divided by the link capacity improvement costs up to that year.

4.3. SELECTED CRITERIA

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A review of the criteria used by various states and the policy objectives explicitly indicated in the PROSPECTUS[12] of the Metropolitan Planning Organization (MPO) indicate that the following criteria are largely exclusive but inclusive of subcategories of such attributes. Transportation Improvements should strive to :

- (maximize) Safety
- (maximize) Level of Service (LOS)
- (improve) Pavement Condition
- (minimize) Total Costs
- (reduce) Total Time
- (improve) Equity
- (define) Politics

4.3.1. Safety (increase) :

The objective here is to improve, enhance, increase, or maximize safety! Safety is defined as the absence of fatality (i.e., the loss of life and property). It is traditionally measured in the number of accidents per million vehicle miles travelled per unit of time usually three years. Approximately 46,000 Americans [15] are killed in motor vehicle accidents each year with about four million injured and about 100,000 of them severely. Estimated monetary losses are in the range of $35 - 40 billion a year.

Motor vehicle accidents constitute the sixth leading cause of death among Americans of all age groups, and are the leading cause of death among those in the fifteen to thirty- five (15-35) age group. The goal of the highway program is to "improve the quality of life"[13] for those in the Boston area. The assumption is that these users will be alive to benefit from the program. Thus one of the most important requirements of the highway program is ensuring the safety of life and property. While the aim of reducing the present level of accidents on the highway has been consensual since the beginning of the motor vehicle age, controversy has continued to prevent the resolution of the problem.

The question of who should be blamed for such loss of life and property as well as the most effective method for ameliorating such loss remains difficult to determine. Until the mid-1960's, the general view actively promoted was that motorists were the source of the problem. They were urged to 'drive defensively' and to support driver-training courses for young people in their school systems who were assured their cars and highways were remarkably safe. In a survey taken in 1966 among 802 drivers in four cities, four out of every five drivers complained about the discourtesy and recklessness of other drivers as the source of accidents without any thought of being possible victims of faulty mechanical design.

However, there were senate hearings at which charges were being aired that the auto makers were responsible for a large proportion of motor vehicle fatalities. Safety was equated with car size, weight, good brakes, and good tires, rather than any special safety equipment. One-third was prepared and willing to pay extra for a lap seat belt, and one-fifth said they would be willing to pay for a collapsible steering wheel.

In 1966, Congress enacted the National Traffic and Motor Vehicle Safety Act along with the companion Highway Safety Act. The former established the National Highway Traffic Safety Administration (NHTSA), empowering it to issue and enforce motor vehicle safety performance standards. The regulatory activities of the NHTSA provided basis for public discussion on safety and gave rise to two ideas which gained general acceptance. First, that nearly, all accidents have multiple causes, and second, that accidents and injury prevention are quite different objectives, because there are numerous means available to protect the occupants of vehicles involved in accidents.

Various views are held as to the role of the driver in accidents. Auto manufacturers urged that the primary strategy of intervention should be to alter driver behavior. Others felt that the most difficult component of the injury-producing environment to change was the driver.

4.3.2. Level of Service (LOS) (increase) :

Technically[16], the level of service (LOS) is the term used to describe the different operating conditions which may occur at an intersection when processing traffic volumes. It is a ratio of the volume of traffic to the capacity of the roadway at its design speed. Six categories of levels of service are used. These are from LOS A through LOS F. Any level of service below LOS C is unacceptable for the higher category of highways though acceptable for rural roads. However, the difficulty of measuring the level of service at unsignalized intersections has given rise to another measure referred to as Reserve Capacity.[17] This study confines itself to the earlier definition of level of service.

The Highway Capacity Manual[18] , produced by the federal highway engineers in conjunction with the highway research board in the 1960's specifies that the following speed-volume relationships may be anticipated on a modern six-lane freeway with a design speed of seventy miles per hour:

- Level A: with peak period demand in the range of 800 passenger cars per lane per hour (variable if trucks and buses are included in the traffic stream) will operate with stable speeds in the range of 60 mph or 96 kilometers per hour(kph);

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- Level C: with demand in range of 1200-1600 cars per lane per hour(depending on local habits and design geometry) will operate in range of 50 mph or 80 kph;

- Levels D-E : with demand levels in range of 1400-2000 cars per lane per hour wil operate at unstable speeds in range of 30-40 mph or 48-68 kph. The level E maximum of 2000 cars per lane per hour is defined as the freeways' capacity. It represents a volume to capacity ratio (v/c) of 1.00.

- Level F: with demand level F, operating speed may range from zero (complete breakdown) to 30 mph.

The Level of service congestion is also a qualitative measure of the congestion experienced at intersections along any segment of the highway system. In this study, congestion denotes any condition in which demand for a facility exceeds its free-flow capacity at the maximum design speed. However, it is the degree to which delay[19] is perceived as a problem requiring public action that determines both public expectations and the perceived costs of remedial measures.

In the 1950's, it was thought that congestion could be addressed by the construction of additional highway capacity; however, with widespread opposition to the development of large scale urban highway construction, congestion has come to be viewed as only one among numerous problems associated with the urban transportation system and used by critics as a symptom of the lack of defined policy

on land use. But this has not prevented congestion from the focus of attention. In fact the relief of congestion remains one of the highest priority objectives of urban transportation policy.

Questions which remain include, (a) is progress being made in the battle against congestion; (b) what precisely are the consequences of congestion, other than immediate user annoyance and time loss; (c) what criteria of benefit should guide congestion relief activities; and (d) which of the several methods available for relieving congestion is acceptable? Satisfactory answers are still elusive.

After World War II[20] it became obvious that virtually no construction had occurred and that road maintenance was neglected although the level of car use and ownership has more than tribled. Official estimates[21] were 302 billion vehicle miles in 1940, 208 billion in 1943, 250 billion in 1945, and 603 billion in 1955. No comprehensive measures of the degree of congestion were available although there was a widespread sense of deterioration in the quality of urban life. On the severity of the situation Wilfred Owen[22] had this to say concerning the problem of congestion on urban highways in the United States in the 1950's:

"American cities have become increasingly difficult to both live and to work in largely because they are difficult to move around in. The Inability to overcome congestion and to remove obstacles to mobility threathen to make the big city an economic liability rather than an asset....The greatest transportation difficulties are experienced while commuting between home and work....This movement is frequently accomplished with the most anticipated facilities and under

and the most frustrating conditions. the trip to work often cancels the gain from shorter hours on the job, and daily battle with congestion is a sharp contrast to other improvements in the moderm working conditions..."

As congestion and blight have multiplied the difficulties and frustrations of urban life, there have growing indications that in many places, urban growth has passed the point of diminishing returns...The threat of greater congestion hasraised the question of whether a nation born of farns is destined to die of cities."

Owen[23] advocated better land use planning to reduce the need for travel, tolls and higher downtown parking charges to constrain peak period demand, and even the use of highway user revenues to subsidize mass transit. His call was for the need to adapt urban spaces to the motor age through the predominant use of limited access freeway construction. There were traffic management innovations such as the use of one-way streets and staggered traffic signals.

Leaders of the automobile and related industries had reason to believe that unless something was done about upgrading the highway network, sales would drop. Leaders in business and labor believed that the growth of the vehicle related sectors of the economy was essential for continued national prosperity.

Public officials hoped that congestion relief might be an important part of the cure for their economic stagnation. Thus the circumstances were ripe for political mobilization in support of a dramatic program of congestion relief.

The thinking was that an expanded national highway program coupled with traffic growth, economic progress and an improved quality of life were inextricably linked and that the pathway to congestion relief was to expand capacity rather than demand constraint.

Although highway improvements do alleviate congestion and improve travel time, the rate at which dispersal effects occur and the extent to which they dissipate travel time savings are still very uncertain. This is made all the more complex by the differences in strategy adopted by various communities especially those with excess road capacity in outlying areas. Thus dispersal of traffic over the landscape reduces peak directional imbalances and may be seen as part of the solution to congestion as well as its cause.

There are often varying persepectives on congestion relief and the circumstances in which they indicate divergence in investments and traffic management strategies: the achievement of free-flow conditions at whatever speeds facilities are designed for; speed maximization within legal limits; highway capacity maximization; and social welfare (utility) maximization.

The choice of which should predominate either in facility planning or evaluating congestion relief programs is central in many circumstances to the definition of facility design objectives, choice of traffic management strategies and the severity of any perceived problem. At some point there is the need to diverge between the two enunciated objectives. On the one hand, speed maximization tends to suggest an emphasis on the construction of new facilities with high design speeds, even at the cost of neglecting many opportunities to improve traffic flow on existing facilities with lower design speeds. On the other hand, the objective of free-flow tends towards the design of new roadways with lower construction costs and lower design speeds, and the allocation of a larger share of available resources to the improvement of flow on existing facilities. The attached tables 4-8 and 4-9 show the standard measures of level of service for signalized intersections and the reserve capacity for unsignalized intersections respectively.

Volume-to-Capacity ratios exceeding 1.00 represent failure of the segment under consideration. The volume of traffic using a segment of a roadway is determined in two ways. Manually for Turning Movement Counts (TMC) at intersections during periods of peak traffic in the morning (between 7AM and 9AM) and at the evening rush hour between 4.15 PM and 6.15PM or as considered appropriate under the specific circumstances.

The other type of traffic count is the Mechanical Recorder Count (MRC) which requires the use of mechanical counters installed in the roadway to count and classify according to time total volume of through traffic. This is given as an Average Daily Traffic (ADT).

TABLE 4-8 : LEVEL OF SERVICE FOR CRITERIA UNSIGNALIZED INTERSECTIONS[24]

RESERVE CAPACITY	LEVEL OF SERVICE	EXPECTED DELAY
400 or more	A	Little or no delay
300 to 399	B	Short traffic delays
200 to 299	C	Average traffic delays
100 to 199	D	Long traffic delays
0 to 99	E	Very long traffic delays
< 0	F*	Extremely long to infinite

Source: Transportation Research Board, Highway Capacity Manual, Special Report 209, Washington, DC, 1985.

* A level of service F is usually taken to mean that drivers are selecting smaller than suitable size gaps to safely cross through a major street traffic. This driver behavior may cause disruption to the major traffic stream.

TABLE:4-9 LEVEL OF SERVICE CRITERIA FOR SIGNALIZED INTERSECTIONS[2][5]

LEVEL OF SERVICE	STOPPED DELAY PER VEHICLE (SEC.)	OPERATIONAL CONDITIONS OF INTERSECTIONS
A	≤ 5.0	Very low delay, most vehicles arrive during green phase.
B	5.1-15.0	Indicates intersection with good progression and/or short cycle lengths
C	15.1-25.0	Individual cycle failures begin to appear ,number of stopping vehicles is significant.
D	25.1-40.0	Many vehicles stop, individual cycle failures are noticeable.
E	40.1-60.0	Individual cycle failures are frequent, intersection reaches limit of acceptable delay.
F	> 60.0	Vehicle arrivals exceed capacity of intersection, delay unacceptable to most drivers.

Source: <u>Highway Capacity Manual</u>, Special Report 209, Transportation Research Board.

4.3.3. Pavement Condition (improve) :

Technically, the Physical condition of a highway segments is defined by two measures: pavement ride quality[26](roughness) and pavement cracking[27](distress). These are defined as the percentage of pavement area in good condition versus the percentage in adequate and poor condition, and the number of years into the future at which the standards are to be met. "Good" and "poor" are defined as follows:

	Pavement Ride Quality	Pavement Condition %
Good	<= 165 in. axle deflection/ mile	<= 10
Poor	> 225 in. axle deflection/ mile	> 30

The axle deflection is measured using standard ridemeter techniques. Pavement quality is a criterion that is most demanding of the quantitative criteria based on clearly defined standards.

The State highway system within a community is a closed system that connects the major centers of traffic attraction with the rural state highway system. The city street and county road systems then are assigned responsibility for all other public roads. The use of the functional classification plan as a basis for redesignation of administrative road system assures system continuity.

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Various portions of the transportation network are the responsibility of either the federal government, the state government, or the local government. Furthermore, the network is classified first by the functions of the roads and then administratively. While the use of the functional classification plan as a basis for redesignation of administrative road system assures system continuity, the proper designation of Federal-aid routes is also important for federal-aid highway funds.

Although many states have their aid programs to cities, counties and towns for improvement of roads such funding is expended on specific classes of city, county, or town roads. Some cities and counties specify administrative sub-classes of city and county roads keyed to policies for improvements. Arterials, collectors, and local residential street classifications are adopted with specific funding arrangement for each. Thus the administrative classification of the street and highway network is in accordance with state guidelines where they exist and are based on alternative plans for administering urban streets and highways. This is based on the functional classification of the network.

These or similar inconsistencies present problems to state, city , town, and county administators; because neither short- nor long-range programming of improvements can be made without firm knowledge of administrative road responsibility.

The tables 4-10 to 4-11 show the administrative and the functional classification of all the roads in the MAPC region of 101 communities. Furthermore, the administrative plans ensure uniformity in miles of state and local street and highway among the urban jurisdictions and among other urban area jurisdiction in the state. A balance is sought in the range of state and local road mileage among jurisdictions.

This balance takes into consideration the variation in geography from jurisdiction to jurisdiction which might cause differences in the portion of street and road mileage assigned to various functional classess. It would be unrealistic to adopt or recomend an administrative classification plan that designated 30% of a county road network as state highway when the percentage of state highways for other urban counties range from 10% to 20%- unless the plan is in line with a statewide plan for reassignment of the jurisdiction of all roads in the state.

Finally, depending on the established relationship between local and state governments, a balance is sought in the amount and nature of travel served. Guided by the amount of travel served by each of the functional classes of street and highway, local responsibility raises the hierarchy of classes until the cumulative travel served reaches the level sought.

4.3.4 Total Costs (R-O-W; Preliminary Engineering; Construction): (minimize costs).

Every project has a preliminary-costs-estimate which may be subdivided into the Right-of-Way (R-O-W) acquisition costs, Preliminary engineering Design consultancy fees both of which are before the project is advertised, and construction costs after the project is advertised. Federal-Aid highway funds are only available for construction. Given the limited funding available for improvement projects, there is a strong tendency to implement the less expensive projects before the more expensive ones.

Thus, if the purpose of setting priorities among projects is to determine which should be implemented first, then given different categories of projects and different funding levels and sources, a project in one category may be implemented while a more important project in another category is not. In other words, project comparism should be made within categories and not across categories since only those within the same category are in a real sense competing against each other. However, such a situation raises two questions: first, to what extent does this categorization affect the true as well as the perceived ranking of projects; and second, on what basis are funds allocated between various categories?

The purpose of setting priorities among projects is to determine which should be performed first. Funding levels for the different categories are determined independently, so a project in one category may be funded when a more important project in another category may not. The relevant group of projects which should be compared, then, is those in the same funding category, for those projects in a real sense compete with each other. But this categorical distinction is only for better control of the situation not that these categories are fundamentally different. It should be possible when situations demand to waive this categorical distinction since it is in essence very arbitrary.

The significant decision that must be made includes : (a) is it more efficient to prioritize all projects according to their respective categories or (b) to prioritize all projects according to those criteria that will in effect reduce these projects to the same denominator to make true comparism and competition possible in the best interest of optimal resource allocation for the good of society? The fact that some categories hardly have any projects and have adequate funds for their needs when some other categories hardly have enough to meet half of their needs reveals the need for more flexiblility in the allocation of available funds (see analysis of TIP- Fiscal Year 1985).[28]

For example, although the Interstate category has only a few projects these are very large scale projects such as the proposed Central Artery depression or the Reconstruction of the I-95/Route 128 Interchange in Peabody. These are prioritized at the highest executive/legislative levels. On the contrary, projects in the Urban Systems, Boston Category are at the discretion of the City of Boston. On the contrary, certain categories such as Pavement Marking, RailRoad Crossings, etc only have a handful of projects for which there are sufficient costs.

Nevertheless, all of these projects are reducible to a common basis for purposes of comparism. That common basis is their unit cost measured either, linearly,[29] superficially,[30] or volumetrically.[31] Whatever authority is responsible for whatever category should set or ensure that priorities are set since resources are always insufficient. From a strictly economics consideration, the less expensive of two projects will leave scarce resources availablr for investment and hence is more likely to be preferred over the other. The only way to standardize such a criterion is to reduce all projects to unit costs. Such standardization effectively neutralizes the categorization of projects.

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4.3.5. Total Time (Precontract Consultancy and Site Works) : (Minimize total time)

The objective is to reduce to a minimum the total time spent from the inception of a project to its commssioning. This is necessary when it is realized that the less the time the project requires the shorter the duration of environmental disruption arising from construction works and the more predictable its final cost (less uncertainty from contingencies due to policy changes, energy, etc) considering the time-value of money.

Although, the final cost of a project is often a function of its complexity and its duration, this is more true for construction site-works (for contracts with fluctuation clauses) than for design work by professionals whose fees are usually a fixed per centage of the estimated project cost for large projects. The significance of such a distinction becomes relevant when the various phases of a project from inception through design to construction are taken together on a total-time basis.

Pre-construction time is profesional time which also concerns the ability of the affected community to retain the professional services of competent engineers who in turn are able to employ time-saving techniques to produce high quality work within the shortest time possible, even if at slightly higher costs.

Construction time is builder's time. Even when construction time is the more perceptible in terms of visible progress made on the project from the public perspective, the Design-time determines how soon progress is made to site works. Without the former, a project cannot move on to the latter. Thus a community may not be seriously considered for federal-aid funding as currently happens, if it cannot purchase the R-O-W for improvements, or where it cannot afford the services of consultants for its preliminary engineering work as a result of a weak fiscal base (including limitations imposed by proposition $2^1/2$). Such a community cannot get to where its transportation needs are taken seriously.

Hence communities that have the 'need' but are financially incapable are in an unfavorable position compared with those communities that have a larger fiscal base. This is almost becoming the norm.[32] This is why the element of time must be isolated from the element of cost. In this respect, the longer a project has been in the 'pipeline' the greater priority it should receive. Between the two criteria of cost and time, the difficulties of both economic as well s technological feasibility are adequately subsumed.

The logic of this approach is similar to that adopted for the maintenance[33] of existing pavements. The sooner the pavement defect is rectified the less it will ultimately cost to rectify. The quicker it is to rectify the fault the less expensive it probably will cost to carry out. But there is an apparent conflict !

While it makes sense to move forward with projects that have been on th pipeline for long periods, this will not be recommended if such projects are expected to take considerable periods of time to implement on site. Therefore it is necessary to differentiate between two notions of time which are inversely related. It is not necessary to develop another scale for each pre-project phase of a project. it is only necessary to recognize that the actual time for projects must begin from the time that project is formally approved by the MDPW project review committee. Therefore the actual time for a project is the sum of time taken to complete the engineering and right-of-way acquisitions up to and including the advertisement and bid; and the construction time on site.

For example, given a project that was in the 1981 TIP listed under the 2-5 Year Element, in 1985, that project would be 5 years in the pipeline or pre-project stage. If the estimated construction time is 9 months, then the composite time factor is the sum of both categories; that is, the time for project implementation is 5 years 9 months. There is no need to categorize projects as short, medium or long-term projects according to their implementation time factor.

TABLE 3-4 : TIP PROJECTS   COSTS   versus   AVAILABLE FUNDS

Category	TIP Project Costs			Available	Difference	
	Annual	2-5 Year	Total	Funds	$	%
C/Primary	19,178	140,075	159,254	264,921	105,668	66%
R/Secondary	500	1,300	1,800	31,439	29,639	1646%
U/Systems,B.	5,300	24,500	29,800	20,200	-9,600	-32%
U/S,Urb Area	20,808	64,943	85,751	47,200	-38,551	-45%
Bridge	30,050	128,989	159,048	230,038	70,990	45%
I/Transfers	14,734	67,999	82,733	88,404	5,671	7%

Note : All amounts in thousands of Dollars.

Source : MAPC Study, Setting Priorities Among Transportation Projects

For The Metropolitan Planning Organization, December 1983, Page 3.

TABLE 3-5 : TIP FUNDING CATEGORIES, 1985-1989 TIP

Category	# Projects	Total $	Funding Basis	Set Priorities?	Reason,if No
Interstate	7	2,413,000,000	Federal	No	Federal projects,federally planned
I/R	15	74,415,000	Federal	No	Federally planned
C/Primary	21	159,253,000	State	Yes	
R/S	3	1,800,000	State	Yes	
Urb/S,B	9	29,800,000	City	No	Locally planned
USBUA	69	85,751,000	Regional	Yes	
H/BR&R	86	159,048,000	State	Yes	
C/P(RRR)	2	5,700,000	State	No	Few projects,sufficient funds
H/Elim	5	2,203,000	Regional	No	,,
P/M	1	125,000	Regional	No	,,
RR/Xing(C)	1	125,000	Regional	No	,,
RR/ ,, (PD)	1	150,000	Regional	No	,,
I/T	26	82,733,000	State	Yes	

Source : MAPC Study, Setting Priorities Among transportation Projects For Metropolitan Planning Organization, Final Draft, December, 1985, page 5

Legend:
Interstate

I/R	-Interstate Resurfacing
C/P	-Consolidated Primary
R/S	-Rural Secondary
U/SB	-Urban Systems Boston
U/SBUA	-Urban Systems Boston Urbanized Area
H/BRR	-Highway Bridge R and R
C/P(RRR)	-Consolidated Primary (RRR)
H/Elim	-Hazard Elimination
P/M	-Pavement Marking
RR/Xing(C)	-RailRoad Crossings(Construction)
RR/Xing(PD)	-RailRoad Crossings(Protective Devices)
I/Transfer	-Interstate Transfers

4.3.6. Equity (increase) :

As a philosophic concept denoting fairness and justice, the equity criterion has tended to resist consensual definition or precise measurement. Harrison[34] (1987) in *The Great U-Turn* on the political economy of corporate America from the mid-1960's suggests that there has been a growing inequality in income[35] since the mid-1970's which has trickled down into other socio-economic aspects of American life. Providing unparalleled mobility for those with ready access to motor vehicles, the urban transportation system has tended to provide increasingly poorer service to those who lack. Such widening inequality claims Altshuler[36] is unusual in modern American society, and gives a special flavor to discussions of equity in the context of urban transportation policy.

It is a sign of justice and fair play to ensure that all members of society have equal access to the good things that are being provided for all irrespective of any handicap that may make particular individuals less able to. An auto-dominated system, which makes the adult driving majority very mobile at the same time reduces the effective mobility of those without ready access to private automobiles. For those unable to walk long distances to transit stops there should be public assistance to reduce perceived inequities. Those specifically affected include the very young, the old, the physically disables, the mentally disabled and the economically disabled.

The traditional perception of equity is in relation to individuals. This study wants to focus on the issue of equity at a higher order of significance. That is on communities not individuals! Since individuals make up communities, equity at this level concerns the inability of communities to meet their transportation needs as a result of disproportionately small fiscal base arising from low socio-economic growth activity and development.

4.3.7. Politics (define) :

This criterion is philosophical and perceptual. The objective here is to define the political dimension of the priority setting problem. Thus, politically, the setting of priorities takes on a significance of its own. This is because, as in a democracy, real power derives from the people through the electoral process. Enhanced by institutionalized participatory planning, political power is severally and collectively exercised. The paradox of this situation is that as a group, the American public appears hostile to public policy affecting urban transportation.

Notable public policies in this category are those on carpooling and vanpooling resisted as intended to reduce automobile use; new highways resisted as disruptive of existing neighborhoods, social patterns and natural ecologies; automobile travel disincentives resisted as disruptive of established behavior patterns, etc, etc.

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Individually, Americans appear as citizens who are receptive to being provided with improved services, and press their public officials to alleviate a myriad of problems   insofar as their environs and lifestyles are concerned and highly pluralistic.   American citizens are therefore, in the perception of   political office-seekers, often very susceptible to taking out their annoyance on elected public officials who are perceived as averting, or, worse still, deliberately creating a situation of inconvenience.

Thus public policy of American governments have assumed symbolic[37] character when legislative instruments have been relatively ineffective in serving their announced objectives when their strict implementation would discomfort large numbers of voters.   Stated differently, the capacity of the American political structure has tended to vary with both the nature of the problem as well as with the nature of the means required to address it effectively.

Public policy in America is increasingly structured to regulate large corporations while empowering the average American voter.   Not only is it far more congenial to distribute benefits than to distribute penalties;   it is more politically expedient to spend through subsidies than it is to regulate!   It is thus the people versus the corporations in the marketplace !

Therefore the power relations between the elected local official as a true representative of the people and the appointed officials ought to be more clearly defined. It is the elected officials who provide or are responsible for the expenditure of funds for various programs including highway programs.

They are accountable to the people, and hence must determine what projects get funded and which do not. They may also accept the advice of technocrats or frustrate it as they please. Politicians must have first cut at the exercise, even if they are not able to agree on which projects deserve first consideration. Thus while the degree of involvement may vary from one state to the other, there is no alternative to involving politicians at the very early stage in the prioritization process for the following role:

- the subjective evaluation of needs as well as the determination of local priority-setting and a defence of such list of priorities as a first stage of an MPO process;

- the mobilization of community residents to participate fully in the public hearings in which to present and defend the prioritization of the local community needs as assessed by the elected local officials before their electorate;

- effective liaison between politicians at local, state and federal levels according to funding source, federal or state.

The increasing degree of involvement on the part of state legislatures either in the form of line-item budget approvals to the appropriation of total budget or approval of individual projects is an indication of increasing awareness on the part of political office holders of their responsibility to their electorate.

This appears to be happening more in those states where there is executive request for additional tax revenue for highway purposes. It cannot be stated too emphatically that establishing highway priorities is only part of an even more complex political decision-making process. Although most decision-makers are not technical experts they nevertheless are responsible to the people while the appointed technical experts are not. More technical professionals should be made aware of this fact.

4.3.7.1 Aesthetics

On the matter of aesthetics there is cause to believe that this factor is subsumed in the political awareness of the electorate, whether it is the pollution of the environment, poor air quality, noise, scenic views, etc. It is thus accounted for by the electoral pledges of those running for elected office who then become politicians. There are precedents with respect to the environmental response that politicians at various times have given to assure communities of action in relation to the rerouting of planned highways.

4.4. Discussion

There are always two sides to a coin. In planning, one side of that coin is the positivist[38] view of knowledge on planning practice which has tended to encourage planners to try to be value-neutral, to focus on measurable issues and general principles, and to see the production of information as distinct from the political process. This is the technical perception of knowledge for planning and policy.

The other side of the proverbial coin is the phenomenological conception of knowledge which in focusing on the every day world, emphasizes the subjective meanings of problems and assumes knowledge as constructed in a community[39] rather than having an independent existence. It accepts information as shaped by preconceptions.

As a planning guide, the latter can better link knowledge to action because it deals with issues in forms more recognizable to decision-makers. It offers a more reliable model of what practitioners actually do, and engages the decision-maker in the information production process so they are more prepared to act on the results.

As the two philosophical criteria earlier discussed, equity and politics may best be considered from the point of view of a 'critical theory' such as that postulated by Jurgen Habermas[40] in his communication theory of society.

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This theory clarifies how planning practice works as communication action, how planning action and broader political-economic forces may work to thwart or foster a democratic planning process and how a planning theory assessing planning practice can be concretely empirical, and immediately normative, offering pragmatic strategy and political vision at one and the same time. A critical theory provides a new way of understanding action, or what a planner does, as attention-shaping (communicative action), rather than more narrowly as a means to a particular end (instrumental action).

Thus if planners do not recognize how their ordinary actions may have subtle communicative effects, planners may be well-meaning but nevertheless counterproductive. Thus critical theory illuminates both structural obstacles to a democratic planning process and the pragmatic opportunities planners have to counter and overcome those obstacles. The emphasis here is from scientific technique to more inter-personal communication as a strategy for consensus building and planning action.

The other criteria namely, level of service, safety, costs and time are largely quantitative if not technical. Technical may be defined as lending itself to scientific and precise measurement. It is however true that not everything that is quantitative is technical.

We may nevertheless consider these criteria as numerical, semi-numerical or non-numerical depending on their form and to what extent they lend themselves to empirical measurement or mathematical computation.

A numerical problem is one which solves a problem where the numerical content including output is essential and meaningful. Numericals in this case form an interval or ratio scale. A non-numerical problem, on the other hand, solves problems the solution of which although in some cases expressed by a number (or set of numbers) is of a non-numerical nature. An example of a non-numerical problem is rank ordering or sorting in order of a set of unordered items. Such ranking could also be a string of letters. Numericals in this instance form an ordinal scale. Between the interval/ratio and the ordinal is the cardinal or semi-numerical problem as in ratings.

It is necessary to differentiate between ranking and rating. Ranking requires the decision-maker (DM) to sort and order the various criteria on the basis of their relative importance. Such relative importance is then quantified with 'weights' which are then standardized by dividing each by the sum of the original weights, that is , $w_i/\Sigma\ w_i$. Rating, on the other hand, requires the decision-maker (DM) to assign weights judgementally on the basis of a pre-determined scale.

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5. INTRODUCTION : REVIEW OF SELECTED METHODS

This chapter reviews selected methods that have been used to set priorities for transportation improvement projects in various states of the country. Various criteria have been used in the selection of these methods. The applications for decision-making are limitless. There are more than 50 methods[1] that have been applied to multi criteria decision making (MODM) within a period of 20 years and there has not been enough opportunity to evaluate them. Some of these methods were specifically developed to address specific problem types while others have been developed for more universal application.

5.1 measurement

The essence of each multiple-objective-decision-making (MODM) procedure is the valid comparism of candidate projects within a more or less well-defined group. This can only be done through measurement. Conceptually, measurement is the "identification of the quantitative relationship between two or more projects and their impacts established by means of a standard that serves as a unit"[2] or as "rules for assigning numbers to projects to represent quantities or attributes".[3] Operationally, measurement is "communication based on rules with a one-to-one correspondence".

Thus unless the recipient of such communication knows the rules by which the sender has made the assignment, there will be ambiguity as to its meaning. Two requirements are that the projects be measured by appropriate attributes and that the standard of measurement be a specific unit representing those attributes.

This is because while the choice of a given standard is optional, the mathematical rules for using it are not, so the methods which are employed require the most rigorous precision and compliance with the objective rules. Another significant aspect of measurements is their multiple-role in concept-formation through differentiation and integration; differentiation in terms of commensurable characteristics which possess a common unit of measurement, and incommensurable characteristics which cannot be integrated into one unit.

Using the proverbial example of apples and oranges, measurement ensures that 20 apples juxtaposed to 20 oranges will give " 20 apples and 20 oranges". They could also give "40 fruits" depending on the selected characteristic. Thus our comparism could choose to focus on the similarities or differences between categories or we could choose to emphasize the similarities or differences within categories. Furthermore, faced with the choice of a fruit based on the simultaneous or successive consideration of both categories of fruit, I could elect to examine each individual fruit by comparing it to what an apple or an orange should be; or, more specifically to the group of fruits under consideration.

Even in the exercise of such choice, I could opt to state, prior to the actual selection process, what the weight, color, taste, profile, etc of the chosen fruit would be such that an assistant may do the actual selection according to specification or I could choose to reveal these specifications as I progressed along. I could even wait to reveal these characteristics after I have made a satisfactory selection in which case I do not run the risk of an observer pointing out any discrepancies between my actual choice and the charateristics specified earlier. Simplistic as this analogy may be, it does at least two things. On the one hand, it suggests the method of comparism. On the other, it suggests both the level of subjective input as well as the point in the process at which it is articulated. It may also suggest the complexity of measurement within and between categories.

Technically, the multi-objective-decision-making (MODM) methods examined include, the Index, Percentile, Successive-subsetting, and the Elimination and Choice Translating Algorithm (ELECTRE) methods. The Index method standardizes the attributes for an alternative project on a range by comparing its raw scores with the specific set of projects in which the project occurs. The Percentile method shows where a particular project stands in relation to a specific set of projects by reporting what percentage of that distribution falls below its scores.

The Successive-subsetting method is a subjective method which relies more on a hierarchical structure of the criteria than on the scores of the projects themselves. The ELECTRE is a two part procedure which reduces the size of a non-dominated set of alternatives projects by comparing and contrasting them in pairs.

The development of over fifty MODM methods within a period of two decades makes the matching of procedure to objective very vital. Some methods lend themselves to discrete sets of alternatives(5-10) while others are more suitable for continuous or infinite sets of alternatives. However, continuous sets of alternatives can be decomposed into clusters based on type of project. Presently, projects are pre-screened by being clustered into categories.

The following is a summary description of four simple methods which have been used by different Transportation Departments in various states of the country. This is followed by a discussion of their relative strengths and weaknesses and the context to which they are best suited. Three aspects of these methods which will be emphasized are, their algebraic complexity, computational complexity and their numerical accuracy. Examples have been adapted from various sources as referenced to further explain the application of these methods.

5.1. THE INDEX RANKING METHOD

The Index Ranking Method or Index Method uses as a ranking method the proportion of distance that a given segment's factor value lies between the best and the worst factor values. The total distance between the best and the worst factor values in the needs list is called the "range". A better value is one that would place a segment lower in the priority list than the segment currently under consideration. For example:

- a better (lower priority) segment with respect to the factor being evaluated would have a lower ADT, higher pavement condition rating (PCR), and lower hazard.(see attached tables. The equations for the segment indices are as follows:

$$I_j = (x/R) \times 100 \dots\dots\dots(1)$$

$$IC = \sum_{j=1}^{n} [(I_j \times w_j)/(\sum_{j=1}^{n} w_j)] \dots\dots\dots(2)$$

where

f_w = worst value of factor for segments in needs list;

f_b = best value of factor for segments in needs list;

x = difference between f_b and the factor value;

R = difference between f_b and f_w, the range of values of factor under consideration;

I_j = segment index value, based on its value for factor j;

n = number of factors in the evaluation j = 1,...n;

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IC = composite factor index of the segment under

consideration, including all factors; and

w_j = weight for j th factor.

5.1.1. Example 1: (adapted from TRR 1124 p. 11)

The ADT index value for segment C, using Equation 1, is

$$I_{ADT}(C) = (5{,}704 - 98)/5{,}606 \times 100 = 100 \quad \ldots\ldots\ldots(3)$$

Segment K will receive an index value of 0 because no segment has a less needy traffic factor than it does. Because of Segment C's very large ADT, the rest of the segments receive low index values, as shown in Table 2. Once all the factors are evaluated, a composite index value can be calculated. Each factor index value can be weighted before calculating the total. In this example, each factor weight is set at 1. Using Equation 2, the composite index for road Segment C, using the first four factors in the order presented in Table 1, is given by the expression:

$$(75 * 1 + 100 * 1 + 0 * 1 + 28 * 1)/(1 + 1 + 1 + 1) = 50.8$$

(see the complete ranked list of segments in Tables 2 below).

The following criteria have been used to determine which of the following candidate projects must be implemented first, second, and which one should be implemented last; i.e. ranking the 11 projects:

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(100) fw—┼— Most needy segment

Range

—┼—┼— Segment under consideration

(0) fb—┼—┼— x   Least needy segment
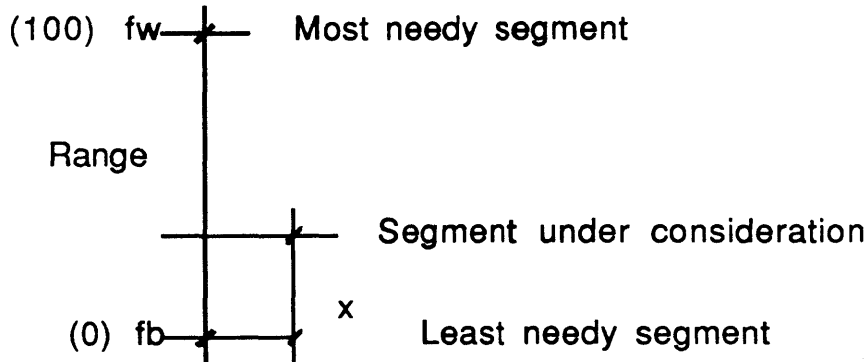
FIGURE 5-1

fw   = worst value of factor for segment in needs list;

fb   = best value of factor for segments in needs list;

x   = difference between fb and the worst value;

R   = difference between fb and fw, the range of values of factor under consideration.; etc.

Ij = segment index value, based on its value for factor j;

n = number of factors in the evaluation j= 1,....,n;

IC = composite factor index of the segment under consideration, including all factors; and

wj = weight for jth factor.

(The completely ranked list of projects is as shown in Table 5-2). The criteria listed below have been used to determine which of the following projects should be implemented first, second and last, that is, ranking the short list of 11 projects. There are various ways in which 11 projects may be selected for use. They may be the first eleven alternatives to emerge in an initial screening process from a long list of hundreds of alternatives or they may be randomly selected as a sample to more easily illustrate the procedures being discussed. These 11 projects are a random sample from a list of projects. The variables being used for the ranking are:

Project	:	Road Segment Identifier
ADT	:	Average Daily Traffic (raw interval measure)
$/MILE	:	Project cost per mile for the segment
TIME	:	Total duration of Project (in months)
PCT	:	Pavement Condition Rating (5=best;0=worst)
HAZ	:	Index of Safety Hazard (0=safest;5=worst)

5.1.2. Discussion

Conceptually, the lower the score (raw or standardized) the better; see figure 5-1. It is thus relatively easy to determine which is the most needy or most preferred project if the decision is based on a single criterion. For example, where the user population is the criterion, then the roadway with the highest volume of traffic will be the obvious choice and this is segement A followed by segment J.

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If cost per mile($/MILE) is the criterion, then segment F which costs nothing since the expense will be borne by someone else is the first choice, segment G is second and segment H is the last to be repaired. If the duration of the project is the criterion, then segment K which will last only one half of a year in duration is most preferred, second is either segment D or segment J and last is segment C.

The difficulty arises when two or more criteria have to be considered simultaneously to determine the most needy project. For example, segment C though most needy when traffic and user population is concerned is the least considered when cost is involved. Segments K,D and J although needy from a time factor are not the least expensive. How are the criteria related to each other from the point of view of accuracy when combined numerically and how are they related in importance?

Stated differently, our problem is to combine across five dimensions where the standards or units of measurement are, vehicles (cardinal number), months or years (time), costs per mile, subjective rating on a reverse scale (from 5 to 0) and an index on a progressive scale (0 to 5). The last two measures are ordinal while the first three though cardinal are different. What does it mean to add vehicles to months to dollars per mile? Nothing! However, the question is: does the index method try to add vehicles to months to dollars per mile ?
Probably not!

What the Index method does is to eliminate the different units and create unit-less indices by first standardizing the raw scores within each dimension. It does this by determining where a particular score happens to be within a "range" of scores and what proportion that is of that range where the entire range could be 100 or 1 at the highest and 0 at the lowest (refer back to figure 5-1). it then adds up all standardized scores to a composite score which is then ranked.

The Pavement Condition Rating (PCR) and the Index of Safety Hazard(HAZ) belong to a different category. They are ordinal. Most sufficiency ratings are ordinal or 'descriptive' since they use a mathematical expression as a measure of immediacy of need. In other words, although they are numbers, it does not make sense to add then together. They may have been derived from cardinal numbers as is the case with PCR and HAZ.

5.1.2.1. pavement condition rating

The major difficulty with pavement condition rating is that it is itself a composite measure. One of the statistical techniques used to determine this rating is the Discriminant Analysis. This technique is used to classify data into groups by maximizing the difference between group means. But to do this, a collection of discriminating variables that measure characteristics for which the groups are expected to differ is made.

Thus the mathematical objective of the process is to weight and linearly combined these discriminating variables so that the groups are forced to be as statistically distinct. The variables are of two broad categories, namely, pavement quality and ride quality. Distress manifestation measure is measured in number of distresses per lane per mile. There are about fifteen manifestations which may be divided into five categories. These are: Ravelling and coarse aggregate loss, Flushing, Rippling and Shoring, Rutting, Cracking of various kinds (Alligator. longitudinal, transverse, etc)

The PCR is a measure of overall pavement serviceability on a scale of 0 to 100. Newly constructed pavements have a PCR of 95; rehabilitation is mostly done on pavement anywhere between 40-60. This figure is got by subtracting the number of distresses from the total of 100. It is therefore correct to say that the PCR is a cardinal number which can be replaced by the expression:

$$z = 1.0 - 0.0071(MPUNT) - 0.3978(SPUNT) - 0.4165(PATCH)$$

where,

z''	= distress index or score
MPUNT	= ln(minor punchouts per mile + 1)
SPUNT	= ln(severe punchouts per mile + 1)
PATCH	= ln(total patches per mile + 1)

5.1.2.2. safety

The elements of safety are three: the vehicle, the driver and the roadway. Accidents are in three categories:

a) fatal accident or fatal accident injury;

b) non-fatal injury accident;

c) property-damage-only accident.

Accident or hazard (absence of safety) is measured in one of many ways: e.g.,   fatalities per 10,000 registered vehicles

fatalities per 100,000,000 vehicle miles traveled

fatalities per 100,000 population

The most preferred measure is the fatalities per 100,000,000 vehicle miles traveled per three year period. These rates are categorized into levels of safety. The most hazardous locations, that is, least safe, are spots or segments which have a product of 5 or more accidents per 100,000,000 vehicle miles. The safest are those that have 0. Statistically, it is correct to say 0-0.99 accidents, 1.0-1.99 accidents, 2- 2.99 accidents, 3-3.99 accidents, 4-4.99 accidents per 100 million vehicle miles traveled could be represented by their class means which are 0.45, 1.45, 2.45, 3.45, 4.45 respectively. These could be rounded to 1, 2, 3, 4, and 5 respectively without serious cumulative rounding errors and these numbers would be cardinal and could be used as such. They could also be as ordinal numbers representing categories. In this study both the PCR and HAZ would be treated differently from the other three namely: ADT, $/MILE and TIME.

TABLE : 5-2

DATA FOR PRIORITY- SETTING EXAMPLE WITH 11 ROAD SEGMENTS

Segment	PCR	ADT	HAZ	TIME(YR)	$/mile
A	1	366	0	2.3	79,000
B	3	448	0	2.5	18,000
C	2	5704	0	6.6	61,000
D	2	106	2	1.2	75,000
E	3	263	1	1.5	31,000
F	5	539	0	2.6	0
G	4	278	0	2.0	11,000
H	2	125	1	1.9	85,000
I	3	119	0	3.2	20,000
J	1	672	0	1.2	65,000
K	2	98	0	0.5	60,000

TABLE : 5-3

RESULTS OF INDEX PRIORITY-SETTING METHOD

SEG #	PCR Index	ADT Index	HAZ Index	$/MILE Index	COMP. Index	Final Rank
A	100	7.4	0	7	28.6	9TH
B	50	6.2	0	79	33.8	4TH
C	75	100	0	28	50.8	1ST
D	75	0.1	100	12	46.8	2ND
E	50	2.9	50	64	41.7	3RD
F	0	4.7	0	100	26.2	10TH
G	25	3.2	0	87	28.8	8TH
H	75	0.5	0	0	31.4	7TH
I	50	0.4	0	76	31.6	6TH
J	100	10.2	0	24	33.6	5TH
K	75	0	0	29	26	11TH

5.2 THE PERCENTILE METHOD

_____

The Percentile Ranking Method represents that proportion of the other segments in a needs list that fail to be as deserving of road funds as measured by the value of the factor under consideration. For a single factor, a road segment is ranked as part of segments being considered in a set. Each segment competes with the other segments on the list to see how much justification there is for allocating road funds to it. For a single factor:

$$P = [B/(B + W)] * 100 \quad\text{...} (3)$$

where

P = percentile rank of the segment

B = number of segments with better values, and

W = number of segments with worse values

As in the index method, a better value is one that would place a segment lower in the priority list than the segment currently under consideration. For simplicity, those segments having the same factor value as the segment being ranked are excluded from the counts of B and W. In the rare but possible case in which all segments have the same factor value, P is set to 50 arbitrarily.

This percentile ranking is done separately for each factor, then combined into a weighted sum pi ($\overline{\pi}$) for each segment. The weighted sum ii is then divided by the sum of the weights w_j to produce the composite percentile PC.

$$\overline{\pi} = \sum_j w_j * P_j$$

with w_j = weight of j th factor, and

$$PC = \overline{\pi} / \sum_j w_j$$

Example 2:

Using Equation 3 above, the PCR values for Segments B, E, and I are translated into the following percentile:

$$P_B = P_E = P_I = [2/(2 + 6)] * 100 = 25 \quad\quad\quad (4)$$

Note that segments with the same factor value were excluded from the counts of B and W in equation 3. Segment F, with a PCR of 5, receives a percentile of 0, as no segments have a better factor value than Segment F does. The same procedure is then followed for the remaining factors. For this example, each factor will be considered equally important. Thus the weights wj assigned to each factor are set to 1.

For Segment C, using Equations 3, 4, and 5 to determine PC, the composite percentile follows:

$$P_{PCR} = [5/(5 + 2)] * 100 = 71 \dots\dots\dots\dots\dots\dots\dots(5)$$

$$P_{ADT} = [11/(11 + 0)] * 100 = 100 \dots\dots\dots\dots\dots(6)$$

$$P_{HAZ} = [0/(0 + 3)] * 100 = 0 \dots\dots\dots\dots\dots\dots(7)$$

$$P_{\$/MILE} = [4/(4 + 6)] * 100 = 40 \dots\dots\dots\dots\dots(8)$$

$$\pi_c = (1*71) + (1*100) + (1*0) + (1*40) = 211 \dots\dots\dots(9)$$

$$PC = 211/(1 + 1 + 1 + 1) = 52.8 \dots\dots\dots\dots(10)$$

Segment C's composite percentile is 52.8. The composite percentile is then computed for each remaining segment. A list of project ranks is then compiled and printed. Table 5-3 presents the results.

TABLE : 5-3

RESULTS OF PERCENTILE PRIORITY- SETTING METHOD

SEG. #	PCR P'tile	ADT P'tile	HAZ P'tile	$/MILE P'tile	COMPOSITE P'tile *	FINAL Rank
A	100	70	0	10	45	7TH
B	25	80	0	80	46.3	6TH
C	71	100	0	40	52.8	3RD
D	71	10	100	20	50.3	4TH
E	25	40	89	60	53.5	2ND
F	0	60	0	100	40	8TH
G	10	50	0	90	37.5	9TH
H	71	30	89	0	47.5	5TH
I	25	20	0	70	28.8	11TH
J	71	90	0	30	55	1ST
K	71	0	0	50	30.3	10TH

*   ALL FACTOR WEIGHTS SET TO 1

5.3. SUCCESSIVE SUBSETTING METHOD (SS)

The most significant aspects of the successive subsetting[1] method are the key assumptions upon which it is based. The first assumption is that the impacts of highway improvements cannot be precisely measured; and even if they could be, their limits of accuracy would be quite large. The second assumption is that the utility functions of criteria are linear. The third assumption is that establishment of hierarchies is basic to nature's way of breaking reality into clusters . That is the systematic decomposition of the complexity encountered. In this method, projects are first grouped into the desired number of small groups, or subsets, using the criteria of highest hierarchy.

Each subset of projects is then clustered into groups using criteria of the next important hierarchy. This process is repeated until each subset has only one project; that is, until it is ranked. The SS method is basically a graphical approach to priority setting and no numerical values are generated for comparism. (see the attached figure). However, the SS method does not lend itself readily to computerization, if that is possible, when there is more than one criterion at one stratum of hierarchy. It is consequently adequate only for a small-scale problem. While this method provides ranking, it does not give the final weights to the projects. Consequently, when some projects have close relative weights, there is no way to logically compare them.
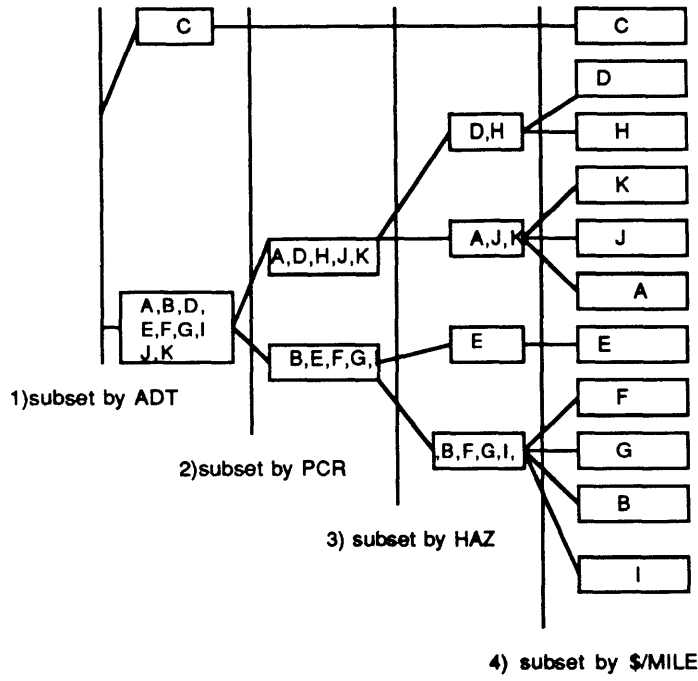
FIGURE 5-2

USE OF SUCCESSIVE- SUBSETTING METHOD OF PRIORITIZATION (TRR,1124,P.12)

This method is advantageous in situations for which subjective judgements can be the only way to solve problems and the evaluation process needs to be based on fuzzy and unstructured criteria measures. A feature of the successive subsetting method is that the sensitivity is controlled by the order in which the factors are chosen for subsetting. There is no need for the determination of specific weights that might be difficult for a number of decision makers to agree upon. The successive subsetting method assumes that projects can be only roughly lumped into subsets according to a given factor. The members of each factor subset should have approximately the same value for the factor under consideration. Each one of these smaller sets can then be further subdivided using subsequent evaluation criteria.

In the attached figure 4, four ADT subsets are distinguishable. The first subset contains only segment C ,with an ADT of 5,704 vpd that is much larger than the second greatest ADT. The second susbset contains only segment J, with an ADT of 672 vpd. Segments A,B,E,F, and G which fall into another subset of similiar ADT values from 263 to 448 vpd. The final subset, Segments D, H, I, and K, consists of segments with low ADT values, from 98 to 125 vpd. The next factor to be considered is the PCR. (Any method of characterising pavement condition is acceptable. In this example, a subjective rating of the pavement surface is used, with 1 = worst and 5= best). Segments C and J remain at the top of the list because they are the only segments in their respective subset.

The third initial subset can be divided into four course new subsets. Segment A with the lowest PCR value of 1 will form an individual subset, because no other segments in the initial subset have as needy a PCR value. The second new PCR subset contains Segments B and E, with PCR values of 3. The PCR of Segments B and E makes them less needy than Segment A, so they are ranked below Segment A. Segments G and F, with PCR values of 4 and 5, respectively, form the final two least needy subsets from the third initial subset. Segment I forms a new subset ranked below the fourth original subset, because segment I has a less needy PCR value than Segments D,H, and K.

The hazard rating HAZ further divides the six subsets. Three segments, D, E, and H have hazard ratings greater than zero, and form new individual subset, ranked below the subset containing Segment H. The final factor to be used for subsetting is the cost per mile($/MILE) to correct the segments' deficiencies. Because the segments are already in individual subsets, the $/MILE factor is not needed for further subsetting. If $/MILE is used, a segment with a lower cost per mile would be ranked above a segment with a higher cost per mile. All road segments are now ranked in individual subsets, according to the order of priorities ADT, PCR, HAZ, and $/MILE. The most needy road segments could be selected for funding.

Using the successive subsetting method, a large number of road segments can be ranked in a small number of steps from information that is not so precise. Because only a limited amount of information has to be collected, savings in acquision costs result. However, for the subsetting method to be effective, decision-makers must clearly understand their priorities. This method requires that the factors be ranked in order of importance. Equal weighting of factors as used in the index and percentile examples is not possible. Also, because the first subsetting step has the greatest effect on the final ranking, the most important factor must be chosen with the utmost care.

5.4. THE ELECTRE

This method of evaluation of candidate projects is one of the most used of discrete methods with prior articulation of the the decision-makers preferences. It is known as the "Elimination and (et) Choice Translating Algorithm (ELECTRE). Although this method is suitable for problems with a discrete number of alternatives it is still suitable for priority setting. Originally suggested by Benayoun, Roy and Sussman (1966), it was then improved upon by Roy (1971), so there are now various versions of this method viz: (ELECTRE I, II,III, etc). Essentially, a search is made for a subset of nondominated alternatives in which a certain degree of dissension or discord is accepted in the dominance relationship i.e. an alternative i qualifies for membership in the subset if it can be said that alternative i is prefered to alternative j (i.e., $i > j$), from almost every viewpoint.

Thus this method structures a partial ordering of alternatives which is stronger than the incomplete ordering implied by nondominance, but allows some incomparability to remain. Then, the construction of the mentioned subset is accomplished by the definition of a binary relation, R, which captures the preferences of the decision-maker that can be well accounted for by means of the available data. This relation R is called an outranking relationship and is built from vague judgements supplied by the decision-maker.

This method does not require that the relationship be transitive (i.e., a^1 R a^2 and a^2 R a^3 does not necessarily imply a^1 R a^3 where a^1, a^2, and a^3 are three different alternatives or actions). This method recognizes that the reasons which allow one to decide a^1 R a^2 and those which allow a^2 R a^3 may be too distinct to allow a^1 R a^3. The outranking relationship is used to form a graph in which each node represents a nondominated alternative. Then the "kernel" of the graph is found and the nodes contained in the kernel represent those alternatives which are prefered on the basis of the outranking relationship. Those nodes not in the kernel are eliminated from further consideration.

5.4.1. Defining the Electre Graph and Kernel

Figure 5-5 below shows the kind of graph with which this ELECTRE method is concerned. In this graph, each node is represented by a circled number and corresponds to a nondominated alternative. There are eight members of the nondominated set. The arrows emanating from the nodes are called directed paths and correspond to the outranking relation; they are thus analogous to preference relationships. That is, it can be said that alternative 1 is prefered to alternative 5; alternative 4 is prefered to alternative 6, etc.
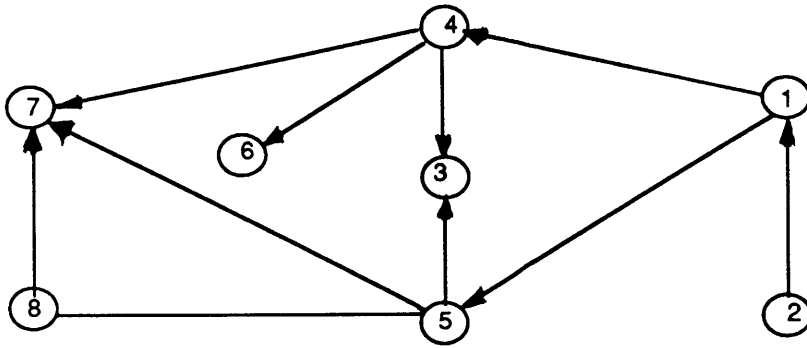
FIGURE 5-5: ELECTRE GRAPH   WITH 8 NODES
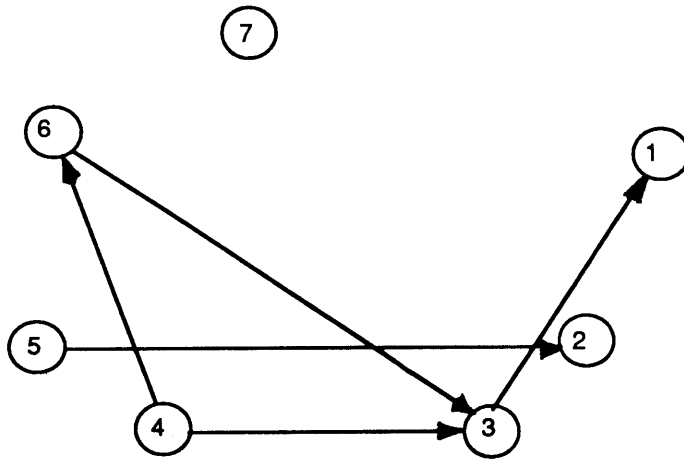
FIGURE 5-6: ELECTRE GRAPH USED TO OBTAIN THE KERNEL

IN FIGURE 5-6 THE NODES ARE LOCATED SEQUENTIALLY IN A CLOCKWISE DIRECTION

THE KERNEL IN FIGURE 5-5 IS GOT FROM THE APPROPRIATE MATRIX (CONCORD OR DISCORD)

The kernel of the graph consists of nodes 2, 4 and 5 and is the subset of nondominated alternatives which the ELECTRE method defines. To define the graph and the kernel, note first that a "cycle" is defined as a directed path beginning in a node and coming back to this node. Relative to a preference relationship, such a directed path is regarded as expressing indifference. Also in the definition below a' and a" denote any two possible alternatives. The graph, G_c, and its kernel, K_c, are defined as follows (Roy, 1971). Let:

C   - be the equivalence relation defined by a' C   a"   if and only if there exists in R a cycle passing by a' and a";

B   - denote the set of classes in the equivalence C;

R_c - denote the relation defined on B and verified by the couple of classes (b', b") if and only if there exist a'$\in$ b' and a"$\in$ b"such that a' R   a"; when R is acyclic: B = A and R_c = R;

G_c - be the acyclic graph asociated with the relation R_c (i.e., a directed path from node a' to node a" exists if and only if a' R_c a"). A subset $K_c \subset$ B is called a kernel of G_c if :

(i)   ¥b', b" in B; there is no b' such that b' R_c b"

(ii) ¥b$\in$ B - K_c there exists k$\in$ K_c, such that k R_c b.

5.4.1.1.Example 4:   Suppose th set of nondominated alternatives, A, consists of 12 elements, that is :

$$A = \{ a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}, a_{11}, a_{12} \}$$

Assume that a cycle exists for a_1 and a_{10}, a_3 and a_9, a_7 and a_{11}, and a_7 and a_{12}; the set of equivalent classes, B, is expressed as follows:

$$B = \{ (a_1, a_{10}), (a_2), (a_3, a_9), (a_4), (a_5), (a_6), (a_7, a_{11}, a_{12}), (a_8) \}$$

or

$$B = \{ b_1, b_2, b_3, b_4, b_5, b_6, b_7, b_8 \}$$

where

$$b_1 = (a_1, a_{10}), b_2 = (a_2), b_3 = (a_3, a_9), \text{ etc.}$$

Now R_c is defined on B (i.e., one and only one directed path goes from node b' to b") whenever a'R a" where a'$\in$ b' and a"$\in$ b". Figure 5-5 could represent R_c defined on B. If this is assumed to be the case, then b_1 R_c b_5 which means that there exists an a'$\in$ b_1 and an a"$\in$ b_5 such that a_1R a_5 or a_{10} R a_5 is true(or both).

Again, assuming Figure 5-5 to represent the acyclic graph associated with the relation R_c and defined on B, it is possible to illustrate the definition of K_c. The nodes, b_2, b_4, b_5 constitute the kernel. Condition (i) of the definition of the kernel is met, since no preference relationship exists among nodes b_2, b_4, and b_5. Addition of any other node to this subset destroys condition (i) (try all the remaining nodes and see if this is not so). Next look at B-K_c = { b_1, b_3, b_6, b_7, b_8} and K_c and determine if condition (ii) of the definition holds. Examination of Figure 5-5 quickly reveals that there exists k $\in$ K_c such that kR_cb for every b$\in$B- K_c.

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5.4.2. An Outranking Relationship

The only item which is yet to be explained concerning the ELECTRE method is the specification of the outranking relationship. It is this relation that allows a partial ordering of the nondominated alternatives. The relationship between the i th and j the alternatives for a given criterion can be represented as follows:

$$i \text{ preferred to } j : \overrightarrow{i > j} : i \text{ and } j \text{ equivalent} : \overleftrightarrow{i = j}$$

Thus, preference relationships between th i th and thej th alternatives can be established for each criterion. ELRCTRE synthesizes these m preference relationships for each alternative to produce the desired outranking relationship between the n alternatives. The synthesis is achieved through a concord index, c(i,j) and a discord index, d(i,j). The concord index measures the weighted relative frequency of viewpoints (criteria) where alternative i is prefered to alternative j. It can be viewed as a measure of the satisfaction the decision-maker receives in choosing alternative i over alternative j. The discord index measures the strength of the view points in greatest disagreement assuming i is chosen over j. It can be viewed as a measure of the dissatisfaction of choosing i over j. Preliminary to defining the concord index, let I ={1,2,.......,m} represent the set of m criteria.

Furthermore, as before, let { wk : k = 1,...,m} represent the set of weights associated with the m criteria. the criterion weights are determined by the value judgements of the decision-maker (DM). The criterion considered the most important receives the highest weight, the next most important receives the next highest weight, etc.

Next, partition the set I with three subsets :

$$I^+ = I^+(i,j) = \{ k \in I: i > j \},$$

$$I^= = I^=(i,j) = \{ k \in I : i = j \}, \text{ and}$$

$$I^- = I^-(i,j) = \{ k \in I : i < j \}$$

Then, define

$$W^+ = \sum_{k \in I^+} w_k$$

$$W^= = \sum_{k \in I^=} w_k$$

$$W^- = \sum_{k \in I^-} w_k$$

And finally, the concord index is defined as

$$c(i, j) = (W^+ + (1/2)W^=)/(W^+ + W^= + W^-)$$

It is often convenient to present the concord indices in a matrix C where $c(i,j)$ is the i th, j th element of the matrix.

To define the discord index, an interval scale common to all   m criteria is defined. The desire is to be able to compare the discomfort caused by going from level k_1 to level k_2 of criterion r with the discomfort of going from level k_3 to level k_4 of criterion s.

This objective is achieved by defining a scale such that a certain number of points out of a maximum of 100 is assigned to every criterion (the choice of 100 is arbitrary, and any other number will work equally well). Choice of the number of points to assign to each crterion depends on the level of importance the decision-maker (DM) wishes to attach to the range between the best and worst levels od each criterion. That is , the higher the point assignment the greater the possible discomfort as one moves from one level to the next of each criterion. With this understanding, the discord index can then be defined as:

$$d(i,j\ ) = \frac{\text{maximum interval where } i < j}{\text{total range of scale}}$$

$$= \frac{\text{maximum interval where } i < j}{100}$$

Thus the normalized discord interval is calculated for each criterion where alternative j is prefered to alternative i, and the largest normalized discord interval of these criteria is defined as the discord coefficient for alternatives i and j . Again a discord matrix D can be constructed in which d (i, j) is the i th and j th element.

The concordance condition and discordance condition are used to define the outranking relation, R. The outranking relation R is then used to form a composite graph G_c. Composite graphs are defined by controlling the concord index and the discord index of the arcs allowed to belong to a graph. Specifically, alternative i is prefered to alternative j (i.e., an arc(i,j) will appear in the composite graph) if and only if

$$c(i, j) >= p$$

and

$$d(i, j) <= q$$

With the outranking relation defined and the graph constructed, the only remaining step is to determine the kernel of the graph. The kernel contains the nodes which represent those alternatives which are prefered on the basis of R. The remaining nodes (i.e., those not in the kernel) are eliminated from further consideration. Generally, the makeup of the kernel is fairly insensitive to the pair of threshold values (p,q).

Example 5-6

The following example is adapted from Roy (1971).

Suppose the decision-maker (DM) is a man who needs to choose a car for his family. There are four criteria he intends to use in selecting his car: namely, price, comfort, speed, and beauty. The following Table 5-7 shows the criteria with the scales or levels he has established. In order of importance, the criteria are; price, comfort and then the less important criteria of speed and beauty. Suppose he has also limited his selection to the seven models described in Table 5-8.

Table 5-7

Criteria	Levels		Code
i = 1: Price	less than 2700		25
	from 2800 to 3200		30
	from 3300 to 3700		35
	from 3900 to 4200		40
	from 4300 to 4700		45
i = 2: Comfort	High		H
	Medium		M
	Low		L
i =3: Speed	Fast		F
	Slow		S
i = 4: Beauty	Beautiful		B
	Acceptable		A

5.5. Concord index

The criteria have been assigned the following weights (by the DM):

$$\text{Price} : \quad 5$$

$$\text{Comfort} : \quad 3$$

$$\text{Speed} : \quad 1$$

$$\text{Beauty} : \quad 1$$

$$\sum \text{Weights} \quad = \quad 1\,0$$

The concord-index calculation is illustrated for models 2 and 4 and models 6 and 1. Note that ties receive one-half of the weight:

$$c(\,2, 4) = \; 1/10 \, (0 \; + \; 3 \; + \; 0 \; + \; 1) \; = 0.4$$

$$c(\,6, 1) = \; 1/10 \, (5 \; + \; 0 \; + \; 1/2 \; + \; 1/2) \; = \; 0.6$$

The complete set of indices is represented by the matrix C with rows i and columns j :

$$
C =
\begin{bmatrix}
- & 0.3 & 0.4 & 0.45 & 0.45 & 0.4 & 0.5 \\
0.6 & - & 0.6 & 0.4 & 0.4 & 0.35 & 0.45 \\
0.6 & 0.4 & - & 0.3 & 0.3 & 0.4 & 0.5 \\
0.55 & 0.6 & 0.7 & - & 0.5 & 0.6 & 0.4 \\
0.55 & 0.6 & 0.7 & 0.5 & - & 0.7 & 0.45 \\
0.6 & 0.65 & 0.6 & 0.4 & 0.3 & - & \\
0.5 & 0.55 & 0.5 & 0.6 & 0.55 & & -
\end{bmatrix}
$$

Table 5-7

Type	1	2	3	4	5	6	7
Price	45	40	40	35	35	35	25
Comfort	H	H	M	M	M	L	L
Speed	F	S	F	F	S	F	S
Beauty	B	B	B	A	B	B	A

5.6. Discord Index:-

The criteria have been assigned the following maximum scale intervals:

Price	100
Comfort	60
Speed	50
Beauty	40

The value of each level for each criterion can now be calculated. For the price criterion there are five levels; therefore, each level is worth 100/5 = 20 points. The levels for comfort and beauty are also worth 20 points. The levels for the speed criterion are worth 25 points.

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The discord index calculation for models 2 and 6 and models 7 and 1 will be illustrated. The discord coefficient for each criterion where i < j is first calculated. Then the maximum coefficient for each criterion is selected as the discord index. The discord indices for the above mentioned models are:

$$d(2,6) \text{ price} = \frac{80 - 60}{100} = \frac{20}{100} = 0.2 \qquad (j > i)$$

$$d(2,6) \text{ speed} = \frac{50 - 25}{100} = \frac{25}{100} = 0.25 \quad (j > i)$$

$$d(2,6) = \frac{\text{Maximum interval where } i < j}{100} = 0.25$$

$$d(7,1) \text{ comfort} = \frac{60 - 20}{100} = \frac{40}{100} = 0.4$$

$$d(7,1) \text{ speed} = \frac{50 - 25}{100} = \frac{25}{100} = 0.25$$

$$d(7,1) \text{ beauty} = \frac{40 - 20}{100} = \frac{20}{100} = 0.2$$

$$d(7,1) = \frac{\text{maximum interval where } i < j}{100} = 0.4$$

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The complete set of indices is represented by the matrix D with rows i and columns j :

$$
D = \begin{array}{ccccccc}
- & 0.2 & 0.2 & 0.4 & 0.4 & 0.4 & 0.8 \\
0.25 & - & 0.25 & 0.25 & 0.2 & 0.25 & 0.6 \\
0.2 & 0.25 & - & 0.2 & 0.25 & 0.25 & 0.6 \\
0.2 & 0.25 & 0.2 & - & 0.25 & 0.2 & 0.6 \\
0.25 & 0.2 & 0.25 & 0.25 & - & 0.25 & 0.4 \\
0.4 & 0.4 & 0.2 & 0.2 & 0.25 & - & 0.4 \\
0.4 & 0.4 & 0.25 & 0.25 & 0.2 & 0.25 & -
\end{array}
$$

Suppose that the decision-maker specifies a minimum concordance condition of 0.6 and a maximum discordance condition of 0.20; that is, $c(i, j) >= 0.6$

and $d(i, j) <= 0.20$. With this specification the graph Gc can now be constructed. The directed paths which appear in the graph are determined by the set of indices that simultaneously satisfy the requirement that $p >= 0.6$ and $q <= 0.20$. These indices are:

(3,1), (4,3), (4,6), (5,2), and (6,3)

The resulting graph is depicted below in Figure 5-8. The kernel of the graph is easily determined. First, select the subset of nodes such that any member of this subset does not dominate any other member. Nodes 1, 4, 5, and 7 satisfy this requirement. Next, check to see if Nodes 2, 3, and 6, and Node 5 dominates 2.

Therefore, the kernel consists of Nodes 1, 4, 5, and 7. Thus the nondominated set has been reduced in size and the choice restricted to four cars instead of seven. Furthermore, the above solution can be subjected to a sensitivity analysis by changing the values of p and q and noting the effect on the current solution.

5.7. An Evaluation of Selected Priority-Setting Methods

The four methods for ranking alternatives reviewed in this chapter are the Index Ranking method, the Percentile method, the Successive-subsetting method, and the ELECTRE. These methods have actually been used in practice to determine the relative ranking of candidate projects under different conditions. The only method that is not discussed is the "Expert Panel" method.

If the goal of prioritization is to eliminate subjectivity from the process, then it is of limited purpose. But if the objective is to make such subjectivity explicit then indeed it may be said at this point that no technical priority-setting procedure can be instituted which does away with the need for informed judgements".   But even this assumes that there are "experts" recognized and acknowledged by all parties and that these are available for such a process.   Shaffer and Fricker (TRR 1124, p.8) in their study compared among others, the Index, the Percentile, and the Successive-Subsetting method.

They observed that unlike the ELECTRE and the SS, the Index and the Percentile were more appropriate for large continuous sets since they do not require simultaneous pairwise judgements. However, input requirements could be responsive to available resources required to generate the required data. Unlike the Electre and SS, the computational requirements for the Index and Percentile are replicated by hand and a computer is not necessary for small cases.

On the Index and Percentile methods the study noted that there was a certain amount of agreement between the two methods but there were also noticeable differences, concluding that decision-makers could base their ranking on any one they were more comfortable with. The study recommended some rules of thumb:

- 1. If factor values are accurate and up-to-date, the index method offers the best combination of precision and simultaneous consideration of factors;

- 2. If the factors are approximate or subjective, but the simultaneous consideration feature is retained, the percentile method is a good choice.

- 3. If factor values are approximate or subjective, and simultaneous consideration of multiple factors is not important, the successive-subsetting method is appropriate. In fact, preliminary results indicate that this method most closely duplicates the rankings made intuitively by individuals.

5.8. Standardization

Even though there are various ways of doing so, the standardization of attributes of alternatives (e.g., volume/capacity ratio) and scores (e.g., expert ratings of prospective disruption potential during construction) is usual and significant in MODM methods. Sensitivity analysis is often employed whether the adoption of a different standardization techniques such as standardization on a range versus standardization around the mean significantly alters the final ranking of alternatives. Standardization on a range is done by converting raw values for weights or scores to a uniform scale such as from 0 to 1, using the range of raw values as the basis.

5.9. Weights

"Weights" are introduced into MODM methods to show the relative importance or 'worth' of the various dimensions under consideration. They are used either as coefficients or as exponents. Yager has argued for the latter because as exponents, weights express relative priorities more clearly by diminishing low scores while magnifying high ones. The result is a non-linear preference function which is more consistent with subjective intuitive preferences than the linear function produced by coefficients. The use of weights may be an area of further research in multiple-objective decision-making.

5.10. a comparism between the Index and the Percentile

Tables 5-9 (a and b) depict the sensitivity of the two methods to weights where the difference between weights is a factor of 3; that is one criterion is three times as significant as another and only three cardinal criteria have been used. The results are also compared with the results in Tables 5-2 and 5-4 where the results of the two methods are computed with five criteria including the PCR and HAZ. The criteria ADT, $/MILE and TIME were simultaneously considered in the evaluation of the eleven projects selected, and they were given weights of 1, 2, and 3 in respective 'runs'. The weights have been used as coefficients. The best and worst ranks were observed together with their modal rank and modal frequency.

The results show that those projects that are 'skewed' or 'outliers' with respect to specific factors, rank highly when such factors are weighted highly and rank low when these factors are given low weights. Examples include project AC in the Index method and AJ in the Percentile method. However, projects which have 'middle-of-the-road' factors rank evenly whatever the weighting of factors, as with projects AA, AD, and AH with the Index method and AA, AC, AE, AG and AK in the Percentile method. However, no formal analysis of the ranking was made. The greatest rank differences of 10 occurred with project AC on the Index and with project AI with a difference of 8 with the Percentile respectively. The least spread occurred with the Percentile method.

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TABLE 5-9A : COMPARISM OF IMPACTS ON PROJECTS (CONTINUED)

CRITERIA	ALTERNATIVES (PROJECTS)										
	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK
INDEX METHOD											
ADT/$MILE/TIME(1:1:1)	9	1	7	8	5	4	3	11	10	2	6
ADT/$MILE/TIME(1:2:3)	10	4	11	8	3	1	2	9	7	6	5
ADT/$MILE/TIME(2:3:1)	10	3	5	9	6	1	2	11	4	8	7
ADT/$MILE/TIME(3:1:2)	11	6	1	8	4	3	2	11	9	5	7
ADT/$MILE/TIME(1:3:2)	10	3	9	8	4	1	2	11	5	7	6
ADT/$MILE/TIME(3:2:1)	10	4	1	9	5	2	3	11	6	7	8
ADT/$MILE/TIME(2:1:3)	11	6	10	7	2	5	3	9	8	4	1
BEST RANK	9	1	1	7	2	1	2	9	4	2	1
WORST RANK	11	6	11	9	6	5	3	11	10	8	8
RANK DIFFERENCE	2	5	10	2	4	4	1	2	6	6	7
MODAL RANK	10	3/4	1	8	4/5	1	2	11	-	7	6/7
MODAL FREQUENCY	4	2	2	4	2	3	4	5	-	2	2
5 CRITERIA	9	4	1	2	3	10	8	7	6	5	11

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TABLE : 5-9B
COMPARISM OF RESULTS

ALTERNATIVES (PROJECTS)

CRITERIA (RUN)	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK
PERCENTILE METHOD											
ADT/$MILE/TIME(1:1:1)	2	4	1	9	8	7	9	5	11	1	10
ADT/$MILE/TIME(1:3:2)	2	6	1	7	8	9	10	3	5	4	10
ADT/$MILE/TIME(1:2:3)	2	4	1	8	8	6	8	4	3	7	10
ADT/$MILE/TIME(2:1:3)	2	3	1	10	9	4	8	7	5	6	11
ADT/$MILE/TIME(2:3:1)	2	5	1	6	7	9	10	4	8	3	10
ADT/$MILE/TIME(3:1:2)	2	3	1	10	9	5	8	7	6	4	11
ADT/$MILE/TIME(3:2:1)	2	4	1	9	7	6	8	10	3	5	11
BEST RANK	2	3	1	6	7	4	8	4	3	1	10
WORST RANK	2	6	1	10	9	9	10	10	11	7	11
DIFFERENCE	-	3	-	4	2	5	2	6	8	6	1
MODAL RANK	2	4	1	10	8	6	8	4/7	3	4	10
FREQUENCY	7	3	7	2	3	2	4	2	2	2	4
5 CRITERIA	7	6	3	4	2	8	9	5	11	1	10

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TABLE 5-10
DIFFERENCE IN RANKING BETWEEN METHODS

PROJECT	INDEX RANK(I)	PERCENTILE RANK(P)	DIFFERENCE IN RANKING (I-P) d	d^2
AA	10	2	8	64
AB	4	4	0	0
AC	11	1	10	100
AD	8	8	0	0
AE	3	8	-5	25
AF	1	6	-5	25
AG	2	8	-6	36
AH	9	4	5	25
AI	7	3	4	16
AJ	6	7	-1	1
AK	5	10	-5	25

$$\Sigma\, d = 5 \qquad \Sigma\, d^2 = 301 \ldots\ldots\ldots(1)$$

AA	11	2	9	81
AB	6	3	3	9
AC	1	1	0	0
AD	8	10	-2	4
AE	4	9	-5	25
AF	3	5	-2	4
AG	2	8	-6	36
AH	11	7	4	16
AI	9	6	3	9
AJ	5	4	1	1
AK	7	11	-4	16

$$\Sigma d = 1 \qquad \Sigma d^2 = 201 \ldots\ldots\ldots(2)$$

AA	10	2	8	64
AB	4	4	0	0
AC	1	1	0	0
AD	9	9	0	0
AE	5	7	-2	4
AF	2	6	-4	16
AG	3	8	-5	25
AH	11	10	-1	1
AI	6	3	3	9
AJ	7	5	2	4
AK	8	11	-3	9

$$\Sigma d = -2 \qquad \Sigma d^2 = 132 \ldots\ldots\ldots(3)$$

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AA	9	2	7	49
AB	1	4	-3	9
AC	7	1	6	36
AD	8	9	-1	1
AE	5	8	-3	9
AF	4	7	-3	9
AG	3	9	-6	36
AH	11	5	6	36
AI	10	11	-1	1
AJ	2	1	1	1
AK	6	10	-4	16

$$\sum d = -1 \qquad \sum d^2 = 203 \ ....(4)$$

AA	10	2	8	64
AB	3	5	-2	4
AC	5	1	4	16
AD	9	6	3	9
AE	6	7	-1	1
AF	1	9	-8	64
AG	2	10	-8	64
AH	11	4	7	49
AI	4	8	-4	16
AJ	8	3	5	25
AK	7	10	-3	9

$$\sum d = 1 \qquad \sum d^2 = 321 \ ....(5)$$

AA	10	2	8	64
AB	3	6	-3	9
AC	9	1	8	64
AD	8	7	-1	1
AE	4	8	-4	16
AF	1	9	-8	64
AG	2	10	-8	64
AH	11	3	8	64
AI	5	5	0	0
AJ	7	4	3	9
AK	6	10	-4	16

$$\sum d = -1 \qquad \sum d^2 = 371 \ ....(6)$$

AA	9	2	7	49
AB	1	4	-3	9
AC	7	1	6	36
AD	8	9	-1	1
AE	5	8	-3	9
AF	4	7	-3	9
AG	3	9	-6	36

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AH	11	5	6	36
AI	10	11	-1	1
AJ	2	1	1	1
AK	6	10	-4	16

$$\Sigma d = -1 \qquad \Sigma d^2 = 203 \quad ....(7)$$

AA	9	7	2	4
AB	4	6	-2	4
AC	1	3	-2	4
AD	2	4	-2	4
AE	3	2	1	1
AF	10	8	2	4
AG	8	9	-1	1
AH	7	5	2	4
AI	6	11	-5	25
AJ	5	1	4	16
AK	11	10	1	1

$$\Sigma d = 0 \qquad \Sigma d^2 = 68 \quad ....(8)$$

According to the rank correlation developed by Spearman, the coefficeint of rank correlation between the Index and the Percentile is given by the expression:

$$r_s = 1 - \{ (6 \Sigma d^2)/[n(n^2 -1)]\} , \text{ where d is the difference in}$$

rank between paired items in a series of terms and n is the number of pairs of ranked items in the series. Hence,

$$rs = 1 - \{ (6* 371)/[11(121 -1)]\} = - 0.69 ....(7)$$

$$rs = 1 - \{ (6*321)/[11(121 -1)] \} = - 0. 46 ....(8)$$

$$rs = 1 - \{(6*203)/[11(121 -1)] \} = 0.08 ....(9)(13)$$

$$rs = 1- \{ (6* 132)/[11(121 -1)] \} = 0.40 ....(10)$$

$$rs = 1- \{ (6*201)/[11(121-1)] \} = 0.09 ....(11)$$

$$rs = 1 -\{ (6*301)/[11(121 - 1)] \} = -0.37 ....(12)$$

$$rs = 1- \{ (6*68)/ [11(121-1)] \} = 0.31 ....(14)$$

The Spearman coefficient of rank correlation between the two methods varies invariably according to the weights attached to the factors under consideration. This rank correlation varies from high to low . Further study is necessary to establish a verifiable relationship between the weights applied to factors and the level of rank correlation between the two methods, Index and Percentile.
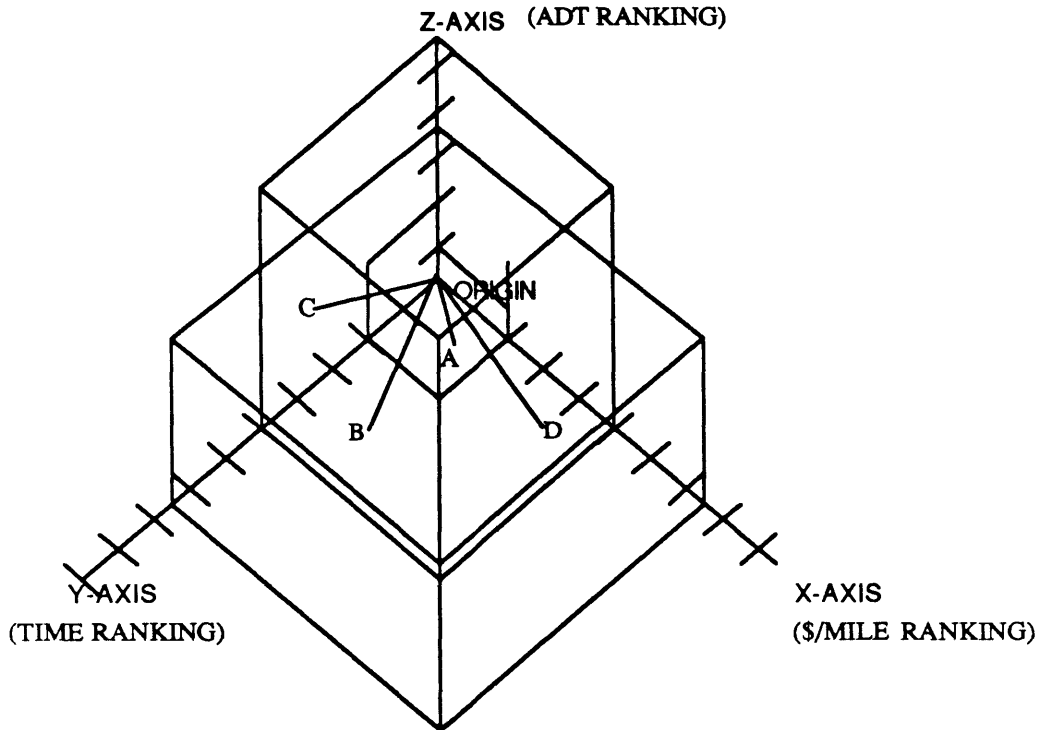
FIGURE 6-5: DEPICTING VECTOR SPACE

GIVEN TWO VECTORS A AND B WHERE VECTOR A IS

DEFINED BY COORDINATES X,Y,Z, (1,1.1) REPRESENTING

THE THREE CRITERIA ,ADT RANKING, $/MILE RANKING/

TIME RANKING ALONG THE AXES RESPECTIVELY

AND VECTOR B HAS COORDINATES (1,2,1) THE VECTOR

CLOSER TO THE ORIGIN IS TO BE PREFERRED.

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PART THREE :

THE PRODUCT

6.0 INTRODUCTION : THE PRODUCT

This chapter reviews the outcome of this study and outlines some of the difficulties encountered. In the choice of a procedure for setting priorities for transportation improvement projects in the Metropolitan Boston Region the following data bases would be used and decision criteria employed.

6.1. The Data

Always, criteria used in making decisions about which projects should receive priority consideration in design, engineering and advertising should be made available to the extent possible. Presently, there is neither the systematic use of information pertaining to those conditions and characteristics discussed under "selected criteria" in chapter four nor are there key items of datafor a complete analysis. There is however a lot of information available in various locations although not in forms that are readily useable. In this regard efforts are being made to provide needed information in a ready to use format.

The MAPC is building a data-base for traffic data to include both the Mechanical Recorder Counts (MRC) for average daily traffic (ADT), and the Turning Movement Count (TMC) for morning (AM) and evening (PM) Peak Hour Traffic Counts. The manual Turning

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Movement Count (TMC) is for intersections at strategic locations all over its region of 101 communities. The MAPC is also building a "Needs Assessment" file for those locations that have been identified for improvement. This will become the TIP file.

The MAPC is also in the process of building a socio-political data-base for each of the 101 municipalities in its region. Such a data-base will include every information about these towns and cities from total available open space, through types of government and tax data to industrial base and waste disposal facilities inventory.

The MDPW through its Bureau for Transportation and Development has built a Networks file that provides all forms of information on all the segments or links in the State Highway Network. It is called the Road Inventory File. The MDPW also has a Hazard Mitigation file for high accident locations in the Commonwealth. However, these files are in different locations, incomplete and not too readily available for use presently.

Thus a logical direction for this study as a further step, is to examine the possibility with which these data-bases could be related into one and the type of institutional support structure that would be required to ensure the effectiveness of such an relational set-up. A substantial proportion of these data are got either from field surveys done by either the MDPW or the CTPS.

Other primary sources especially for traffics counts are the Environmental Impact Reports (EIRs) which are prepared by various consultants on behalf of their clients who are undertaking different types of development.

6.1.1 The Network File

The entire transportation improvement program is founded on this inventory. The Network[1] File is a highway network file built by the MDPW using an appropriate manager. It contains data on all the highway links or segments in the entire state. It is structured by communities alphabetically. Its primary field is the COMLINKNUM, which consists of the community number from 001 to 351 and the beginning and end nodes of the link or roadway segment.

It provides data on the design capacity of link, the geometry, that is pavement width, the width of shoulders, medians sidewalks, length of the link, the number of lanes, the functional classification, the administrative classification, the pavement specification and history of maintenance, etc. One piece of geometric data which the Roadway Inventory File does not contain is the right-of-way width, an important factor in determining the feasibility of such improvements as road widening and the addition of turning lanes.

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6.1.2 The Municipal File

While the Network file focuses on the "infrastructural base", the Municipal[2] File emphasizes the socio-economic conditions of each of the communities in the MAPC region. These are 101 in number. It is built by the MAPC. The primary field is the STATMUNINUM which is the Commonwealth of Massachusetts number followed by the town or city number alphabetically to agree with the MDPW number. It provides data on every aspect of the municipality including its name, the total land area, the employment level, the type of government, the population as the last census, the total length of roadway by both functional and administrative categories, the number of school children, the tax rate, the number of registered motor-vehicles, etc. It thereby provides the necessary socio-political information required to determine the political will behind a proposed improvement as well as the need for economic development.

6.1.3 The Traffic Count File

This file is managed by database 3+ and is built by the MAPC. It is in two parts; namely the Mechanical Recorder Count (MRC) for average daily traffic counts using permanently installed, well located traffic meters; and the Turning Movement Counts (TMC) which are manually recorded at appropriate intervals of 15 minutes during the morning (AM) and evening (PM) Peak hour traffic periods. In addition, this file contains data on high hazard-prone zones and accident locations with descriptions of the probable cause, type and

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fatality of the accidents. The primary field is the LINKNUM. This file also contains data on dates to allow for computation of traffic growth rates along the affected links.

6.1.4 The TIP File

The TIP file is also being built by both the MAPC in the form of a "Needs Assessment" list. This list identifies those segments or links and intersections within the highway network that should be considered for improvement using either federal, state funds or local funds. The primary field in this TIP file is the TIPNUM, the number of the TIP project. This file will also contain such fields as TIPNAME, the name of the project, MUNINUM, the number of the municipality, and the allocation according to the TIP elementary breakdown such as the Annual Element (TIP/AE) or the 2-5 year Element (TIP/FE), or the Future Element (TIP/FE).

Other deatails are the project description, funding, by type of source- federal, state, local, etc. In the TIP file projects are not entered alphabetically, but according to when they become identified ; i.e., first entered into records first served; the type of improvement proposed ; the estimated costs; how determined and by whom; proposed type of inprovement, and duration construction work.
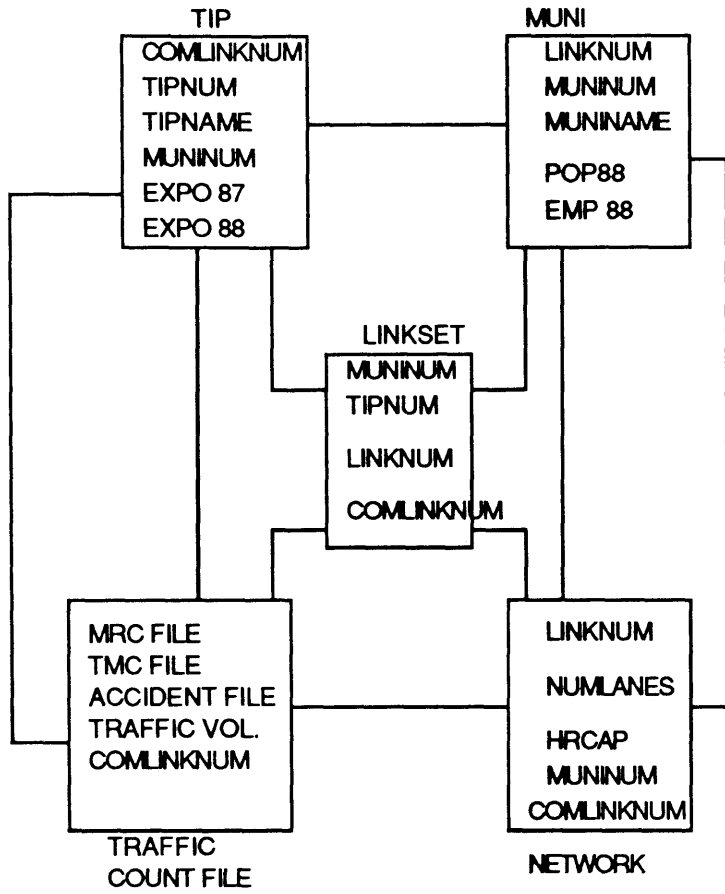
FIGURE : 6-1

A MODEL FOR RELATING DATABASES

FROM THE VARIOUS AGENCIES OF THE BOSTON MPO.

6.1.5 The Linkset

This file is the link between all of the other files in the TIP program. It contains all the links affected by each TIP project. The key field in this file is the COMLINKNUM, as with the Network file.

It may be different in structure from the other files because of the nature of most TIP projects which encompass a number of different transportation links. In view of this it may be necessary to breakdown projects into their smallest units or devise some other way to make transportation improvements cost efficient overall. Figure 6-1 shows the relational structure for the TIP subprogram proposed to inform the main TIP process.

6.2. RISK AND UNCERTAINTY

As in other areas of endeavor, feasibility studies in transportation planning are conducted under the assumption that the most likely or the expected values of the benefits (monetary and otherwise) can provide an appropriate basis for the evaluation and comparism of alternative plans. Current methodological frameworks are not able to accommodate ranges of values for all input parameters. Even when the effort is made to consider parameter ranges, it is not clear how to proceed with the analysis of risk and uncertainty. That is, what analytical tools are to be used and what trade-offs to generate in order to assist in the decision-making process.

The Science Council defines risk in terms of those situations in which the potential random outcomes can be described in reasonably well-known probability distributions (e.g., site variables). In situations of uncertainty, potential outcomes cannot be described in objectively known probability distributions (e.g., social and environmental impacts). Like the classical demand theory after which they are patterned, a great majority of multiobjective methods assume a state of complete information on the number and nature of outcomes of these processes. This is deterministic. However, in view of the vagaries of the formal decision-making environment comprising the burdens on the decision-maker, the integrative and mathematical demands on the consultant, and the high costs of procuring additional information, this inadequacy is overlooked.

It is worth the efforts of those parties to formal decision-making arena to delve into research areas which deal with the human ability to perceive and quantify elements of risk and uncertainty, so that human behavior and response can consistently be better related to those perceptions. The other area of research would deal with mathematical representations and manipulation of measures of risk and uncertainty bearing in mind the muliplicity of scenario, audiences and technologies.

6.2.1. the sources of uncertainty in TIP -(funding levels)

In this study, the strongest indications of uncertainty were in:

- budget forecasting;
- programming method
- project information listing;
- estimated duration of project construction;
- estimated cost of project;
- expected impact of improvements;
- contingencies.

The inclination on the part of transportation planners to see the future as an extrapolation of trends has often resulted in revenue shortfalls and fiscal chaos. The task of setting priorities is uncertain as it is without the additional burden of budget forecasting. Since this study sees prioritization as essentially one of ranking candidate projects not speculating on the size of the budget, this area of uncertainty was effectively eliminated. If programming is considered to be more than project prioritization, but also integrating projects with fiscal plans, then this study was not an exercise in programming. This study has made every effort to maximize the information on all projects on the list. Costs and Times are only given as estimates.

This is necessarily so because in a dynamic and uncertain environment, programming must recognize the inherent uncertainties associated with impact assessments, changes which occur in technology, in community values and social concerns' and in funding. Estimates thus provide needed flexibility to changing conditions without complete recycling of projects and planning efforts.

6.3. A PROPOSAL FOR SETTING PRIORITIES-HIERARCHICAL LEVELS

A review of the social and political and institutional setting is necessary to adequately select a priority-setting process. The decision-making process of transportation planning in the Boston MPO, takes place within a complex institutional/ organizational framework where agency mandates, plan development, council guidelines, plan preference, elicitation, board reviews actions and decisions are distributed across several hierarchical levels.

Priority setting strategy would occur at five levels hierarchically structured. As suggested earlier, the MAPC is moving towards the setting up of sub-regions made up of communities willing to cooperate in identifying their development needs. Such cooperation in the case of the North Shore Coalition has already developed its priorities for transportation improvements. This sub-regional effort will be the first hierarchical level of decision making.

The second hierarchical level of the planning process should first attempt to re-integrate the subregional priorities into a continuing regional approach. This would be achieved through the use of a method such as the Index or the Percentile methods. Once the planning activity is specified, the MAPC and field planners of the CTPS proceed to identify and consider the entire population of potential or feasible projects and solutions. The current 'needs list' is one attempt to do this. Either of both continuous methods, namely, Index and Percentile are suitable so long as the process recognizes the time-frame involved and peculiar institutional relationships.

The third hierarchical level of project identification, would result in a finite choice of prefered alternatives or potential improvements. This would entail the partial ordering of the population of projects derived from the second level, using such a subjective and more discrete process as the successive-subsetting and the Electre respectively which can accommodate such criteria as political input (including environmental quality); sub-regional distribution of projects and equity concerns intended to improve regional economic development and social well being. This level produces an ordered list of projects in the form of a 'recommended plan'. In the fourth hierarchical level of transportation improvement planning for the TIP, the MPO board (expert) and the MAPC board (communities) separately review and examine the 'recommended plan' examining the list of alternative projects and assessing the merits behind the plan. These two groups each conduct their ordering independently.

The final hierarchical level of the TIP process would be the advisory recommendation of the JRTC in its role as advisor. A final review of the ordering would contain the same recommended projects emphasizing, the engineering, economic, social and institutional aspects of the hierarchical levels discussed earlier.

6.4. COMPARISM OF METHODS

It is significant, once a multiobjective problem has been formulated to match it with an appropriate solution technique; that is , a solution technique that matches with the type of problem and the preference of the decision-maker. MODM techniques can be categorized by means of five binary classification criteria and four choice criteria(Gershon, cited by Goicoechea et al, 1982).

6.4.1. marginal versus non-marginal difference between alternatives:

This categorization of methods focuses on the marginal differences between alternatives and thus the same. To the extent that all four methods investigated have been examined in the context of transportation improvements, there are only marginal differences between candidate projects. A selection between bridges, and highways would represent a non-marginal difference. So also would be comparism between a design or capital project under the TIP and a maintenance project under the Pavement Management Program.

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6.4.2 qualitative versus quantitative criteria

From the Index to the Percentile to the Successive-Subsetting, there is a progressive shift from hard quantitative data to soft qualitative judgements. The Index, the Percentile and the Electre can all handle hard data; the Successive-Subsetting method is used for the qualitative criteria.

6.4.3. prior versus progressive articulation of preferences

The Index, Percentile and Electre require the decision-maker to express prior to the analysis his or her preference function. However the Subsetting method requires a progressive articulation of the decision-maker's preference as it proceeds.

6.4.4. interactive versus non-interactive

The Index and the Successive-subseting methods are interactive but the others are relatively non-interactive. The more interactive the method, the greater the ease of use. The Electre is non-interactive. It requires considerably more effort to follow the progress of the outranking process and the susequent matrix formation. The Percentile method is the least interactive in the sense that as a ranking method, ties in respective dimensions are difficult to break and become indeterminate.

6.4.5. comparism of alternatives to a given solution alternative or to each other

The Index, Percentile and the Electre compare alternatives to each other with varying levels of pointedness. However, the SSub-setting compares alternatives to stated goal point. This is because of its basic tendency to creat a hierarchy of criteria more in line with the hierarchy of goals and objectives. Also MODM methods are classified by other characteristics. These include:

6.4.6. mandatory binary criteria :

According to this classification, the Index and the Percentile methods are suited to continuous problems with infinite alternatives while the successive-subsetting and the Electre are only able to solve discrete problems of between 5-10 alternatives.

6.4.7. non-mandatory binary criteria :

Only the Successive-subsetting method attempts to compare the solution to an aspiration. This is because it is subjective and more easily goal or quality related.

6.4.8. technique-dependent criteria :

In computational complexity, the Electre is most difficult followed by the Percentile. The subjectivity of the SS method makes it the most

time consuming since it does not lend itself to computation. However in terms of ease of use, the SS method and the Index are the easiest to use and most robust when it comes to changes in parameters

6.4.9. application- dependent criteria :

Where objectives translate directly into criteria, the more the criteria, the more the dimensions across which to collapse to achieve a single-objective composite index for ranking. However, the Index and Percentile are able to handle as many criteria as are relevant in a simple spreadsheet format. The SS method and the Electre are only able to handle problems with discrete number of alternatives becaues of the iterative pairwise comparative structure. For a given number of alternatives, n, there are $[(n)(n-1)/2]$ pairs to simultaneously judge.

6.5. AMALGAMATION AND SYNTHESIS ACROSS DIMENSIONS

Although seven criteria have been identified and isolated in this study, there is still the issue of mathematical complexity that has to be resolved if these seven dimensions must be collapsed into a single dimension for final ranking. This is as a result of the difficulties of standardization across dimensions when data are both irdinal and cardinal. Therefore, the process of prioritization has neen stretched out into three phases as follows.

The two qualitative criteria of politics and equity will be introduced successively. Two additional criteria of the five remaining, namely. safety (HAZ) and pavement condition (PCR), are composite subjective ratings which cannot be meaningfully added to standardized scores, since they are ordinal. This study is therefore left with three criteria that are cardinal. These are the Average Daily Traffic (ADT) in number of vehicles per unit time; the Estimated Project unit cost in dollars per mile ($/MILE) and the Estimated Duration of Project (developemnt and construction) in months.

At this stage a decision needs to be taken to determine which one of two possible options for measurement ought to be adopted to minimize or eliminate difficulties of amalgamation through different dimensions.

6.5.1. option 1 : (Index)

This approach attempts to provide an index by standardizing ADT scores by range, and adding across dimensions to arrive at ordinal ranks. Then consecutive 'runs' varying the weights of the factors up to an arbitrarily set ratio of 3 were made to observe its impact on ranking. The summary of this process is found on the following page.

6.5.2. option 2 : (Percentile)

As an alternative, this option ranks projects within dimensions yielding ordinal numbers which are not meaningfully computed across dimensions. However, ranking is a measurement which is consistent across dimensions. Although direct additive or multiplicative treatment of ordinal ranks is numerically inappropriate, ranks have magnitude and scale or magnitude and hence may be treated as vectors. The three criteria have the same direction, that is, less is better, so a graphic analysis of these projects in a 3-dimensional space is possible.

6 .6. VECTOR SPACES

An n-dimensional Euclidean space is denoted by E^n and defined as the collection of all vectors (points) $x = (x_1, x_2, ...x_n)$. Vectors in the

space can be added or multiplied by a scalar, by performing the corresponding operations on the components.

The scalar product of two vectors $\mathbf{x} = (x_1, x_2,....x_n)$ and $\mathbf{y} = (y_1, y_2,....y_n)$ is defined by

$\mathbf{x}^t\mathbf{y} = \mathbf{y}^t\mathbf{x} = \sum\limits_{i=1}^{n} x_iy_i$. The vectors x and y are said to be orthogonal if

$\mathbf{x}^t\mathbf{y} = 0$. Also, the length or magnitude of a vector x, written $|x|$ is defined as $[\mathbf{x}^t\mathbf{x}]^{1/2}$.

Let x and y be two vectors in $\mathbf{E}^n$. Then it follows that

$$|x + y|^2 = |x|^2 + |y|^2 + 2\mathbf{x}^t\mathbf{y}$$

$$|x - y|^2 = |x|^2 + |y|^2 - 2\mathbf{x}^t\mathbf{y}$$

and by adding we get

$$|x + y|^2 + |x - y|^2 = 2.|x|^2 + 2.|y|^2$$

If one vector in a set of vectors from $\mathbf{E}^n$ can be written as a linear combination of some of the other vectors in that set, we say that the given vector is linearly dependent on the others. That is, a set of vectors, $a_1, a_2,....a_k$, is said to be linearly dependent if the scalars μ, not all zero, such that

$$\mu_1 a_1 + \mu_2 a_2 + ...\mu_k a_k = 0$$

If the only set of μ for which the equation holds is $\mu_1 = \mu_2 =...\mu_k = 0$, then the vectors are said to be linearly independent.

A linear combination of the vectors $a_1, a_2, ...a_k$ is a vector of the form

$$\sum\limits_{i=1}^{k} \mu_i a_i$$

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A set of vectors $a_1, a_2, \ldots\ldots a_k$ from E^n is said to span or generate E^n if every vector in E^n can be written as a linear combination of a_1, $a_2,\ldots a_k$. Any linearly independent set of vectors which spans E^n is called a basis for E^n. As vectors, the criteria rankings for each project become the scalar quantities along three axes X,Y and Z. See the graphical depiction following.

6.7. conclusion

TABLE 6-1 below shows the relative ranks of the various projects as a result of both the number of criteria and whatever weights attempt to depict their relative importance and the weaknesses or strengths of the candidate project itself. Where a large traffic volume is considered to require the most immediate transportation need projects with large ADT's were put in advantageous positions ,etc,ect. For example, by it self, project AC with a very large traffic flow, is the most needy. However, with another criterion namely project cost, turns out to be the fourth most needy project. Together with two other criteria, namely, $/MILE and Time in months, Project AC fluctuates anywhere between the most needy and the least needy. How apparently urgent a project is, is a matter for the decision-maker; and everything is only as important as we define them to be.

PART FOUR

....ON THE TRANSFER OF TECHNOLOGY

FROM THE MORE DEVELOPED

TO THE DEVELOPING

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7. INTRODUCTION : LESSONS FOR NIGERIA

7.1. The Problem

Ever increasing levels of knowledge of the inner laws of the capitalist mode of production in general and their operation in the present Nigerian neo-colonial political economy in particular is not the subject of this study but a brief recapitulation of the efforts of Nigerians to regain control of their destiny politically, socially, economically, culturally, through the instrument of technological development may be summarized from the perspective of the following policy initiatives. Technology is here appropriately defined not as an array of industrial machines but as methods of subsistence techniques capable of greater effectiveness and nett efficiency in all fields of human endeavor from industrial innovations through scientific inquiry to managerial effectiveness given the environmental experiences of the more industrialized countries:

(1) The current indigenization and Nigerianization policy is historically subsumed in the British colonial process, which is directly related to the growth and development of capitalism in present-day Nigeria.

(2) More clearly and purposefully articulated in the Second and Third National Development Plans (1970 - 1980), indigenization proper is basically a modern reactionary policy consistently pursued by an historically ill-equipped Nigerian lumpen-bourgeoisie[1] against persistently foreign economic domination and control of the 'commanding heights' of the country's economy.

It is also an extension of the civil libertarian policy of accommodation and 'assimilation' within the imperial colonial system evolved by the first breed of African aristocratic elites who were propped up by merchant and colonial capitalism itself, especially during the era of the trans-Atlantic trade.

(3) Contemporary indigenization process is not only predicated on Nigeria's traditional 'open-door' socio-economic policy; it is also essentially diffusionist in orientation and, therefore, wholly dependent for its effectiveness on foreign monopoly capital and its operative institutions and machinery within and outside Nigeria.

(4) Finally, indigenization as enunciated in these national development plans practically reflects the prevailing petty bourgeois nationalism and externally motivated entrepreneurship among the Nigerian ruling class and its capitalist allies; as such, it amounts to what Andre Gunder Frank[2] calls 'lumpen-development'.

In other words, rather than promoting authentic development and progress for the benefit of the majority of the Nigerian producing masses, indigenization intensifies, often quite covertly, the prevailing multinational control of the Nigerian political economy, and hence, the country's persistent underdevelopment.

7.2. The need for caution

This study therefore views with every seriousness any discussion on the transfer of technology. The thesis is often presented that the developing nations could benefit from decades of scientific and technological advances made by industrialized nations through massive technological importation, rather than establishing autonomous science and technology base of their own.

Previous studies of the capitalist mode of investment and capital formation in Nigeria during the colonial and post-colonial periods, as well as studies of the role of multinational corporations in the Third World in general and in Africa in particular, suggest that indigenization as an instrument for engineering-oriented technological transfer is a myth.4 This myth feeds on the absence of national science and technology policies, which in turn leads to the official tendency to view imported pieces of obsolete equipment as a substitute for concerted national efforts in development of an indigenous technology.

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This assignment of a development role in Nigeria to foreign technology is based on the erroneous assumption by the Nigerian leadership that monopoly capitalism is capable of manifesting humanistic and philanthropic tendencies. The history of the role of multinational corporations in Nigeria and other developing countries, however, suggests that monopoly capital which is essentially propelled by profit maximization at minimum cost, is generally extra-sensitive to the kinds of technology that are imported to developing countries, and in what particular venture they are invested.

Since the international mobility of monopoly capital is primarily guided by the search for higher profits, the scientific and technological under-development of non-industrialized countries normaly renders them easily susceptible to capitalist manipulation and exploitation.

Hence, technologies imported into Nigeria from Western capitalist countries have generally consisted of obsolete and scrapped materials, often repainted and then exported as newly-manufactured equipment; machinery is often inappropriate for the prevailing ecological, edaphic, and tenurial conditions in Nigeria; equipment which perpetuates existing contradictions between the country's urban growth enclaves and impoverished rural areas.

These technologies also enable controlling foreign interests to take full advantage of the government's ultra-liberal incentives and concessions usually designed to safeguard foreign investments establishments incorproated in Nigeria against stiff external competition.

Also safeguarded are foreign-patented, low-cost capital goods generally invested in high profit but low-capital formation ventures (assembling, processing, packaging, distribution and other import substitution establishments), and consumer durables radios, television-sets, vehicles, etc, which are frequently subject to inelastic demand and whose increased importation has contributed immensely to the country's trade imbalance and depeletion of foreign reserves; and capital goods which facilitate the diversification of foreign investments in order to avoid or contain local competition.

Deleterious consequences of Nigeria's dependence on foreign , particularly Western technology, include the inextricable subjection of Nigerian workers to the dictates of foreign technology required by externally-oriented work organizations operating in Nigeria; the constant depletion of Nigeria's scarce resources, especially foreign reserves, partly due to the high cost of imported equipment and high interest rates on loans borrowed to finance the importation of expensive mechanical equipment.

Others are the subjection of Nigeria's educational, scientific, and general research and service orientations to the restrictive logic of foreign science and technology and the continued dependence of local industries, including the completely indigenized ones, on foreign material and human input required by foreign technology. Thus creating booming markets not only for the imported technologies but only for the foreign resources required to operate them. Considerable government subsidization of Nigerian enterprises which depend solely on foreign capital equipment; high unemployment rates occasioned by capital-intensive technology; frequent employee turn-over, and inter-factory as well as inter-sectoral transfer of workers.

Also the intensification of the prevailing system of clientelistic and inequitable distribution of assets, materials, material resources and opportunities, which are generally skewed in favor of urban businessmen, rural capitalists, and the generality of the country's lumpen-bourgeoisie. Other unsavory consequences of 'technology transfer' the Nigerian approach, include the incessant subjection of the nation's economy to imported depression and stagflation (inflation plus unemployment), various forms of chaotic labor mobility, such as the migration of young people and umployed rural youths and school-leavers to urban areas, the migration of the Nigerian workers from the public to the private sector.

Also of concern is the emigration of highly skilled Nigerians to Western capitalist countries; in otherwords, the migration of scare productive labor and other essential resources, away from the exploited and neglected Nigerian rural peripheries that need them most to the exploiting growth centres within and without Nigeria. The first question that may come to mind is this. What is the relevance of all this to the TIP ? Although it may not be directly related to the TIP, so long as it is related to the question of technology transfer which in turn is related to the TIP then it is indirectly related to the TIP.

Transportation and consequently transportation improvements affect every facet of life not only in the developed world but also in the developing world. It only requires cursory reflection to confirm this. Hitherto the transfer of technology programs have not been subjected to thorough comprehensive appraisal of both direct and indirect impacts and hence the negative effects of such programs.

7.3. Politics

Politically, Nigeria became independent from British colonial rule in October 1960. It is the most populous and potentially one of the richest countries of Black Africa with a population of 116 million people in 1986 (UN, Office of Population Studies). It is estimated that one in every four Africans is a Nigerian.

In addition to a large internal market, it has experienced rapid growth in oil revenues from the early 1970's. This has tended to make Nigeria the economic giant of the sub-Saharan West African region. However, the instability of the Crude Oil market and the falling oil prices have resulted in an economic down-turn and an acute debt crisis and weak balance of payment and foreign exchange position in the 1980's.

Since becoming a republic in 1961, Nigeria's development in every way has been characterized by political instability, ethnic and regional animosities and antagonism and distrust culminating in a civil war in the late 1960's and the politicisation of every sphere of activity including technical activities. Military rule has been so prevailent it has almost become the normal form of government.

At independence in 1960, Nigeria had a federal constitution, with three semi-autonomous regions namely: Northern, Eastern and Western Regions dominated respectively by the Hausa, Ibo and Yoruba majority ethnic groups. The three regions and the federation as a whole each had a Westminster style parliamentary system of government. A fourth region, Mid-West, was created in 1963. The politics of ethnic loyalty became dominant as regionally based political parties struggled for power at the federal level.

The first civilian government coalition was the federal government comprising the Northern People's congress (NPC) as the dominant partner and the minority partner called the National Council for Nigeria and the Camerons (NCNC) which was based in the Eastern Region. The NPC's leader, Sir Abubakar Tafawa Balewa became Prime Minister, and Dr Nnamdi Azikiwe of the NCNC became governor-general and subsequently president.

The third major political party, the Action Group, with its base in the Western Region was in opposition and its leader was Chief Obafemi Awolowo. This was at the federal level. The split in the Action Group gave rise to political unrest in the then Westen Region which deteriorated to a state of emergency while the federal government looked on. In January, 1966, there was the first military intervention in politics in Nigeria in the form of a coup.

The Prime Minister was killed, along with two regional Premiers and federal ministers. The violence and rumours of collusion between two regions against the third ultimately led to the Nigerian Civil War between 1967 and 1970. Since the cessession of hostilities the task of national reconstruction and redevelopment has been the goal of the successive governments. There have been military regimes from 1970 to 1979, then civil rule from 1979 to 1983. Then a return to military rule since 1983 to the present military regime under the Presidency of General Babangida.

7.4 Present-day Nigeria

In this period between 1960 and 1986, Nigeria grew from a country of three regions ,then four regions; then it was divided up into 12 semi-autonomous states in 1976, then into 19 states with a federal territory at Abuja in 1976. Now Nigeria is made up of 21 states of different linguistic groups, and varying geographical sizes as well as populations(see Table 7-1).   Presently, the structure of government at the federal level is as described below.

At the top of the hierarchy is the Armed Forces military Council (AFRC) as the Supreme decision-making body. This is made of top-ranking military Officers with the Head of the Federal Civil Service as the Secretary to the Council. Next in authority is the Council of Ministers made up of the Ministers in the various ministries and their Permanent Secretaries (PS).   This body is responsible for the effective running of public affairs;i.e., the day to day business of government rests with the Federal Civil Service whose Head is the Secretary to the AFRC.

In advisory capacity, there are the Council of State made up of the Paramount Traditional Rulers from the major ethnic nationalities. Included in this assembly are such Eminent Rulers such as the Oni of Ife, the Spiritual Head of the Yoruba and King of the Ife Kingdom; the Alake of Egbaland the king of the Oyo Empire;

the Oba of Benin, the King of the Bini Kingdom; the Jaja of Opobo; the Obi of Arundiziogu; the Etsu Nupe of Nupe; the El Kanemi of Bornu Empire; the Sardauna of sokoto; etc and others who are accorded the role of "fathers of the Nation".

The day-to-day business of government is in the hands of the various ministries in which the minister is the political head with responsiblilty for internal consistency with overall policies and the Permanent Secretary (together with other intra-ministerial committees) is responsible for the implementation of policy. It is therefore possible for the business of government to continue uninterrupted even when there is a change in the political leadership of the of a ministry or the government.

Below the ministries are Parastatals and other agencies and public corporations whose Executive Officers report either to the Permanent Secretary in the appropriate ministry or a higher authority according to the decree establishing such parastatal or corporation. In each of the other 21 states there is a military governor as executive head but with the same structure as at the federal level. The Federal Capital Territory of Abuja, which is the new capital of the country has an Administrator as well as federeal ministries such as the Ministry of External Affairs and other organs of government that have to do with the International Community in Nigeria.

The Second Republic which was ushered in by the 1979 constitution was patterned after the American Presidential system. This was considered necessary in light of the First Republic which was patterned after the Westminster Parliamentary system. This system of government was held responsible for the failure of the first attempt at nation-building. Thus in 1979, Nigeria had an Executive President by the name of Shehu Shagari; a Senate and a House of Representatives. The States had Executive Governors with State Senates and State Houses of Representatves and they had the constitutional responsibility of selecting "their own men" at every executive level. This change in style caused extreme discontinuity in the civil service as well as in the parastatals and public corporations. Where there had been a sense of job security, suddenly there was no longer any such perceived security, etc.

7.5. Resources

Nigeria has the potential to accelerated development on account of its diversity climatically and otherwise. From the coastal equatorial mangrove swamps in the south through the rain forest, the deciduous forest, the arid savannah grasslands, the tundra and sahel to the semi-temperate zones in the high plateaux of Kukuruku Hills in th north and the Cameron mountain in the South - seven distinct climatic zones. Ethnically, Nigeria has over 250 distinct linguistic groups with discernible socio-cultural traditions, lifestyles,

with the major groups being the Yoruba in the western areas, Bini, Urhobo and Ijaw in the Mid-western riverine areas, the Igbo-speaking groups in the Eastern areas; the Calabari and Efiks, Ibibio in the riverine areas of the east, the Hausa-fulani to the North West, the Kanuri to the North East, and the Tiv and Nupe in the Middle Belt. These three regions are defined more or less by the two major rivers Niger and Benue. The former flows from the Futa Jalon Hills in Republic of Guinea to the west and the Benue from the Cameron mountains to the east. Both rivers meet at a confluence and flow together southward into the Atlantic Ocean in a delta.

The natural resources of the country range from agriclutural produce such as rubber, cocoa, palm oil, in the south; cotton, groundnuts, rice, in the north through variegated wild-life, fisheries, and forests to minerals including coal, columbite, uranium and petroleum and natural gas.

Although all of the diversity in social, cultural, political as well as physical environments indicate a potential for accelerated development, it has instead been employed by politicians to appeal to baser emotions of regional and ethnic identity. Hence, rather than reinforce a sense of national unity, its diversity has actually been used to undermind the much needed sense of national identity and unity vital to the development of Nigeria. This has led to ethnic distrust, "equal-share-of-national-cake" mentality, nepotism and self-interest manifesting as corruption.

7.6. transportation planning in Nigeria

Transportation decisions in Nigeria are the responsibility of the Ministries of Transportation, Land Transport, and Public Works, as client ministries with responsibility for liaison and coordination with the owner ministries. The capacity stands at 130,000 km with 60% of the capacity being the joint responsibility if the Federal Ministry of Works and Land Transport. Improvements to the network are the responsibility of the Federal authorities with their state counterparts are responsible for the state network and the local governments receiving grants from the state to for purposes of maintenance but generating its own revenue for capital extensions to the network.

The categories of roadways are: expressways (dual carriageways), trunk A highways (interstate highways), trunk B highways (arterials), trunk C roads (local distributors) and access roads each with its design standards according to the Nigerian Standards often derived from British Standards. Funding for maintenance and capital projects on the federal network are part of the federal exclusive list for revenue allocation while the the rest of the system comes under the concurrent list which is the reponsibility of each state.

7.7 On the Concept of Technology Transfer For Development

Formal techniques for prioritization of transportation projects must be seen as only one aspect of the overall problem of technology transfer from the developed to the developing nations. However, developement must be viewed as a comprehensive and global process which embraces all aspects of the social system and its interrelationship with natural environment. In this dynamic interrelationship, technology is the fundamental link between the social system and the natural system. At the same time, it is the essential instrument for the achievement of sustainable and environmentally sound development in the long run. It is also true that each technological pattern implies specific approaches to management of resources and must be associated with a given value system and life style. It is through technology that development may be achieved just as it is through the application of such technology that man has the most impact on his physical environment.

Almost every day since the last fifty years have witnessed the most tremendous and impressive technological development in human history in the highly industrialized countries. The human habitat especially in these industrialized countries is in great measure a man-made environment, resulting from the transformation of nature by practical and systematic application of scientific and technological knowledge.

7.8   mixed blessings

But it is not only the natural system that has been modified. Society and its institutions, values, patterns of development and life styles also reflect the characteristics of technological development. To suggest even in the context of these industrialized countries that all is well is to be insensitive to criticisms directed to specific and concrete environmental problems such as groundwater contamination and disposal of hazardous man-made substances. It is axiomatic that the uncontrolled introduction of technology, the lack of consideration for its adaptability to specific situations are indicated in its negative effects. Thus on the one hand, technology application has created new opportunuities and fostered development and on the other hand it has created new problems. While technological development in the industrialized countries has been according to their specific needs, the adaptation of such technology has frequently had negative results in other countries of the developing world for which those technologies were ill adapted.

One of the dubious benefits of stepping the steps of those in front is that we learn to benefit from their mistakes. If the countries of the developing world are able to extract the benefits of western technology without the problems then a lot real technological development has been made in these countries.

This is the reason why, any strategy to transfer modern western technology from the United States of America to a developing country such as Nigeria in the form of transportation improvement models must meet certain criteria. Two aspects of the appropriateness of any technology to be transfered are the criteria to be used in its selection and the procedure for using these criteria. These are in fact the theme of this study: The need for selecting criteria in the choice of technology are as vital as the criteria for setting priorities :

7.9. significance of an open process

When criteria are explicitly stated, they have to be reckoned with, and this enforced reckoning tends to counteract arbitrariness in policy- and decisioin-making. Also when criteria are made explicit and spelled out, the process of publishing them is facilitated. The more broadcast the awareness of the criteria is, the less the risk of their being ignored in policies and decisions. When ignored the greater the consciousness that this is being done, and the greater the need for an open justification of the ommission, deletion, or suppression. Hence, criteria, have an impact on both policy-makers and decision-makers, as well as those who are affected by policies and decisions. In this regard, the purpose of setting down criteria is to broaden the base of policy- and decision-making. An increase in awareness of the criteria to be used in the choice of technology on the one hand generates a widespread demand for such technology

and on the other hand guides those who generate technologies. The significance of this consciousness among scientists and engineers has often been underestimated to the detriment of capital projects. The definition and appreciation of criteria is an inhibiting factor against the development of inappropriate technologies. Notwithstanding the obvious importance of establishing criteria for the choice of technology, it is interesting that no explicit list of criteria exists today. Implicit criteria can be deciphered from the technologies in vogue and the decisions that ushered in these technologies. Where sound, these decisions could be further improved by exposing them to the scrutiny of public participation. In so far as criteria must be derived from objectives, the criteria for the choice of appropriate technologies must emerge from development objectives. This is undoubtedly a normative approach to the definition of criteria.

The approach is based on some value judgements. One of these is that economic development, particularly of the developing countries, is an urgent goal of the highest priority, and that this development is contingent upon the establishment of a new order economically and internationally which new order must include a new relationship between the developed and developing countries founded upon mutual repect for each other not disparagement and aspersion as is currently the case. Secondly, it is a basic need of human beings to participate in the decisions and processes concerning their destiny and to exercise increasing control over these decisions and processes.

This is self-determination! Finally, the physical environment is the sole irreplaceable habitat of man and must therefore be jealously protected and husbanded, not left to the whims and caprices of technology-merchants and business barons who have no motivation other than the insatiable desire to get rich through the peddling of untested industrial processes or the use of potentially hazardous materials without the ethical constraints to make such risks known to unsophisticated yet trusting buyers. Stimulated by the above perspective, it becomes easier to propose a list of preferences to be used in the choice of technology.

7.10. economic dimension of transfer

The economic dimension of development requires the exercise of preferences for technologies that are need-based, rather than those that amplify inequalities between and within countries. Such technologies which are consistent, rather than incompatible with, the basic factor proportions of Nigeria as a developing country with a high rate of population growth with an economy that is energy- and capital-deficient. Thus preference should be for energy-conserving, capital-saving, employment-generating technologies rather than the energy-extravagant, capital-intensive and labor-saving variety; and for technologies of goods and services relevant to mass consumption, rather than to individual luxuries.

More significantly, preference should be for technologies that require the input of local materials, rather than materials which have to be imported from outside the country or transported from distant parts of the country considering the vast size of Nigeria geographically (although not as big as the USA); for technologies which generate employment for under-privileged masses, rather than for privileged elites; for technologies which produce for local consumption, rather than for remote markets: and technologies which promote a symbiotic and mutually reinforcing relationships not dependency relationships.

7.11. social dimension of transfer of technology

The social dimension of development necessitates the exercise of preferences for technologies which promote endogenous self-reliance by increasing social participation and control. The preference is for technologies which lead to an enhancement of the quality of life, rather than to the mere increase in the consumption of goods; and for production technologies which require satisfying creative work, rather than boring routine labor. Such technologies relate men to work, not alienate them from it reducing human beings to mere cogs in the wheels of industrial production. Furthermore in such production environments, machines are subordinated to men and do not dominate their lives. It is technology with a human face.

These are technologies which lead to human settlements (i.e., cities, towns, villages) that are designed to suit the collective and individual lives of the people who live and work in them, rather than mere agglomerations of productive units in which the gains of industry are neutralized by the breakdown of the very social fabric of society, with a cancerous rash of violence and crime and the exclusion of groups of people. In recognition of differences in development these technologies should promote ease, rather than sophistication of operation and blend with, rather than disrupt other traditional technologies and the fabric of social life. These are developed endogenously from the local context, rather than transfered from alien settings and intended to meet different needs. and

7.12. environmental dimension of transfer of technology

The environmental dimension must be concerned with the rational sustained use, rather than the indiscriminate rapid devastation, of the resource-bestowing and life-supporting bio-geophysical environment. Technology transfer must focus on energy-production technologies based on renewable rather than depletable, energy sources (e.g., sun, wind, biogas, geothermal, rather than oil or coal); technologies that are resource- and energy- saving, rather than resource- and energy-intensive; and technologies which produce goods that can be recycled and reused, designed for durability rather goods designed for obsolescence to be used once and thrown away.

When ultimately thrown away, these should be biodegradable rather than non-biodegradable. Production technologies shoud use raw materials which are replenishable (e.g., wood or cotton), rather than exhaustible materials (e.g., steel or petroleum-based synthetic fibres). Production and consumption technologies should inherently minimize noxious or dangerous emissions and wastes, rather than require "fixes" to curb their intrinsically polluting tendencies; and incorporate waste minimization and utilization procedures as integral components, rather than require them as appendages; blend into natural ecosystems by causing minimal disturbance, rather than threaten the biosphere with major perturbations.

7.13. WHAT IS BEING TRANSFERED ! !! !!!

Having discussed, the preferences or criteria that should guide the transfer of technology from a developed country such as the USA to a developing country such as Nigeria, it becomes very necessary to also state very specifically what is being transfered. Based on the assumption that technology is more a matter of "how a thing is done" rather than "what is used", it appears that what is being considered is not the use of transportation planning tools such as mini-computers per se, nor even the procedure for prioritization, but issues of transportation improvement planning process, standards and criteria, and the relationship between the political setting, the need for more efficient and equitable resource allocation and the environmental impacts of networks.

Thus the transfer of technology would not be a "hook, line and sinker" adoption of an MAPC senario. It would be a broad review of what may be acceptable and how it may be applied in its new context given socio-political differences. The political setting refers to the number and type of institutions and their statutory relationship and responsibilities, including their relative position in the hierarchy of institutions including levels of government in the provision of transportation improvements. It also asks the question: how well does this arrangement work and how can it be improved upon? What are its shortcomings?

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The resource allocation element attempts to look into issues concerning government spending on transportation from the recent past to the present with projections for the future; as well as the need for a most judicious utilization of such funds. It looks at the rationale for a multiplicity of programs and the ever present threat of the bigger programs swallowing up the smaller ones and their struggle to stay "alive".

The need to continually seek alternative funding for transportation improvements is also reviewed. The question : how best may available resources be applied to achieve the greatest good is answered by the priority-setting method itself. Environmentally, the lesson is summed up by the Secretary of Transportation for the Commonwealth of Massachusetts, Frank Calucci who said:

" the solution to the traffic congestion is not to build more

and broader roads..(but).. how best the existing network

could be optimally used...such as emphasis on Higher

Occupancy Vehicles (HOV's), public-private partnership on

flexible work schedules (refered to as Flex-time) and better

coordination between land-use and transportation planners

to reduce the length, frequency and direction of work-trips

through more mixed-use development and higher densities".

7.14. environmental considerations in transportation improvements

The two most important considerations in the transfer of transportation improvement technologies are pollution and land-use. Pollution may further be divided into water pollution, air pollution and noise pollution.

7.14.1 air quality

Air quality level as an environmental factor in urban transportation is the product of the interaction among five distinct factors. Namely:
- the source emissions per unit of area;
- the overall size of area;
- the climatic characteristics of the locale (locality)
- the topographic characteristics of the locale; and
- the vegetative characteristics of the locale.

However, the degree to which the air quality in any locale constitutes a health hazard depends to a large extent, on the susceptibility of those who live and work in that locale. Also the degree to which it constitute an economic problem depends on the susceptibility of the particular activities and types of property that are located in that environment. Most significantly, the degree to which any level of substantive health and economic effects arising from poor ambient air quality becomes a political problem tends in turn to be a function of the following:

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- the state of scientific knowledge about air pollution levels and consequences;

- the levels of risk or harm that are considered acceptable in the society;

- the intensity of public concern;

- the costs associated with specific clean-up alternatives; and

- the likelihood that elected public officials will be held responsible for these and related problems.

As a developing country, Nigeria's youngest Ministry is the Ministry of the Environment in the Office of the President; while the Ministry of Transport is one of the oldest and established ministries. The political implications of this is that bureaucrats in the latter are more likely to draw on their experiences to best the former in any situation of conflict of objectives although both are members of the Presidential Advisory Committee on the Environment (PACE). The frequent tendency for official goals to be established in a highly charged political atmosphere, on the basis of inadequate scientific evidence and with little regard for precise costs, benefits and even technical feasibility of policy alternatives makes the problem of air quality in hot, humid equatorial climate of Nigeria a very serious consideration.

7.14.2. the nature of the problem

The one single factor at the bottom of the air quality problem is the level of car ownership and use!   The assumption being that the standards of manufacture of imported and locally assembled vehicles does not drop as a result of the absence of stringent environmental regulations.   The USA has the highest level of car ownership and use in the world with an average of between 1.8 to 2.3 cars per household in the early 1980's. The freedom of movement which a personal automobile provides makes any alternative mode infintely unpopular.   Although the level of car ownership and use in Nigeria as a whole is not as high as in the USA, it is nonetheless higher in selected urban areas.

The   level of congestion in these areas coupled with the absence of stringent air quality controls makes the prompt action on the increased use of personal pleasure cars of immediate priority.   It was between 1964 and 1968, that automobile vehicle mileage tripled in urban America. It was during this period that manufacturers implemented engine modifications that increased engine horsepower which also increased average emissions, particularly of lead and nitrogen oxides per mile. Total lead emissions, in consequence, increased more than fivefold and nitrogen oxide emissions more than sevenfold.

Attention then shifted to the most obvious pollutants : smoke consisting mainly of particulate matter; sulphur dioxide which has a strong, pungent and unpleasant odor; and then photochemical smog which is the product of hydrocarbons and nitrogen oxides, both colorless and invisible yet combining in specific ways under sunlight and warmth to form photochemical oxidants. These are whitish substances that are perceived to cause respiratory and eye irritations, coughing, exhaustion and sleepiness. The Environmental Protection Agency (EPA) is charged with the responsibility for implementing the Clean Air Act which is one of the policy instruments being used to regulate, the quality of cars, and the use of approved quality materials in the generation of electricity.

7.14.3. water pollution factor in transportation improvements

The threat to ground water as a result of run-off from highways would not as great in a tropical climate as it would be in a temperate climate because of the absence of salts on the highways. However, since this is not the only source of pollution to ground water, the threat still remains.

In fact because in Nigeria vehicles still use asbestos brake pads and linings, whatever effects are reduced by the absence of salts is more than made up for by the presence of asbestos in the urban run-off from highways and parking lots. It is also true that while the USA has the Clean Water Act there is yet to be an equivalent legislative instrument in Nigeria.

7.14.4. noise abatement

Noise is more commonly defined as unwanted sound. However, the physiology and the psychology of noise are two different and often conflicting signals. While the latter is subjective,changeable and subject to the percetion of the individual at a point in time and place, latter is objective fixed and measureable. The simplest measure of noise is the decibel (dB) scale which measures the physical intensity of sound waves in the air.

However the most commonly used for regulatory purposes is the A-weighted decibel (dBA) scale which weights decibel readings to accommodate the finding that most people judge high and low-pitched sounds to be louder than sounds of equivalent intensity in the middle range of pitches. The dBA is also the basis for all equipment standards under the federal Noise Control Act.

7.14.5. Sonic qualitites of the Highway

Ironically, various studies on the sensory qualities of cities have shown that "live" noise (within the mid-range) has the most informative effect to the stranger in a new environment and has been used as sonic devices by very experienced travellers for guidance as to the hospitality or lack of it wherever they find themselves. Commuters have also been found to be favorably disposed to the "doppler effect" of sound as they mentally orient themselves in relation to the speeds of other departing or approaching road-users.

In the USA, the most progress in motor noise abatement has been from manufacturers who recognize that noise loud enough to disturb residents and pedestrians would most probably also be offensive as well to potential buyers. Their remedy was the development and installation of low-cost mufflers that reduced the noise of car engines to unobstrusive levels. Where noise was a non-issue as in the case of trucks or where it was a distinguishing feature as in motor-cycles no noise abatement was achieved.

It was in 1970 that Congress gave direction to the EPA to conduct a comprehensive study of the effects of noise on public health and welfare and to develop recommendations for federal legislative action.

This study translated into the Noise Control Act of 1972. Nigeria has no Noise control Act and in light of the gregarious disposition of Nigerians there is little cause to expect much to change in the sonic environment in the urban centres in Nigeria especially from the persepective of transportation improvements. Whatever actions are taken to minimize highway noise must be intrinsic to the highway design and route alignment which is the task for transportation planners and engineers working in multidisciplinary teams with landscape architects and urban designers.

7.14.6. Land-use and economic development

It is cause for reflection that Transportation Plans do not seem to be explicit on the interrelationship between transportation and land use. The criteria for transportation improvement projects hardly ever include economic development and growth as objectives that the network ought to achieve and foster. This is in spite of numerous corridor studies that reveal accelerated growth along these corridors. This is also in spite of the often certified "3C" process with which transportation improvements are supposed to comply. This situation is changing rapidly in light of findings of various studies on growth management, fringe parking, trip origin-destination, etc in the study locale. Although there is increasing aggreement that policy-makers should consider the land use consequences of transportation decisions, there is still no consensus on the degree to which such transportation decisions should shape development trends.

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While on the short run, trip-making patterns and volumes are a function of the spatial distribution of activities, on the long run transportation is a significant factor in shaping land use. The influence of transportation technology, services, and infrastructure on urban form has been the focus of various theories of city form including the well known works of Lynch on the "image of Cities" and Doxiadis theory of "Ekistics". The speed of change in transportation development has been unpredictable. For sixty-eight hundred years following the invention of the wheel, humanity made almost no progress in transportation. People kept pushing and pulling wheeled carts or getting animals to help. But once the railroads introduced a mechanized means of transport, the rate of change becomes accelerated. It was only 80 years from the railroad age to the motor age, 40 years from the motor age to the age of commercial flight, and 20 years from the air age to the first travel in space.

The burden of urban surface transportation has been enormous and uneven on various communities. Within the MAPC region, there are communities that low-mileage communities that have used up between 2% and 5% of their available land area on roads. Then there are the "normal" mileage communities that have applied between 5% and 10% of total available land area to roads. The high mileage communities that have used up more than 12% of their land area for roads have had to cut back on other more vital spaces such as communual open spaces.

Open spaces (green spaces) either private or communual are the "pores" through which settlements respire and perspire and the reduction of these spaces is equivalent to asphixation of the settlement. Also the higher mileage a community has the greater the fiscal burden of keeping the network in a state of good repair and the less land is available for other land uses. To achieve low-mileage highway designation, the entire network must be conceived and incorporated in the structure plans for communities and adequate right-of-way provisions also secured to prevent future delays to transportation improvements. This is a very important lesson for a developing country such as Nigeria.

7.14.7. The Institutional Setting

The key statutory provision requiring analysis of the interrelationships between land use and transportation is section 134(a) of Title 23, U.S. Code, enacted as part of the Federal-Aid Highway Act of 1962. Section 134(a) requires that federally aided transportation investments be based on a **coordinated, comprehensive , continuing** planning process. This has come to be known as the "3C" process. The term **comprehensive** is defined to include economic factors, population, land use, transportation facilities, travel patterns, terminal and transfer facilities, traffic control, zoning, financial resources, and social and economic value factors.