AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
**BIBLIOGRAPHIC INPUT SHEET**

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Batch 80

1. SUBJECT CLASSIFICATION
A. PRIMARY: Development and economics — DP00-0000-0000
B. SECONDARY: Transportation

2. TITLE AND SUBTITLE
Highway planning manual

3. AUTHOR(S)
(101) Jorgensen (Roy) Assoc.,Inc.,Gaithersburg,Md.

4. DOCUMENT DATE: 1975
5. NUMBER OF PAGES: 195p.
6. ARC NUMBER: ARC 625.7.J82c

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Jorgensen

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

9. ABSTRACT

10. CONTROL NUMBER
PN-AAF-354

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Construction
Development
Highway planning
Manuals
Organizing
Policies
Professional personnel
Project planning

13. PROJECT NUMBER

14. CONTRACT NUMBER
AID/otr-C-1420

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

025.1
J82c

AID/OTr-C-1420
Jorgensen
PN-AAF-354

# HIGHWAY PLANNING MANUAL

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for

UNITED STATES AGENCY FOR
INTERNATIONAL DEVELOPMENT

Project Number - Highway Manual AID/OTr C-1420

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SEPTEMBER 1975

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UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

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## ACKNOWLEDGEMENT

In compiling this Highway Planning Manual, information has been utilized and incorporated from various sources. Roy Jorgensen Associates, Inc., wishes to gratefully acknowledge the following sources of information:

- American Association of State Highway and Transportation Officials,
- Transportation Research Board, and
- the Highway Engineers employed by the United States Agency for International Development for their outstanding help in reviewing and editing this Manual.

Financial assistance to compile and publish this Manual was provided by the United States Agency for International Development.

## FOREWORD

This Manual is one of a series of five publications prepared under the auspices of the United States Agency for International Development to provide guidance and assistance to highway agencies in other countries. The other publications are:

- Standard Specifications for Highways and Bridges,
- Design Manual,
- Construction Manual, and
- Accounting Manual.

Although these publications reflect the best of current known practice, they are intended principally as models from which individual agencies might develop specifications, manuals and procedures to fit their own unique needs.

This Manual is directed primarily to highway agency personnel who are responsible for supervision and control of planning activities. The principal objectives of the Manual are:

- to provide basic orientation and understanding of planning organization, policies, practices and responsibilities,
- to document policies and procedures with regard to routine planning activities,
- to provide guidelines for judgments and decisions by planning personnel, and
- to describe the most effective techniques and procedures for highway planning in developing nations.

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# CHAPTER I

## PLANNING CONCEPTS AND PROCEDURES

What is planning? In general, planning is the process of defining objectives and identifying those steps and procedures needed to accomplish the objectives effectively. Objectives must be carefully selected, resources must be allocated in the most cost-effective manner, and actions towards the objectives must be carefully scheduled and controlled. When funds are limited, planning becomes all the more important.

Good planning is recognized as an essential first step in the development and maintenance of highway transportation systems. In well-established highway agencies, planning is usually undertaken as a routine action. But in younger developing countries planning is often neglected, or at best performed superficially. And because of their limited resources and extensive needs, it is in developing countries where good planning is most sorely needed.

Highways in developing countries can greatly influence social and economic development patterns and other environmental attributes. They can change the shapes and sizes of cities. They can increase production from the land. They can create industry and commerce. They can provide for social needs and comforts. But it does not follow that the consequences of any highway development program will be the same regardless of where or how the highways are built and maintained. The economic influence of a highway, for example, is largely dependent on the economic characteristics and potentials of the area it serves.

Therefore, it is possible for a highway agency to have substantial highway development under way which is not of a type to produce maximum potential benefits from the funds which are being spent. A highway agency cannot properly measure its success in terms of the lengths and types of highways being built without regard to the potential ultimate influence of those highways.

General concepts and procedures for highway planning are fairly well established. New techniques and refinements are introduced periodically, but the basic processes are universally accepted. The purpose of this Manual is to identify and describe these processes in ways that they may be adapted to the needs of highway agencies in developing countries. The basic concepts remain the same -- the techniques and degree of sophistication may require modification, depending on the size and capabilities of the individual highway agencies.

Discussions in this Manual are directed to several basic categories of highway planning:

- system planning,
- route and project planning,
- programming and scheduling,
- budgeting, and
- supporting functions.

Subsequent chapters provide detailed descriptions of each of the above types of planning. The purpose and concepts of each are briefly summarized in the following sections.

## SYSTEM PLANNING

A first step in highway planning is to define some long-range objectives for the highway system. What kind of a road network is needed to adequately satisfy present and future transportation needs? Many factors must be considered to answer this question. Among them are:

- Travel desire lines -- both existing and those expected in the future.

- Traffic data -- the numbers and types of vehicles that will be using the roads.

- Economic data -- what effect will road development have on economic growth, and subsequently what effect will economic growth have on future road transportation needs?

- Road classes -- what levels of service are to be provided? Which will be principal arterial highways and which will serve as secondary or local roads?

- Responsibilities -- what responsibilities, if any, will be assigned to regional and local government levels for construction and maintenance of segments of the total highway system.

As a further part of system planning, there is need to thoroughly review and evaluate existing road facilities in terms of adequacy, to identify needed improvements, and to develop rough estimates of the costs and benefits of needed improvements.

Further, there is need to establish general priorities for undertaking needed improvement and development. Usually, the priorities are based on economic analyses to assure that those improvements with greater potential economic benefits are accomplished first. And there must be some long-range financial planning to estimate the rate of progress in system development.

## ROUTE AND PROJECT PLANNING

System planning is concerned mainly with the total highway system and the corridors for traffic movement. When the time comes for identifying specific projects, there is need for much more detailed planning.

First, the entire routing between major termini must be studied. Often there are significant advantages to a completely different routing rather than following existing roadways. And in the case of new development roads, the entire route should be defined before constructing individual segments of the road. Route planning is usually guided by economic analysis of estimated construction costs and road user benefits for each of several alternative route locations within a corridor. Also, in recent years, increasing attention has been given to the social, economic, and environmental effects of highways.

Project planning becomes more detailed by defining the precise beginning and ending of individual projects and sets forth the geometric characteristics of the improvements.

## PROGRAMMING AND SCHEDULING

When individual projects have been identified and priorities have been established, a formal highway improvement program and schedule should be prepared to document the short-range (about 5-year) objectives.

The programming and scheduling process involves consideration of:

- improvement priorities,
- project development time, i. e., time required for preliminary engineering, design, right-of-way acquisition, etc, and
- available funds and constraints on funding.

Improvement programs should be updated annually to accommodate changing conditions, but the basic plan and schedule should be adhered to as closely as possible.

## BUDGETING

Budgeting is the connection between the planning and programming functions and the actual accomplishment of objectives. It is the allocation of resources and commitment of funds for specific purposes during specific time periods.

Formal budgets must be directly tied to approved work programs. If additional work is added to the program, the additional funding must clearly be shown in the budget. If the budget is reduced, specific planned work must be eliminated from the proposed program.

The budgeting process usually includes many improvement projects, concurrently ongoing over a period of years. Formal funding may be on the basis of annual budgets, but longer-range budget planning must be performed to assure continuity of funding for projects under way over a period of several years.

## SUPPORTING FUNCTIONS

The various planning functions require accurate and up-to-date information or the highway system. Compiling this information usually is a continually ongoing operation which supports all of the basic planning functions.

The required information is principally related to road and bridge inventory data and to traffic data. Data systems are provided to process and summarize the information in ways to be effectively utilized for various planning purposes.

These basic supporting functions are described in detail in Chapter VII.

## ORGANIZATION FOR PLANNING

There are no fixed criteria for an organizational structure for planning. The organizational framework and responsibilities can be adapted to the characteristics and practices of individual agencies. The important thing is that objectives and policies be clearly stated -- and that the planning functions and responsibilities for performing those functions are clearly understood.

Chapter II discusses objectives and policies and suggests organizational practices and procedures for carrying out planning functions within a highway agency.

## CHAPTER II

## OBJECTIVES, POLICIES AND ORGANIZATION

The role of planning is to operate as a support function to management. Planners should not be decision-makers with respect to the agency's plans, programs and budgets. Instead, planners should conceptualize, initiate and formulate, for management approval, an appropriate structure of plans and programs devised to provide an efficient working basis for the agency to achieve its goals.

Management should expect planners to provide:

- a well-devised, thoroughly supported, and adequately documented general plan and financial estimate for substantially accomplishing the organization's long-range goals;
- priority recommendations; and
- identification of specific projects and available funds that will allow the agency to carry out improvement programs in accordance with approved priorities, toward ultimate accomplishments set forth in the general plan.

The specific delineation and organization of projects to be accomplished with available funds will be referred to as a "program" in this Manual to distinguish it from the longer range and more general system development plans and from priority plans.

### DEVELOPMENT GOALS

A problem often faced by highway planners is the lack of officially stated goals for national development -- as well as goals for comprehensive transportation systems.

The power of transportation systems to mold the development of nations and their subdivisions has been dramatically demonstrated in many countries. The planning of highway systems should be directed toward obtaining the kinds of economic growths, societal arrangements and land uses that will prove to be most beneficial to the people. This requires advance determination of the most desirable growth patterns, which is beyond the scope of responsibility of highway agencies.

However, highway agencies cannot afford not to plan. Transportation has too much influence on how nations will develop. Without plans, developments are completely motivated by present circumstances including the present demands of industry, commerce, social need, and social custom. These may be short-term and may not ultimately be to the best advantage of the country. Highway developments based on them could become obsolete or could tend to encourage their continuation. But most importantly, without plans, opportunities are lost to use highways to help shape the future of the country and its people.

It is practical for a highway agency to do a limited amount of national goal planning if little or no progress has been made by a more appropriate agency. Projections can be made of population growths in different environments. Trends in industrial, commercial and agricultural development can be identified and projected. Traffic flows can be associated with the needs and dispositions of the populace as a whole and by segments, and these can be projected. Judgments can be made.

In some cases, transportation planners have developed sophisticated models to relate the carriage of persons and merchandise on the highways to the exchanges of goods and services that occur between sources of supply and demand. Projections reflect expected growths in industry and agriculture as well as future population patterns.

There are relatively simple, shortcut methods for approximating the same results. For example, desire-line techniques used in functional classification, described later in this Manual, may be used.

When highway planners are faced with the absence of plans for national development, they should get together with any agency assigned the responsibility to do this kind of planning. This can have good results in developing a cooperative planning activity -- highways, and other modes of transportation will be significant ingredients in the ultimate national plan. It can have good results in encouraging progress toward the actual formulation of a national plan.

## OBJECTIVES

Objectives of the planning division of a national highway agency come from three sources and form a hierarchy in the following order:

- national development goals and objectives,
- goals and objectives of the highway administration, and
- objectives of the planning division.

Specific objectives of the planning division of a national highway agency should include the following:

1. Provide management with a recommended long-range plan for highway development which is thoroughly justified from the standpoints of national transportation needs, national development goals, and optimum social, economic and environmental impacts consistent with financial feasibility and the principles of economic justification.

2. Provide management with guidance and supportive data indicating the most desirable order of development of the highway systems from the standpoint of maximizing early returns on public investment in terms of benefits to the nation and its people.

3. Be reponsive to the desires of those it is trying to serve, including top management, other responsible officials of the agency, other members of the government, and the general public, in making such amendments of plans as may be more acceptable and in developing any additional information requested.

4. Provide management with a recommended detailed program of individual highway projects that will make the most effective use of current funding provisions in progressing toward the goals indicated by the plan.

5. Provide management with all of the support, information and recommendations needed to schedule annual expenditures and develop annual budgets properly.

6. Supply any data or information normally or appropriately produced by the planning function which is needed for the performance or support of any of the highway agency's functions.

7. Supply a regular flow of recommendations and information to management providing for the continual updating of overall plans and the timely development or revision of programs and budgets.

8. Develop and present reports, for public relations purposes, describing the plans, programs and accomplishments of the highway agency.

## POLICIES

The formal establishment of planning policies can be helpful in promoting and maintaining an effective planning operation. It is worthwhile to have policies of two types:

- Basic Policies: A basic policy expresses the overall intention of the agency with respect to its planning performance and output.

- Operating Policies: An operating policy establishes the way the organization will function to carry out basic policies.

Basic policies generally will be established by the chief administrator of the highway agency. However, they can be developed and recommended by divisions of the organization or by management committees.

Operating policies may be established by the chief administrator, in which case they control throughout the entire agency and its divisions, or by the director of a division, in which case they control within the division only.

A basic policy should generally be brief and consistent with the overall goals and objectives of the agency. It should express something that agency management considers important to have established and publicized in order to assure thorough comprehension of its intentions as well as suitable performance to meet its objectives and obligations. Two examples of basic policies are given in Figure 1.

An operating policy may be more lengthy and generally will specify particulars of how the requirements of basic policy will be met by units of the organization. These particulars may include such things as: component outputs that will result in the basic policy being achieved; methods that will be utilized; important considerations that will be included; and records that will

## FIGURE 1

## EXAMPLES OF BASIC POLICIES

### NATIONAL HIGHWAY PLAN

The Highway Agency will prepare and annually update a National Highway Plan. The National Highway Plan will be published and will become the working basis for all current programs. It will represent a feasibly attainable target objective for the development of highway systems over a reasonable period of time, giving due attention to national goals for economic growth and social change as well as the needs of rural and urban local jurisdictions. It will show desirable priorities for development based on obtaining maximum early benefits from investments. It will contain estimates of finances required for complete accomplishment of the plan in appropriate stages. The National Highway Plan, as approved annually by the Administration, will constitute official objectives of the Agency.

### HIGHWAY IMPROVEMENT PROGRAM

The Highway Agency will prepare and annually update a five-year Highway Improvement Program for highway improvements based on expected revenues over the period. The Program will be composed of specifically delineated projects which have been established as a result of initial planning studies culminating, for each project, in a Project Planning Report. This report will describe the limits of a project, characteristics of work, and improvement standards, and will provide an estimate of project costs. The Program will reflect priorities in the National Highway Plan.

At each annual updating, the amended five-year Highway Improvement Program will show, as deleted, those projects which were awarded during the previous year and, as added, those projects selected for a new fifth year. Some adjustments may be made to projects in intermediate years. The five-year Program, as approved by the Administrator, will constitute official objectives of the Agency and will provide the working basis for annual budgets and schedules.

be maintained. Operating policies may require the use of standardized procedures. However, the procedures ordinarily would not be spelled out in detail in operating policy statements, but would be incorporated by reference. Examples of operating policies are given in Figure 2 -- these relate to the basic policies in Figure 1.

## ORGANIZATION

The organization of the highway planning division should make provision for the following basic work processes:

- systems planning,
- route and project planning,
- programming and scheduling,
- budgeting 1/
- data development and maintenance, and
- research.

---

1/ Under some organizational arrangements, neither budgeting nor scheduling would be carried out within the planning division. However, if the financial division does not have well-established capability to develop performance budgets, it may prove desirable to have such budgets developed in the planning division temporarily or permanently.

## FIGURE 2

## EXAMPLES OF OPERATING POLICIES

### CONTINUOUSLY UP-TO-DATE INVENTORIES

To provide a sound basis for annual amendments to the National Highway Plan, the Planning Division will maintain an up-to-date inventory of all highway and road systems under national jurisdiction which will contain detailed information on the geometric and structural characteristics of each road section and appurtenant structures; the service condition of each section and of the structures; and the present amounts and characteristics of traffic using each section. The inventory of geometric and structural characteristics, initially developed through field surveys, will be kept continuously up-to-date through an established reporting procedure which will furnish information for the record whenever there are construction or maintenance changes to the geometric or structural features of any road section. The condition inventory will be kept up-to-date through annual field surveys conducted on a sampling basis. The traffic information will be kept up-to-date through an annual traffic count program. The inventory maintained in accordance with this policy, as well as associated cost records, will provide the basis for regular updates of needs on existing highways, roads and streets in accordance with the annual planning work program.

### FISCAL STATUS REPORT

The Highway Improvement Program will be developed and maintained by the Planning Division. The Financial Division will cooperate fully in providing up-to-date financial information, as required. To partially meet this requirement, the Financial Division, at the beginning of each month, shall prepare and transmit to the Planning Division a report which shall show the current obligation and expenditure status of all funds available to the agency by fund

**(FIGURE 2 continued)**

category and appropriate purpose of expenditure categories. For a particular fiscal period, the obligation status will show the aggregate amounts available to date for obligation in each category and the amounts obligated to date. Obligations will include totals of all future expenditures to which the agency is committed through approval of the Chief Administrator. Close attention will be paid to change status and extra work orders. For the same fiscal period, the expenditure status will show aggregate cash balances or equivalents available for expenditure in each category. The amounts shall include any amounts owing to the agency for fulfilled commitments including amounts billed but unpaid and amounts unbilled and unpaid. For comparison with these amounts, the expenditure status will show, by category, all expenditures made up to not more than 30 days prior to the report date. Copies of the Fiscal Status Report will be circulated to the Chief of the Administrative Division and the Chief Administrator.

In a fully developed highway planning division, it is common to find each of these processes assigned to one of the major units under a manager who reports directly to the division head. In a less fully developed organization, one or more of the processes may be missing and may not be immediately required. For example, in some countries, route and project planning -- feasibility studies -- are performed entirely by consultants.

Sometimes, the indicated basic processes may be subdivided, for organizational purposes, into two or more activities regarded as having equivalent status. This may be acceptable, provided there is a clear division of responsibility for different specific outputs which contribute to a desired aggregate product, and responsibility is specifically assigned for the product. However, fragmenting of basic processes does tend to obscure the basic objectives of the planning division to which the basic processes are directed.

In many respects, the data development and maintenance process does not belong in the same category with the other basic work processes. It has no single product. It does not satisfy any of the basic objectives of the planning process. Its exclusive function is to contribute to other basic processes.

Nevertheless, there is a substantial amount of work associated with the gathering, analyzing and recording of data pertinent to the planning operation. Such data include: different types of traffic data; road inventory data; highway safety data; environmental data; highway cost data; legislative data; and government finance data. Good organization is required to gather, analyze and record these data cost-effectively so that they are available in proper form when they are needed, without unnecessary and costly duplication.

In many instances, the same data are needed for more than one basic process and by more than one organizational unit. Also, data development and maintenance often employ similar skills, organization and equipment. Therefore, assignment of responsibility to gather, process and analyze all routine data to one unit of the organization -- sometimes two -- has proven effective and efficient. The Manual will assume data organization of this type.

## System Planning

If major units of the planning division conform to the basic work processes, there will need to be some organization into subunits below this level. System planning can be effectively divided into sections responsible for: (1) functional classification, sufficiency ratings and continuous needs studies; (2) socio-economic projections, systems development and long-range plans; and (3) environmental impact analyses and priority planning. The last indicated section would be responsible for putting together the working plan document and keeping it up to date with an annual submittal to management as a minimal requirement. There would need to be close coordination between the three sections.

## Route and Project Planning

Route and project planning is best handled by making team assignments to studies as they are initiated. The size and composition of a team is determined by the scope and content of the required study. The teams may be composed of engineers, economists or other disciplines trained to make appropriate environmental impact assessments. The composition of a team might be changed during the course of the work where there are significant environmental impacts requiring technical expertise in more than one environmental area. Route and project planning studies should be scheduled in advance with team assignments for a working period of several months, and with the schedule revised no less than monthly.

In an effective use of environmental disciplines in planning, a number of specialists might be assigned principally to the route and project planning unit. These, then, could be utilized more or less on a consulting basis by the system planning sections with requests being made well in advance for individual assignments. This would fit in with the team type of operation of the route and project planning unit.

Even with the section organization of the systems planning group, the same principle can apply in reverse. The composition of the sections should be kept flexible enough that personnel can be shifted between them, or loaned or transferred to other units as the nature of the workload changes. Planning is a dynamic process which is often reduced in effectuality by the establishment of inflexible minor organizational units with responsibilities for limited processes which, ultimately, may not make a significant contribution to the accomplishment of planning objectives.

## Programming and Scheduling

Programming can be divided conveniently into two sections, a project evaluation section and a financial programming section. As well as making all of the financial determinations, the financial programming section would formulate the recommended program in priority order. If scheduling and monitoring are to be performed in the planning division, it will probably be assigned to a section in the programming unit.

## Budgeting

Although budgeting has been shown as a basic work process, it probably would not be organized as a major planning unit in a developing country. If the responsibility for performance budgeting is assigned to the planning division, the most effective organization probably will be to assign it to a section in the programming unit.

## Data Development and Maintenance

The data development and maintenance unit can be divided into several sections and some of these may have subsections. The basic division will depend on the type of work to be carried out -- most of the employees of this unit will be technicians. Logical sections might include: (1) traffic; (2) inventory; (3) statistics; (4) records (data processing); and (5) mapping.

The records section would be responsible for coordinating the records of all of the other sections to see that the major units, such as system planning and route and project planning, are supplied with the data they need, in the form they need it, at the time they need it. On the basis of demand, they would formulate schedules to supply data and check with the other sections to assure data availability. Where a computer is available, this would be the data processing section.

The traffic section might be subdivided into a traffic analysis subsection and a field surveys (traffic count) subsection. The analysis subsection would be responsible for the development of the traffic count program. The field surveys subsection would consist of a manager and his field crews. The inventory section might be organized similarly.

## Research

The researchunit, in a developing country, would probably be small and not subdivided.

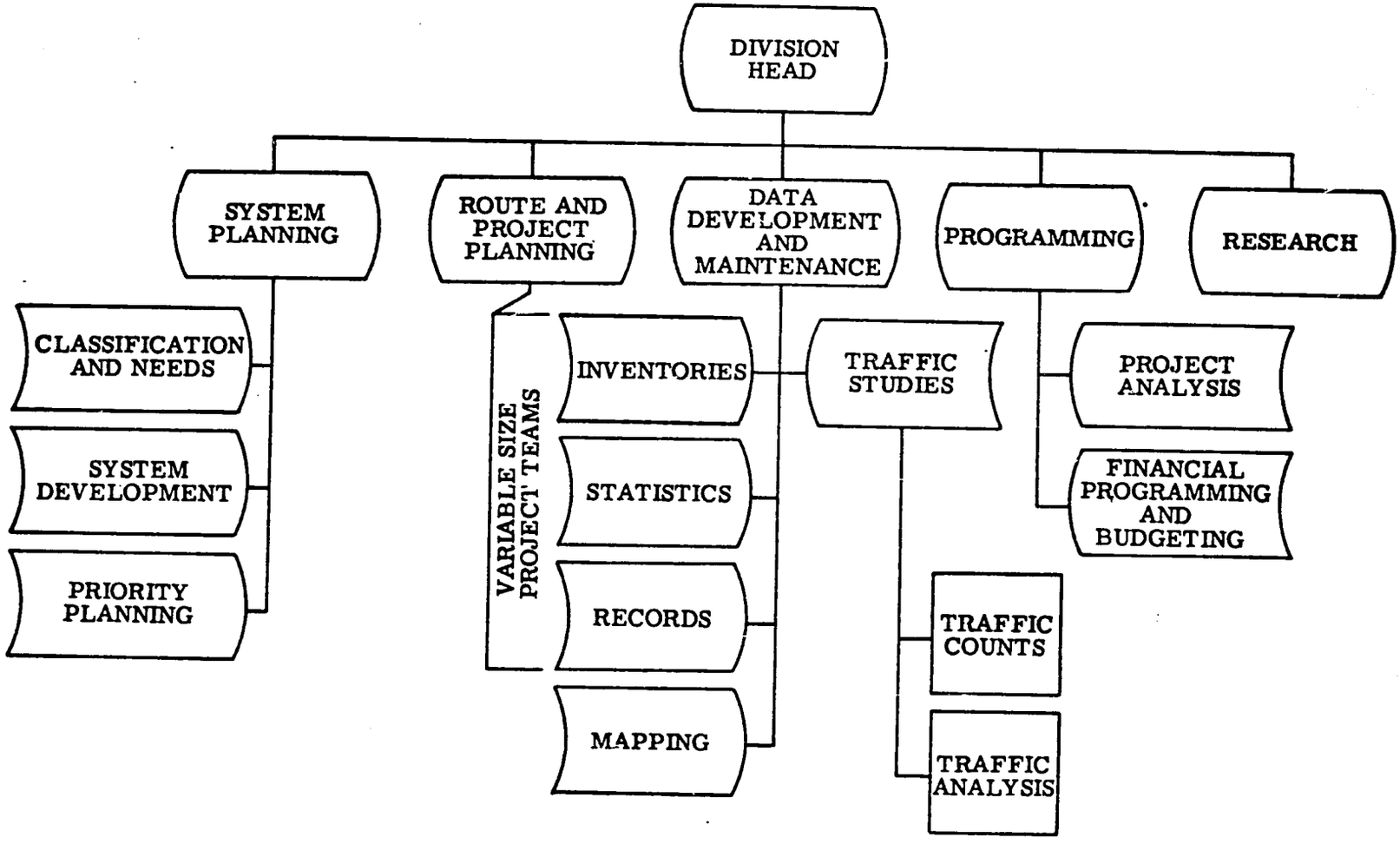
## Recommended Organization

A recommended typical organization for the planning division of a highway agency in a developing country is shown in Figure 3. The functions of the units are described in the following chapters.

FIGURE 3

TYPICAL ORGANIZATION:

HIGHWAY PLANNING DIVISION



## CHAPTER III

## SYSTEM PLANNING

### SETTING HIGHWAY GOALS

The organizational unit responsible for system development should undertake first to determine general goals and objectives towards which their efforts should be directed. These should be set down in writing. They may come from several sources:

1. Chief Government Executive and Legislature: Sometimes the chief executive has indicated in speeches or press releases what he feels should be the goals and objectives of highway development, and sometimes goals and objectives can be inferred from the chief executive's published programs. Also, goals and objectives may be specifically stated in highway laws or may be inferred from the laws. Or they may be stated in executive documents establishing or empowering the highway agency.

2. Lending or Granting Agencies: In developing countries whose highway funding is significantly derived from outside agencies making loans or grants, requirements pertaining to the application of these funds possibly can be translated into highway development goals and objectives.

3. Subordinate Governmental Jurisdictions: Related programs and expressed objectives of lower levels of government, including local jurisdictions, should be taken into consideration in formulating national highway development goals and objectives.

4. Governmental Planning Agency(ies): A well-established governmental agency responsible for socio-economic and general environmental planning may set goals and objectives which directly apply or are pertinent to highway development.

5. Highway Executive or Policy Board: The highway agency executive or policy body -- commission, committee or board -- may specifically have adopted or publicly stated goals and objectives for highway development. These also might be reflected in management policies.

6. Formulated by Planning Division: Since there may be very few statements of highway development goals and objectives available from any source, planners may need to develop a set by intuitive logic and submit them to management for approval.

Not only is it necessary for system planners to have an approved listing of goals and objectives for highway development, but there should be priorities associated with the listing. Figure 4 gives an example of typical goals and objectives which might influence the direction of a highway program. However, pursuit of some of these goals and objectives would tend to conflict with equal achievements of others. Therefore, in order for a highway plan to have a firm direction, priorities should be indicated.

Although it is necessary to formulate goals and objectives and have them approved, it is essentially a one-time task, with minor revisions required from time to time.

## FIGURE 4

## TYPICAL HIGHWAY DEVELOPMENT GOALS AND OBJECTIVES

1. To encourage the growth of industry, commerce and agriculture throughout the country by providing economically justified highway facilities at locations where they most significantly will influence this growth.

2. To bring all highways and roads and their appurtenant structures to standards of adequacy with respect to capacity, safety and structural condition and as related to service demands presently existing or expected within a reasonable future period.

3. To provide the maximum degree of highway safety that can be economically justified.

4. To provide an efficient basic system of commercial arteries.

5. To provide a strong farm-to-market system which will open new land, reduce farming costs, provide better consumer prices and encourage rural living.

6. To provide the populace with avenues for recreation.

7. To enhance the use and protection of the environment and avoid unnecessary damage to any aspect of it.

8. To encourage tourism.

## HIGHWAY DEVELOPMENT CONSIDERATIONS

Planning future highway developments ordinarily will be accomplished on an area-by-area basis. For each area under consideration, the system planner first needs to gather all available information on such things as population size and characteristics, land characteristics and land use, commerce and industry, road characteristics and travel, other transportation systems, living patterns and social characteristics, recreation, tourism, and highway and transportation costs. In addition, information should be developed on trends for all of the foregoing.

Initiation of highway development possibilities will largely be conceptual, based on recognition of transportation needs. For example, there may be some beginning commercial, industrial, agricultural, or recreational venture that indicates a potential for significant development in an area if additional highway sources are provided. Judgment might indicate that appropriate highway services are the only missing ingredients.

New highways can influence where industrial and commercial growth will occur; change the size and shape of population centers; provide for the development of national resources; influence rural life patterns; increase tourism; and both harm and enhance the environment. Enhancement of the environment occurs when access allows people to make better use of it and to protect it. These are a few examples of the potential influences of new highways -- there are many more.

## TRENDS AND PROJECTIONS

Economic growth considerations will weigh heavily in decisions on highway development. Commonly, trends may be established from recent history to indicate the types of change that are occurring. Highway service requirements may be related to these trends. Projections of the trends thus indicate projected service requirements and it may be assumed that provision of these will encourage the desired growth. Statistical methods should be utilized in projecting trends.

## Population

Projections of national population growth may be based on several formulas using recently experienced growth trends as well as trends or rationalizations pertaining to such things as fertility, mortality, age composition, racial composition, sexual composition, and immigration. National population projections for developing countries should take into consideration expected economic changes. Local population projections usually require analyses and projections of economic growth. For approximations, however, accepted national projections can be disaggregated in proportion to straight-line local projections weighted by judgment factors indicating relative economic growth potential. Because the job is basically one for experts, highway system planners would be well advised to refer to official government projections and those made by universities or other agencies with the necessary expertise.

## Vehicle Ownership and Operating Characteristics

Population projections are basic to many of the other projections needed by highway planners, such as projections of motor vehicle ownership, motor vehicle travel, fuel consumption on the highways, and tax revenues from motor vehicles.

In making these projections, the first activity usually involves establishing a relationship between population and motor vehicle ownership. Sometimes gross population is used. However, driver-age population usually produces better results. Population and number of motor vehicles, as shown on registration lists, are established for each year of a base year period -- at least ten years. The ratio of number of persons per vehicle is established. A definite trend should be discernible in this ratio for the base period. This trend is projected into the future and applied to population projections to give estimates of future numbers of motor vehicles.

Separate ratios can be established for passenger cars and commercial vehicles . The trend relationship is established for passenger cars and driver-age population. Passenger car projections are made on this basis. The trend relationship is established between passenger cars and total vehicles. Once the passenger car projections have been made, the latter trend can be used to project total vehicles.

Once numbers of vehicles have been predicted, the average annual miles travelled per vehicle can be established for the base period and projected. 1/ Average fuel consumption per vehicle-kilometer can be treated similarly. In each case, the projected ratios are applied to a characteristic value of population or motor vehicle usage which already has been projected.

It is a good general principle to project trends on characteristic relationships instead of trends on base values, wherever possible. The logic in a relationship allows unusual deviations to be spotted and reasonable limits to be established.

## Highway Use

One way of developing highway-use projections, as related to limited areas or individual routes, is to divide the projection of total annual vehicle-kilometers by present total annual vehicle-kilometers. The resulting traffic growth factor, usually expressed as a compounded percent per year, is then applied to traffic on existing routes. Traffic on new routes is determined by

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1/ This presumes that an annual traffic counting program has been conducted to provide estimates of total annual vehicle-kilometers for the base period. If not, typical figures may have to be used from limited studies or studies in other countries.

assigning some of the traffic from existing facilities which serve the same points. These general procedures may be modified by developing trends on particular routes and by estimated "generated" traffic on new routes.

Research has indicated that traffic on a main highway linking two populated places can often be approximated by a traffic "interactance" formula:

$$T = \frac{k\sqrt{P_1 P_2}}{d^2}$$

where: $T$ = traffic in trips (vehicles per day)

$P_1, P_2$ = populations of places 1 and 2

$d$ = distance between places (km)

$k$ = constant.

The constant value, k, will vary from country to country and even from region to region within a country. The constant may be determined empirically by a regression analysis, using origin-destination survey data and population data. Caution needs to be exercised because reliability of the formula breaks down when (a) the population of one place is very large as compared to the other, and (b) the distance is very great. Populations generally should not be less than 500 or distances more than 160 kilometers. Allowances also should be made for components of through traffic on a route -- traffic not generated in either of the two places.

Modifications of the formula which have proved useful include the following:

1. $T = am^2 + bm + c$ (North Carolina) [1/]

where: $m = \frac{\sqrt{P_1 P_2}}{d^2}$

$a, b, c$ = constants.

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1/ See James S. Burch, "Traffic Interactance Between Cities," Highway Research Board Bulletin, No. 297, National Academy of Sciences, Washington, D. C., 1961, p. 15.

2. $T = ce^{-kd}\sqrt{P_1 P_2}$ (Illinois) [1/]

where: $e = 2.718$ (base of natural logarithms)

$c, k$ = constants.

The form of these equations is not so important as the potential to develop and calibrate an interactance formula that can give reasonable estimates of traffic on the main highways between population centers.

## Commercial Vehicle Use

Commercial vehicles usually represent a large percentage of the traffic stream in developing countries. Estimates may be developed by using percentages and trends in percentages of total traffic projected by one of the methods indicated above. However, this would not give due consideration to the particulars of area development.

It is possible to develop relationships between shipments on the highway -- by numbers, weight and vehicle size -- and population characteristics as well as land uses. Such relationships are needed in order to properly plan highway development within an area.

It is suggested that surveys can be conducted to relate such things as:

- numbers and weights of shipments of basic commodities on service highways to supply various sizes of urban populations, so estimates can be made in terms of city size;

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1/ See R. E. Whiteside, et. al., "Intercity Traffic Projections," Highway Research Record, No. 205, National Academy of Sciences, Washington, D. C., 1967, p. 125.

- numbers and weights of shipments to serve a class of industry by size, such as number of shipments related to a type and volume of manufactured product;

- average numbers and weights of shipments on service highways to serve a component of population with some commercial activity index;

- numbers and weights of shipments to supply a rural land use category; and

- typical vehicle distributions by size and weight class to handle numbers and weights of shipments by class.

With information like this and estimates of potential population and commercial growth as well as land use changes, system planners can rationally develop a commercial source plan showing general alignment and capacity requirements for different functional classes of highways.

As an initial step in the development of the plan, information needs to be gathered from all available sources and maps need to be constructed to show present and anticipated future population and land-use characteristics in a target year or perhaps in more than one target year.

There is an alternative method which can be applied to a developing country as a whole, providing answers on an area-by-area basis. While this method is ambitious and the associated data gathering costly, it is practical and already has been applied in some developing countries. The method involves location of sources and destinations of all goods and materials produced in or consumed in the country. Estimates of quantities produced, consumed or transshipped at all points are needed. Using a computer, a model is constructed to show the flow of shipments from source to destination and the highways involved, including proposed highways. Sources include manufacturing centers, basic industry centers, agricultural production centers, national

boundaries, and ports. Destinations include population centers, national boundaries, and ports. The resulting movements by commodity class are translated into estimated commercial traffic volumes.

Generally, the model would be developed and calibrated first for the existing situation. Then, by projecting future consumption, production, exports and imports by location, future volumes of commercial traffic can be predicted.

Forecast Period

Although planning and designing highway facilities for traffic volumes twenty years in the future has been common practice in developed countries, it may be inappropriate in developing countries. Where motor vehicle ownership and use currently are low but increasing rapidly, twenty-year traffic growth projections on specific highways may be overstated and generally unreliable.

Although they may be unreliable to the degree that it would be unwise to use them as a firm basis for specific highway developments or design standards, very long-range traffic projections -- 15 to 20 years or more -- can provide a valuable guide in developing future highway service patterns related to socio-economic growths. These patterns -- the best that can be produced within the limits of predictive capability -- minimally provide a worthwhile direction for shorter range plans and programs.

## SYSTEM DEVELOPMENT PLANNING

System development planning is normally carried out for regions, districts or areas which appear as logical subdivisions of the country for planning. patterns of socio-economic growth and highway service. Boundaries of system planning areas may logically be suggested by such things as changes in general terrain configurations, changes in population and/or land use patterns, political boundaries, and existing highway configurations.

Normally, the system planners will gather all available pertinent information pertaining to the planning area including population characteristics, motor vehicle characteristics, travel patterns, community values, and environmental factors. They also will procure all pertinent area development plans. Most of this information will be visually portrayed or referenced into maps of the area.

By logic, using the best available data, the system planner then must conceive a general population, land use and economic plan for the area by trending and projecting existing information of the type noted. Caution should be exercised not to seek more refinement than can logically indicate a need or demand for particular highway services. For example, characteristics of industry and commercial activities in population centers are pertinent only to the extent that they create demands for traffic service on rural highways. It may be possible simply to relate total commercial vehicle trips on main routes to aggregate annual gross revenues or employment in certain industry and commercial categories. However, the traffic demands of industry or commercial establishments at rural sites may need to be treated separately.

It is not necessary to cover the whole country at one time. A small group of planners generally treating regions progressively on a priority basis can result in an efficient and productive planning activity. Gaps in the continuity of regional treatments may occur when the system development planners may wish to develop a national picture or model for full system integration. However, the creation of a fully-integrated long-range national development plan should not be the central purpose of system development planning.

Instead, the main purpose of this subfunction should be to provide input into the priority plan which will constitute the long-range working objective of the highway agency. The input specifically should consist of recommended system plans in particular regions fully documented by descriptions or maps of growth changes to which the highway plan is related and by analyses of

the need for and value of the highways as recommended. The priority plan will be developed on the basis of these recommendations and consideration of existing system needs.

## Economic Analysis

In order to evaluate system development alternatives and to support system development recommendations, economic analyses should be made to compare benefits of a particular proposal with costs.

The benefits to the users of a new facility are the calculated savings in operating costs.

Operating costs can be determined for different vehicle types traveling on different classes of highways under different highway conditions. Basic reference books are available for these calculations.[1/] There also have been papers published internationally. Most of the reference materials contain and describe the use of tables and charts which relate costs of fuel and oil consumption, tire wear, maintenance and repairs, depreciation and value of operating time for different vehicle types to different highway types and conditions. These include gradient class, surface type, and surface conditions. The tables and charts will need to be constructed to reflect typical costs and types of operation in each country. Closely related tables and charts may be available from other countries.

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1/ For example, see:
Road User Benefit Analysis for Highway Improvements, American Association of State Highway Officials, Washington, D. C., 1960.
Robley Winfrey, Economic Analysis for Highways, International Textbook Co., Scranton, Pennsylvania, 1969.

Many economists hold that savings in transportation costs can be made to reflect all of the economic benefits due to new transportation facilities. Although this may be true where there are viable transportation alternatives, of which the new facility is one, it does not appear to be true where a new facility causes extensive development by opening new possibilities of transportation which were not previously available. As an extreme, consider an area which is not served by highways or any reasonably competitive transportation mode. When a highway is built, development occurs. The area now realizes its productive potential and supplies products of value to the country as a whole or, in other words, contributes to the Gross National Product. The aggregate market value of the new production may reasonably be assumed to be the amount of the contribution. Its market value might be considered as resulting from costs of production and transportation plus a profit, or:

Value = production cost + transportation cost + profit

This indicates that the provision of transportation -- the new highway -- adds a specific value to the products of the area being transported which is equal to the transportation cost, an aggregate of motor vehicle operating costs. The benefits are assumed to be equal to the increase in Gross National Product contributed by use of the new facility.

If there were no tendency for prices to equalize, the production consumed within the area would be sold at lower prices than that transported. There would be no need to recover transportation costs. In other words, there would be no transportation cost value included in the market value of the production consumed internally.

This suggests that benefits due to new highway facilities, which represent the only reasonable transportation mode from the standpoint of competitive cost, are minimally equal to the aggregate operating costs of vehicles on the new facility for the useful life of the facility.

If a new facility is built to serve as a more attractive alternative to the existing facilities and, therefore, is expected to draw a significant proportion of the future traffic, it would be reasonable to assume the benefits would be equal to the aggregate of all transportation costs on all facilities after the new one is built and for its useful life minus the aggregate of all transportation costs that would have been incurred on the old facilities during the same period.

Caution must be exercised both in considering and using this approach to determine the benefits of a new highway. The analysis deals with aggregate operating costs which are presumed to increase because new traffic is generated due to development of a production area. Other reasons for increases in operating costs, including increases in unit costs, do not contribute to increased market value based on constant dollars, but tend to operate against increased productivity. Careful examination will show that this effect of unit operating cost increases does not conflict with the idea that operating costs increases, in aggregate, can be used to measure benefits due to a highway development.

This approach to benefits measurement, in the case of new facilities supplying a potential development area for the first time, is presented because of its simplicity and general supportability. Other useful approaches, available through such organizations as the International Road Federation, tend to be much more complex.

Alternative Method No. 1[1/]

This method is used when the proposed new facility is a highway into a previously undeveloped area or little developed area with little or no previous highway service of the kind needed to spur development.

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1/ It is not within the scope of this manual to describe in detail the economic evaluation procedures that should be applied in these determinations. Some basic considerations are discussed under Alternative Method No. 2. Additional reference works should be consulted such as Economic Analysis for Highways by Robley Winfrey, International Textbook Company, Scranton, Pennsylvania, 1969. Some basic considerations are discussed under Alternative Method No. 2

1. By methods previously discussed, on the basis of anticipated area development, project the number of vehicles expected to use the new facility by vehicle type classification. Make projections for the expected life of the facility.

2. Using the traffic projections and appropriate reference tables and charts, calculate the aggregate annual operating costs of all vehicles which will use the new facility during its useful life. Useful life occurs from the time the new facility is built to when it will need to be substantially replaced. Operating costs are calculated from estimated unit operating costs for each future year for each vehicle type.

3. Convert aggregate annual operating costs for each future year to present worth by use of a present worth factor and appropriate interest rate, as follows:

$$PWCN_j = CN_j \times PWF_j$$

where:

$PWCN_j$ = Present worth of aggregate annual operating costs on new facility for the $j$th year after construction.

$CN_j$ = Aggregate annual operating costs on new facility for for the $j$ th year after construction.

$PWF_j$ = Present worth factor = $\frac{1}{(1+i)^j}$

$i$ = Interest rate

$j$ = Any year during the useful life of the facility.

4. Calculate total benefits by summation as follows:

$$V_B = \sum_{1}^{n} PWCN_j$$

where

$V_B$ = Present worth of benefits from new facility

n = Number of years of useful life of new facility

The same methodology may be applied to more than one new facility in the same area for the same time period.

Alternative Method No. 2

This method is used when there is an existing highway system and significant development of the area would occur even though original facilities were not replaced. The new facilities might be expected to spur development. This is the "standard" method.

1. By methods previously discussed, project the number of vehicles expected to use all facilities, with and without the new facilities, by vehicle type classification. Project all traffic to the midyear of the economic analysis period. This period may be (1) the useful life of the facility before substantial replacement is required or (2) a shorter period if terminal or salvage value of the facility is considered on the cost side. Determine where proportions of the traffic are likely to originate and terminate to permit evaluation of time savings. Assign traffic to the new facility(ies) if (1) there is savings in time from origin to destination, and (2) there are significant non-time related savings in operating costs. Judgment will be necessary.

2. Using the traffic projections and appropriate reference tables and charts, calculate the aggregate annual operating costs, by vehicle type, for traffic using the old facilities and traffic using the new facilities. Also determine the relative average operating speeds, by vehicle type, for the facilities and calculate timesavings for traffic using the nes facility.

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1/ For convenience, make all cost determinations for the midyear of the economic analysis period.

3. Determine savings in operating costs due to the new facility by subtracting the aggregate costs to traffic when the assigned proportion is assumed to use the facility(ies) from the aggregate costs when all traffic is assumed to use the old facilities. The fact that the new facility may be on the same alignment as an old route does not alter the nature of these calculations.

4. The total savings will need to be reduced to present worth by a series present worth factor and appropriate interest rate, as follows:

$$V_B = (CO - CON) \times SPW$$

where:

$V_B$ = Present worth of benefits from new facilities

CO = Average annual operating costs for traffic using existing facilities with no new facilities

CON = Average annual operating costs for traffic using existing plus new facilities

SPW = Series present worth factor = $\frac{(1+i)^n - 1}{i\,(1+i)^n}$

n = Number of years of useful life of new facilities

i = Interest rate

## Benefits Versus Costs

Although it may appear so on the surface, there is no real conflict in philosophy between the above two alternative methods. One starts from a zero situation. If presently developed countries had not produced highways, railroads or similar relatively inexpensive transportation, productivity would not

have increased to anywhere near the present extent. It would be tremendously expensive to move goods far from the production source to a far-removed market. Therefore, the first provision of transportation modes which can be utilized by modern vehicles has a very large effect on productivity or creates a very large benefit to the total economy. In a totally free enterprise economy, it is appropriate to relate the amount of benefit to what people are willing to pay for the transportation movements.

When transportation facilities have been built and will accommodate modern modes, the situation is different. Production is established to the extent transportation costs allow. Here, it is the negative increment in costs, operating cost savings -- if taxes are relatively fixed -- that produce the additional productivity.

It is important that both methods intend to express benefits in terms of a factor that relates entirely to traffic, including the composition of traffic. This means there has to be great care in relating traffic closely to the specific developments that are expected to occur. Too often, traffic growth is based on average growth rates and estimated percentages of vehicles.

Instead, in establishing desirable system improvements, there should be a real effort to determine the reason for traffic and its composition as related to the anticipated developments.

Thus, there should be an attempt to determine how an area is going to develop with respect to land use, commerce and social patterns. Then, exploration of subject literature combined with rough calculations can provide the basis for determining traffic relationships. Note that the highway system development planners may need to develop their own land use plans when it is not being done elsewhere. This has been discussed already. These are reasons why continuous system development planning basically should be limited to one area at a time, although there needs to be some consideration of the regionwide and nationwide systems and their economic, environmental and social relationships.

Determination of benefits must be accompanied by determination of costs. Comparative costs should be determined by aggregating all costs during the economic evaluation period for the construction and operation of the new facility less any costs eliminated from operation of the old facilities. Costs include any capital improvement costs, including replacements, during the evaluation period and all project maintenance and traffic engineering costs. For the type of economic evaluation suggested, all annual costs will need to be determined on an average annual basis at the midyear and reduced to present worth. Some analysts deduct annual costs, such as maintenance, from annual benefits rather than add these costs to annualized capital costs. Either method may be used and will produce similar results.

When there has been a mathematical determination of the benefits and costs related to a development alternative, the relationship of the two needs to be expressed in a way which will allow comparison with other alternatives.

The most common way, at this stage of planning, is to use a benefits-costs ratio. More refined considerations can be left to more refined planning stages.

In this case, it is necessary to express benefits and costs in the same relative terms. That is, if benefits are expressed on the basis of present worth, costs must be expressed similarly. If costs are expressed as uniform annual costs, benefits must be expressed as uniform annual benefits. Alternative No. 2 indicates how benefits can be reduced.

Costs often involve one or two fairly large outlays at fixed points in time plus annual recurring expenses. In reducing these costs to a uniform basis for benefits-costs determinations, it may be necessary to use more than one formula. A capital-recovery formula is appropriate to derive average annual expenditures related to an initial investment. A subsequent investment might be (1) reduced to present worth using a present worth formula, or (2) expressed as annual expenditures by using a sinking fund formula. Once costs are expressed on an average annual basis, they can be added to annual recurring

costs and the results can be totalled and averaged. If the recurring costs are determined as averages or regularly increasing costs, it may be more desirable, initially, to reduce all costs to present worth by appropriate investment formula. A good reference book on economic analysis for highways or similar enterprises should be consulted (see earlier reference).

## Environmental Impacts

System planning is the place to start an environmental impact analysis. Highways, and other transportation modes, are built to have environmental impacts. Some are service-related; some are economic; some are social; some are physiograhic; some combine elements of all of these. Some are desirable, others are undesirable.

Any one of these impacts can be important. It is not sufficient to consider only the engineering and economic impact at the time of system planning. There should be careful consideration of all possible impacts with respect to each alternative and each should be considered in an orderly way. Some may require calculations. All require judgment.

The system planner should document all environmental decisions thoroughly, and this documentation should become part of a continuing record relating to all decisions on highway development in the area. At a later stage, in a good planning operation, this documentation will be reviewed and play a role in the decisions related to route and project planning.

## System Development Planning Reports

The output of system development planning is a report describing the systems planning study for an area and recommending, with full support (engineering, economic and environmental), the system development for an area. This report should be reviewed by top management for approval of recommendations or comments, and later indication of priorities. The report then becomes an input to priority planning.

## CLASSIFICATION AND NEEDS PLANNING

Although system development planning and classification and needs planning cannot be altogether divorced -- each needs to know intimately what the other is doing -- the two systems utilize basically different approaches which need to be specifically provided for in the system planning process.

Classification and needs planning involves the examination of existing highway systems to determine how they are functioning and are likely to function as related to current and projected service demands. It also involves selecting and evaluating improvements to present systems on the basis of providing the most beneficial and cost-effective service throughout the highway plan. It involves organizing potential improvements in priority order with respect to benefits and costs. In itself, it is a substantial job. In fact, in many highway agencies, it occupies so much attention that system development planning -- heading in new directions to influence social and economic developments -- is practically forgotten.

The heart of classification and needs planning is an adequate data system. There needs to be provision for a continuously current inventory of all of the salient features of all highway route segments as may be related to the service demands on them. In addition to detailed information on physical features and conditions, there needs to be up-to-date information on traffic and highway safety. There must be commensurate information on design policies and standards and on costs associated with various kinds of highway improvements in various situations.

The information which is most expensive and difficult to obtain -- inventory and traffic information from the field -- can be developed by appropriate sampling procedures on a regular coverage basis. Because this information is also indispensable to other basic planning processes, procedures for obtaining and maintaining it are contained in Chapter VII, Planning Support Functions.

The responsible system planners, however, have a large stake in seeing that these procedures are carried out properly and usually have an input into their formulation and implementation.

Other information not developed from field surveys, such as information on improvement costs, can be maintained through establishment of a system of regular reports[1/] to planners from other agency divisions.

Once all of the necessary up-to-date information is available, the process of evaluating existing highways in terms of present and future needs can be undertaken. This commonly begins with a procedure called "functional classification."

## Functional Classification

### Classification Terms

Functional classification distinguishes the traffic service characteristics of different highways, roads, and streets and indicates the relative importance of individual roadway facilities at different economic and social levels.

Terms such as "arterial" or "trunk" are used to designate highways or streets which provide for relatively long-distance travel at relatively high operating speeds. At the national level, these facilities traverse the country connecting major cities and, thus, are significantly important to the economy of the nation as a whole. At the city level, arterial facilities traverse the city connecting residential areas to the suburban shopping centers, to each other, to city centers, and to rural highways. They are significantly important to the economy and social life of the city. For long-distance, high-speed travel, regions are served both by the arterial system that serves the nation and additional regional routes having arterial characteristics.

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1/ A system of reports by occurrence can also be immensely helpful in keeping basic roadway information up-to-date.

The term "collector" is used to designate routes which collect traffic from land service roads and streets and feed this traffic to the arterial systems. Collectors may serve an arterial function over shorter distances than highways or streets that are designated as arterial. At the same time, collectors also may serve individual establishments -- even residences -- in addition to carrying the longer distance traffic.

The terms "local road" and "local street" are used to designate facilities that carry traffic from individual residences, farms, or industrial or commercial establishments for relatively short distances at relatively low travel speeds to collectors which then may carry the traffic to arterials or trunk highways.

All of these terms are intended to convey relative instead of absolute concepts. Arterial highways or streets predominantly provide a through-type service. Local roads or streets predominantly provide land-use service.

Arterials usually deserve the most attention because of greater economic importance to the community as a whole. These facilities also invariably cost more to construct or maintain because of relatively more traffic and relatively higher design speeds.

Local roads or streets are most important to the people who live, farm, or work in adjacent establishments. Collectors usually are of in-between importance to the community as a whole, affecting more people than local roads or streets -- but less than arterials.

It obviously would be uneconomical to improve more routes to high arterial standards than are required to provide adequate traffic service. It would also be uneconomical to have a larger collector system than is needed because designs for collectors are more expensive than designs for local roads or streets.

The terms "primary" and "secondary" commonly are used in connection with classification, but these indicate the relative importance of systems, from a community standpoint, instead of their functional differences. For example, both a national primary and national secondary system may be arterial in nature, with the primary system being more important to the whole nation. Regional primary sytems are often composed largely of collector roads to distinguish the region-wide importance of these as compared with local roads.

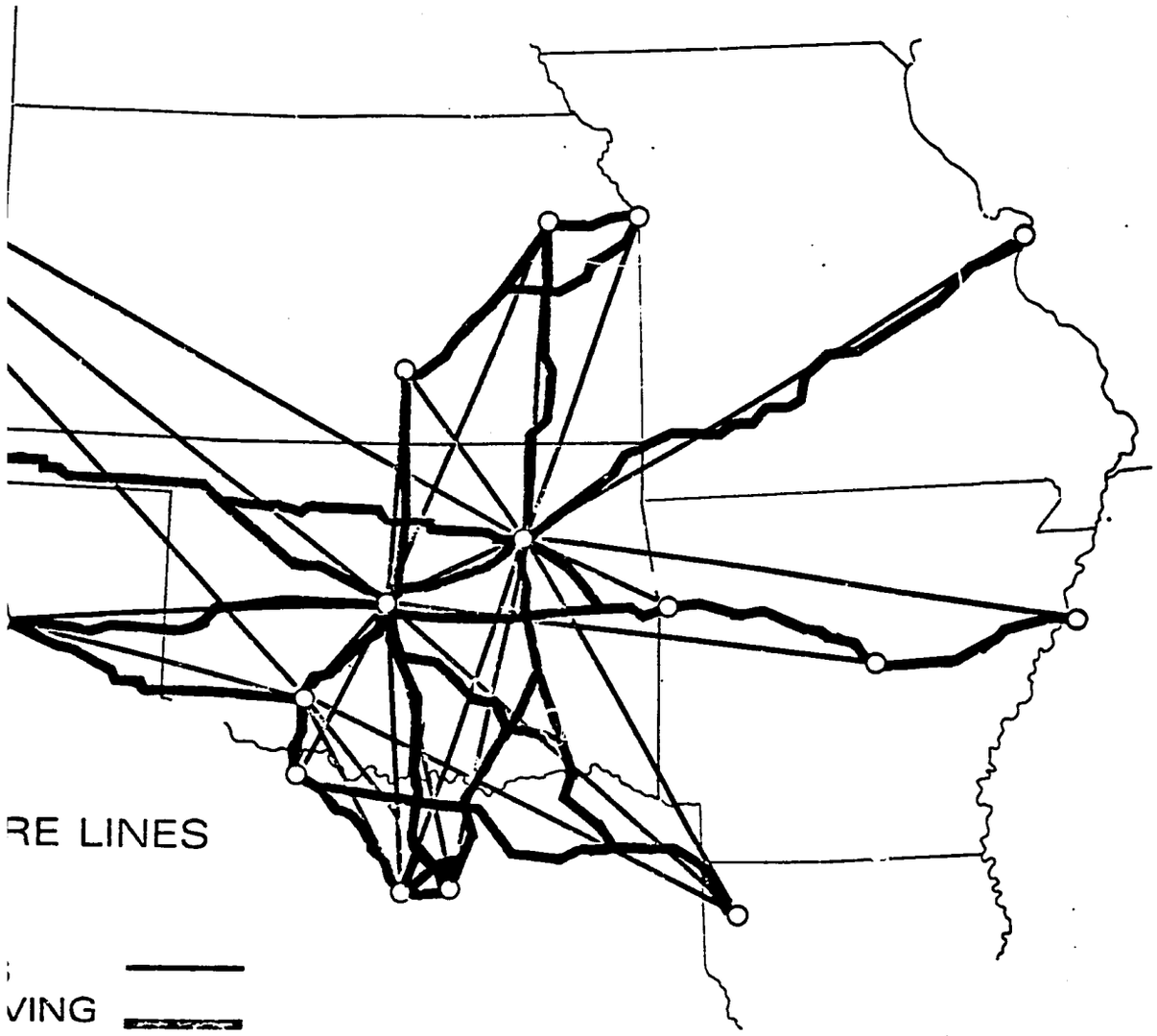
Methodology

Functional classification is performed by establishing criteria for different classes of highway, road, or street service; by analyzing the characteristics of travel on each facility; and by comparing these characteristics with the criteria to determine the particular classification of the facility. It may be performed from the results of detailed comprehensive transportation studies or by a standard methodology for identifying traffic service desires.

For example, cities and recreational centers -- centers of population -- generally produce the volumes of traffic traveling long distances that desire to use rural arterial highways. This applies both to passenger car and commercial traffic. The larger the center of population, the larger the arterial traffic desire. Figure 5 is illustrative of the traffic desires influencing the need for some major arterial routes in an actual situation. The desire lines shown interconnect several larger cities.

Within cities, centers of activity such as the downtown business center, major peripheral shopping centers, residential zones, or universities give rise to arterial traffic. Arterial streets serve both to interconnect these centers and to provide connections to rural main highways. Figure 6 is illustrative of these arterial traffic desires within cities.

In determining both where arterial roads and streets are needed and the degree of arterial need, the traffic-producing centers are ranked according


RE LINES
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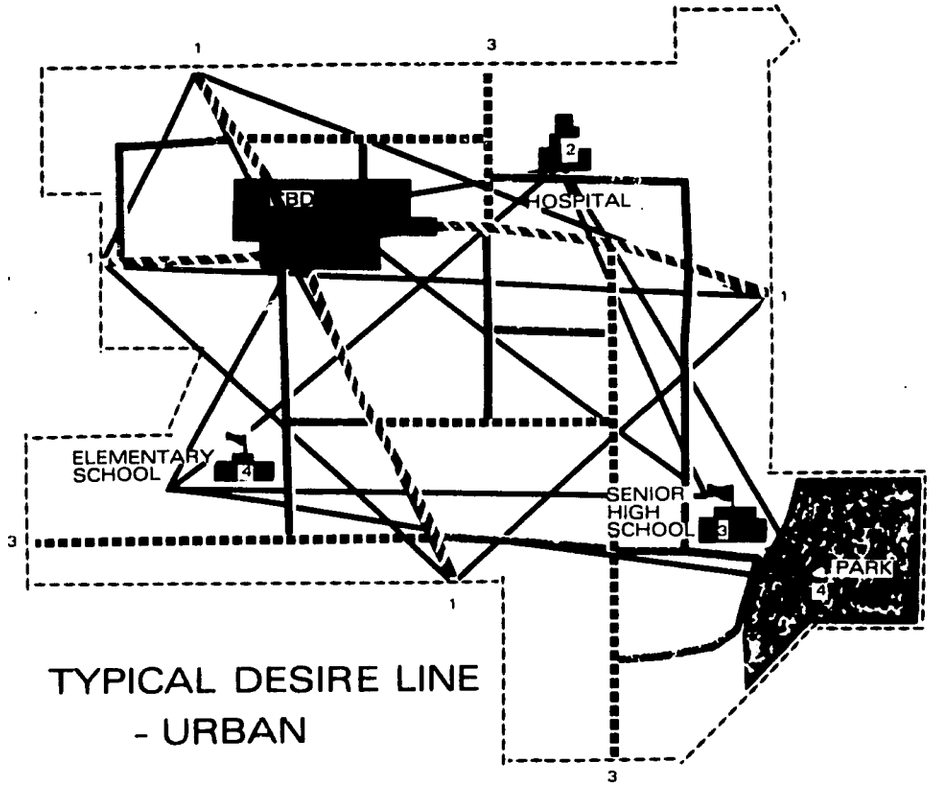
## FIGURE 6




TYPICAL DESIRE LINE
- URBAN

**LEGEND**

- URBAN BOUNDARY
- MAJOR ARTERIAL
- MINOR ARTERIAL
- COLLECTOR
- DESIRE LINES

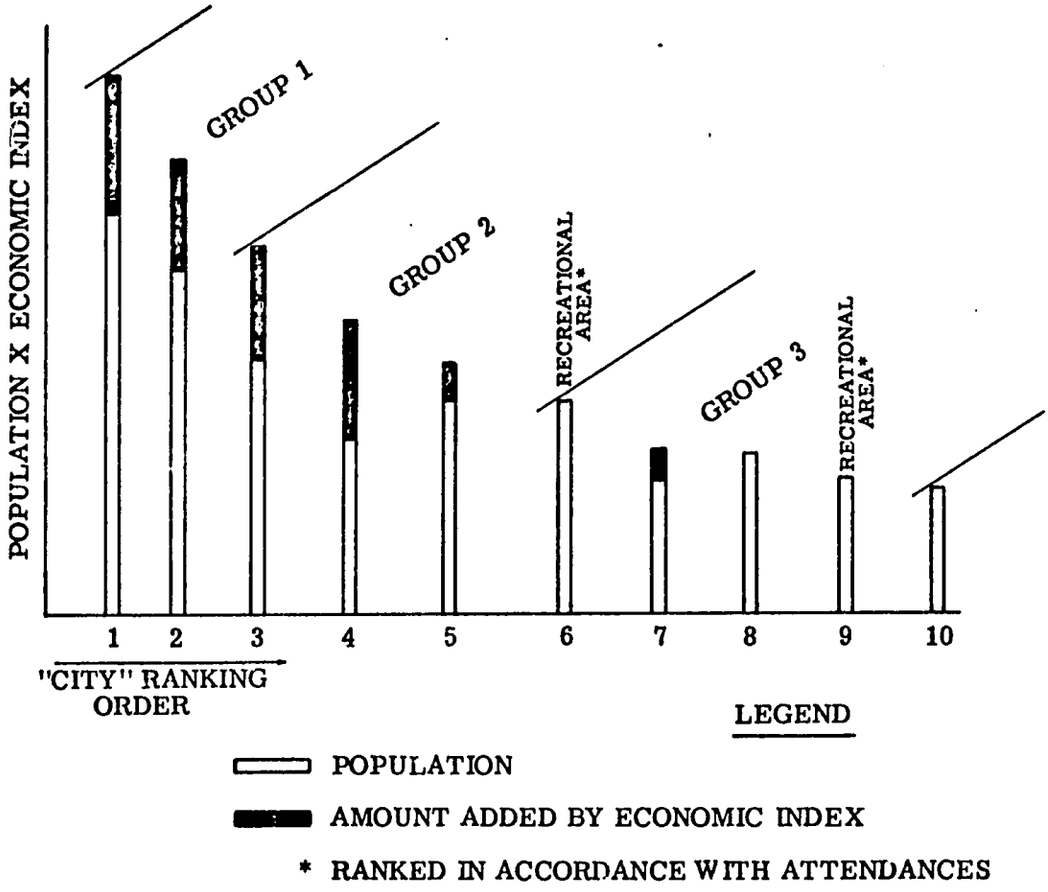
to their population and economic and other factors having an influence on arterial traffic production. Figure 7 illustrates the ranking of cities by population and economic multipliers. An economic multiplier typically might range between 1 and 1.5 to give weight to cities with heavy industrial and commercial activity which generate more traffic than cities without this kind of activity. To illustrate a principle, Figure 7 also includes recreational areas with projected attendances converted to equivalent populations. Figure 8 illustrates how traffic activity centers in cities are ranked.

As indicated previously, collectors -- which may be primary roads in rural areas -- perform both an arterial and land service function. In rural areas, they connect farming areas to local government centers and other cities or to centers of commercial activity such as grain elevators and stock-loading points. In cities, they connect neighborhoods to high schools, hospitals, parks and regional shopping centers as well as to arterial city routes. In all cases, the size and nature of the activity centers determine the degree of arterial function -- the traffic importance of the collector. For this reason, grouping of the generators into categorical groups of a general size and economic or social characteristic can be helpful in identifying functional systems. Thus, grouping of smaller activity centers helps identify the collector system. Group IV in Figure 8 represents these smaller activity centers in cities.

After ranking population or activity centers at the different levels, traffic desires between these major traffic-producing centers are analyzed first to identify major arterial corridors. The analysis proceeds in strict order of the size of the traffic generators. The desire line joining the second largest and largest generators is identified first and a route is chosen to satisfy this desire. Then, lines from the third generator -- third-ranked city in the rural area -- are joined (1) to the largest generator and (2) to the second-ranked generator. Routes are selected to serve these desires respectively. Reasonable use is made of routes previously selected. For example, if City 3 is reasonably close to a freeway connecting Cities 1 and 2, it would use the freeway to satisfy its desires with respect to these two cities, provided the adverse distance is not too large. In this case, a shortest distance connector to the

FIGURE 7

RANKING OF RURAL TRAFFIC GENERATORS




LEGEND

POPULATION

AMOUNT ADDED BY ECONOMIC INDEX

* RANKED IN ACCORDANCE WITH ATTENDANCES

**FIGURE 8**

RANKING OF MAJOR TRAFFIC GENERATORS IN CITIES

| Ranking | Generators |
|---|---|
| Group I | Points of intersection of the Rural Arterial System with the urban boundary<br>Central Business District (CBD)<br>Identifiable Neighborhoods<br>Major Air Terminals |
| Group II | Major Transportation Terminal<br>Major Colleges, Hospitals or Institutions<br>Major Shopping Centers (excluding CBD)<br>Major Industrial or Employment Centers |
| Group III | Regional High Schools<br>Regional Parks<br>Regional Shopping Centers<br>Points of Intersection of the Rural Collector System |
| Group IV | Elementary & Junior High Schools<br>Neighborhood Parks<br>Neighborhood Convenience Shopping Centers |

freeway would be selected as the routing to satisfy the indicated travel desires. This procedure provides the most economical system layout since it allows subsequent route selections to tie into higher routes already selected avoiding traffic service duplication.

Thus, the classification procedure basically identifies the arterial function of highways, roads, and streets beginning with those that perform an almost exclusive arterial function -- perhaps freeways -- and ending with those that perform an almost exclusive land-use service -- local roads and streets.

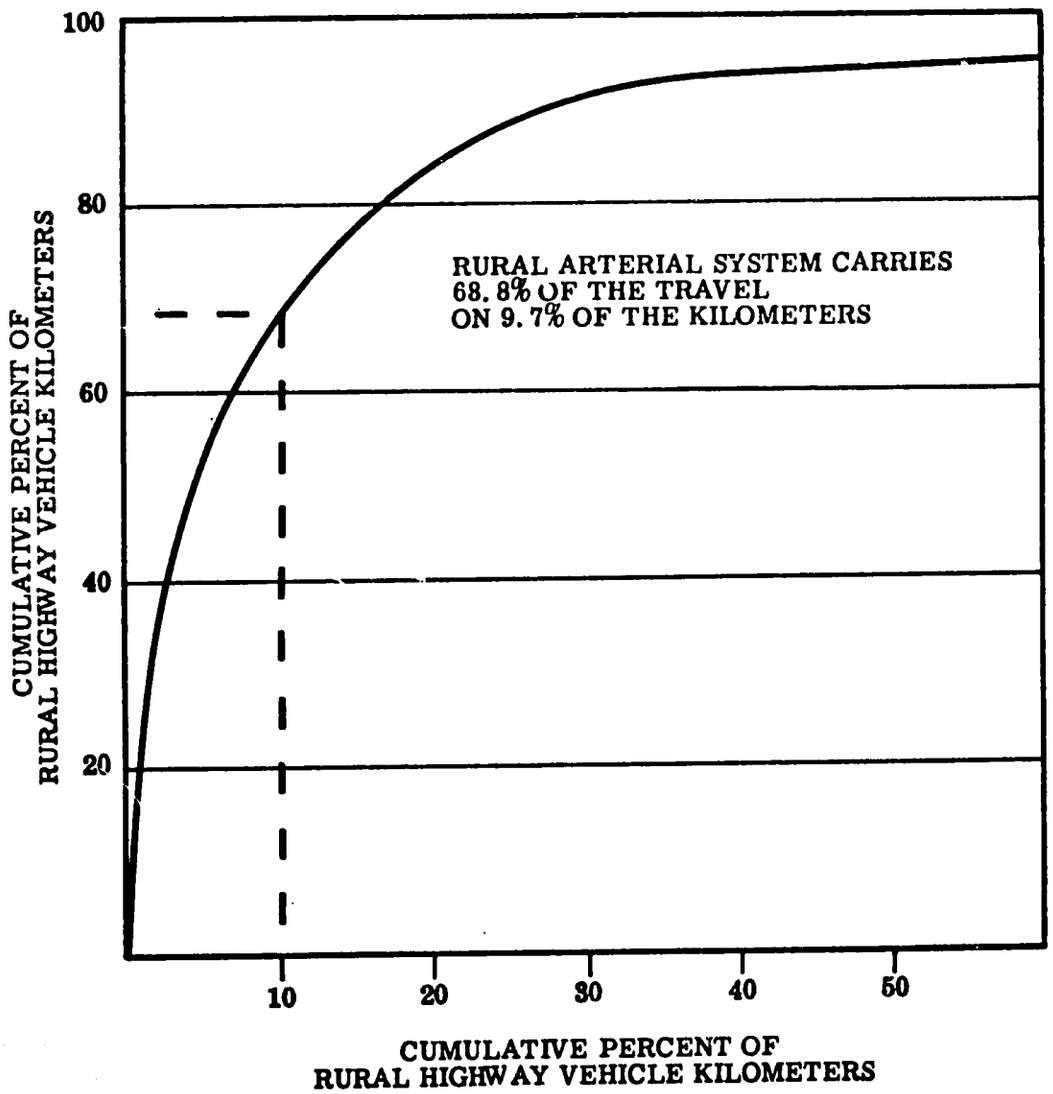
Other criteria are utilized objectively to round out systems and select between alternate possible routes. For example, major systems should provide an interconnecting pattern. The majority of population in rural areas should be no more than a reasonable number of kilometers from a collector or higher type highway. Similar criteria also are applied to govern the spacing of collectors in cities. To some extent, this varies with densities of population and land use.

For economy in planning road and street development, percentages of total kilometers of roads and streets designated for the higher systems should be limited to provide no more of these facilities, with their more costly designs, than are absolutely needed.

A good judgment can be made of the routes which should be included on the higher systems once actual traffic volumes are known or can be estimated. These volumes can be multiplied by the kilometrage of appropriate segments of the selected routes to determine the total vehicle-kilometers accommodated by each route. Figure 9 shows a typical plot of cumulative percent of vehicle-kilometers in relation to cumulative percent of kilometers when these are calculated route-by-route in reverse order of traffic importance.

## FIGURE 9

TRAFFIC SERVICE ADDED
BY
CONSECUTIVELY LOWER SYSTEM KILOMETERS



Functional classification can be developed on the basis of existing traffic and systems or projected traffic and systems. Often, the desire-line methodology provides an indication that a new routing would be desirable. If not, the new routing is proposed as a tentative addition to the system and classified accordingly. This procedure should not be confused with system development planning. Usually, the projections utilized in functional classification follow existing patterns whereas system development planning is concerned with social and economic change. Nevertheless, the identification of new routings to provide more efficiently for traffic on existing facilities can make a significant contribution to general system planning. Those performing functional classification should keep system development planners constantly aware of any proposed changes to existing systems. Figures 10 and 11 show typical classified systems in rural and urban areas.

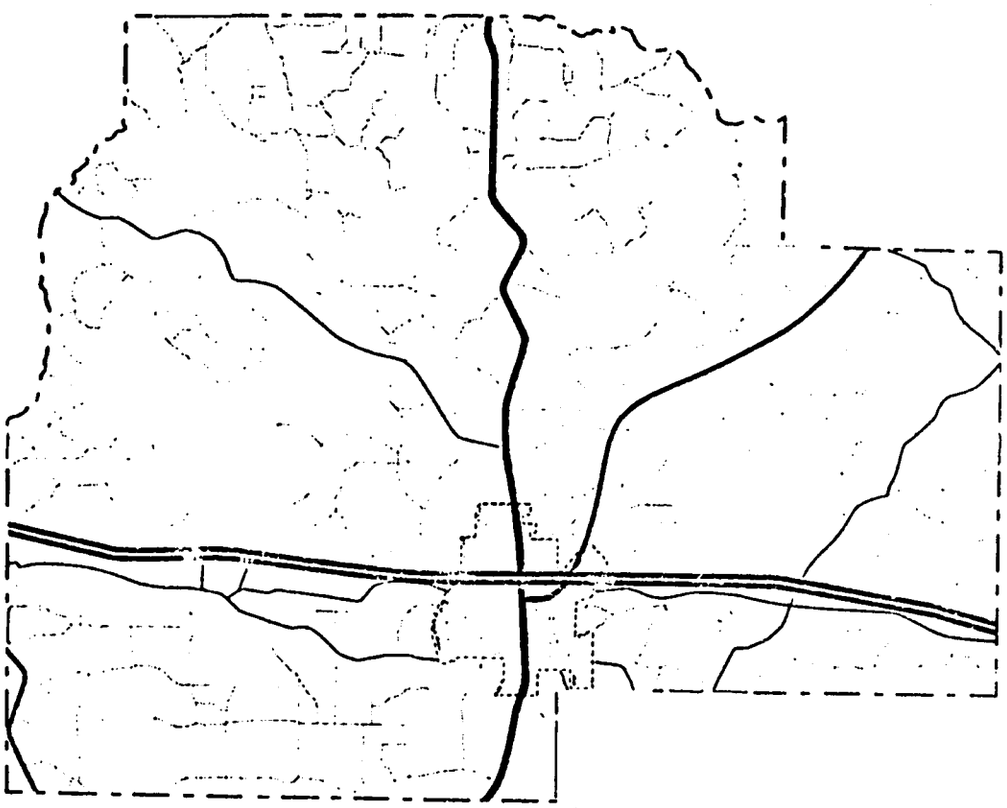
## Highway Needs Analysis

Highway needs analysis is the process of (1) identifying where existing highway systems are deficient in providing the level of economically justifiable service that is most beneficial to the nation or other community; (2) determining the types of improvements that should be utilized to correct the deficiencies; and (3) estimating the costs and priorities of the improvements.

Deficiencies initially may be evaluated in terms of design standards. These are the standards set by engineers for building a new facility in a similar traffic category and environment within the same functional classification. The relative departure of the geometric and structural characteristics of a highway, road or street from these standards is an indication of the degree of its deficiency in being able to provide a desirable level of highway service for its functional classification.

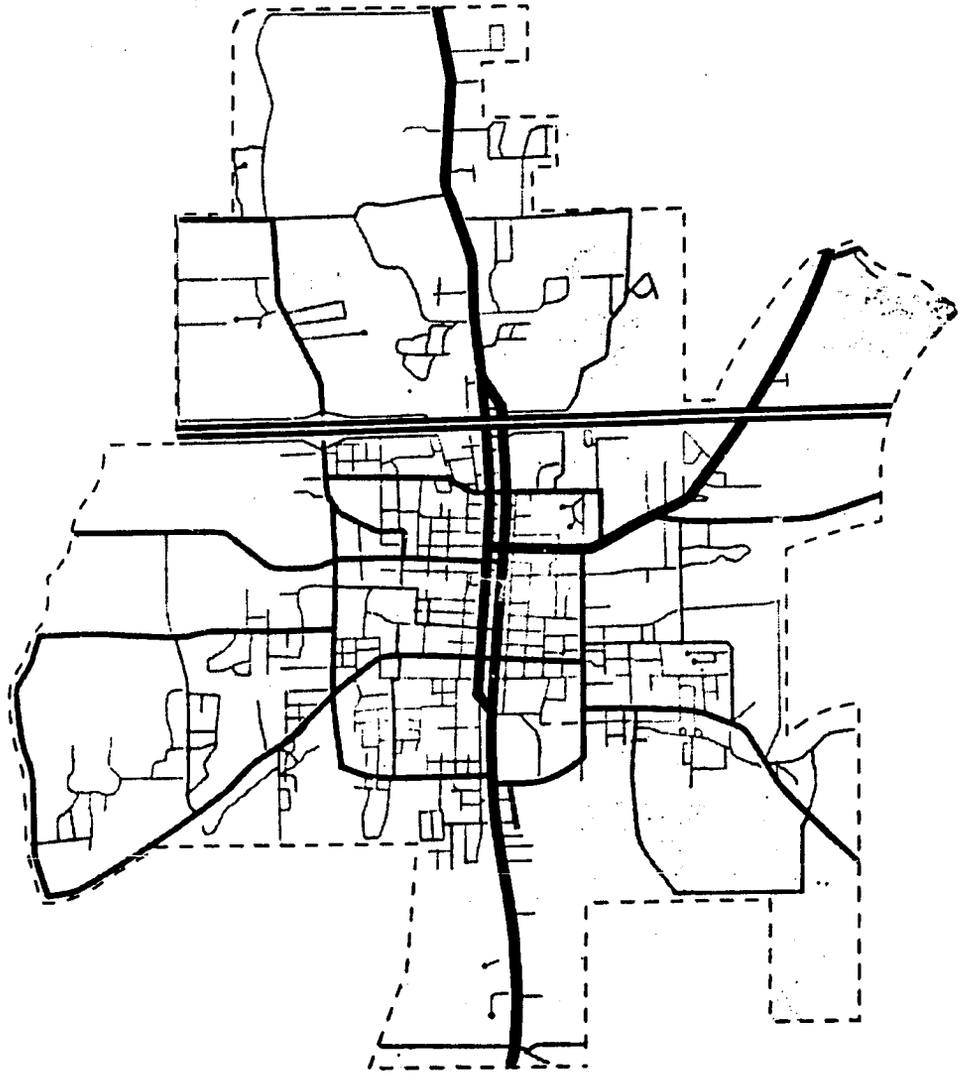
Departure from standards is an indication of need only. It, in itself, is not an absolute determinant of need. There also must be economic justification for an improvement. Design standards may be too high. There may be another facility close by that provides reasonably for the traffic service demand.

**FIGURE 10**



TYPICAL RURAL CLASSIFIED SYSTEMS

FIGURE 11



TYPICAL URBAN CLASSIFIED SYSTEMS

Improvement may not be economically justified because projected traffic is not sufficiently high -- design standards usually cover broad traffic groupings. Need for an improvement only exists when its implementation will produce an adequate return on the necessary investment.

One approach to needs determination utilizes "tolerable standards" for each functional class. These are a reduction from design standards presumably representing a bottom limit of tolerability. Any facility not meeting these standards, which are set by a committee of engineers, is automatically deficient. A problem with this approach is the arbitrary nature of "tolerable standards" which are never actually utilized in construction. Another is the inflexibility of the approach in identifying deficiencies regardless of economic considerations.

A better approach is the "adequacy rating or "sufficiency rating" which indicates the degree of departure from design standards. A rating of 100 indicates a facility that altogether meets design standards for its functional class. A lower value is selected by judgment to indicate a critical deficiency -- a sufficient departure from standards to warrant improvement. This is known as the cutoff rating. Tests can be conducted to determine total improvement costs as related to alternative cutoff values which can be economically related. Thus, it may be demonstrated that improvement of all facilities below a particular cutoff rating generally will justify the cost in economic benefits.

Even so, adequacy or sufficiency ratings should not be viewed as absolutely identifying where highway improvements should take place. They are best used as a screening device to indicate a number of highway segments which need further study to see if improvement is warranted.

Other methods of needs analysis involve a more detailed study of system deficiencies in terms of the quality of traffic service that should be provided under specific headings. Thus, there can be a capacity analysis of each highway segment to see that it provides sufficient capacity for the level of service associated with its functional classification or otherwise indicated individual

service requirements. There can be a safety analysis to indicate the relative safety of the existing facility. Or, there can be a structural analysis to indicate the degree of deterioration of surface or structural qualities and need for replacement. An index -- weighted or otherwise -- may be used to combine the results of these analyses to reflect relative deficiency. This is actually what a sufficiency rating purports to do but without the same degree of refinement in analyzing the different deficiency considerations.

Sufficiency Ratings

Sufficiency ratings are a way of describing the relative adequacy of features of the highway in providing the degree of safe, comfortable and efficient service that reasonably may be expected from it. Specific considerations are condition, service, and safety. Specific characteristics are identified for each of these headings which are indicative of relative adequacy.

A facility with geometrics and structure which entirely meet the design standards [1/] set by the agency for corresponding traffic volume group and functional classification is rated at 100 points, if its structural condition is perfect. This rating is made up of component ratings for each structural and condition element, sometimes listed under condition, service or safety headings. (Use of these headings, based on theoretical considerations, is probably more confusing than helpful.)

Instructions are given to raters, in connection with the regular road inventory, on the evaluation of road elements. Ratings are carried out by road

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1/ For construction, these standards are set for design year traffic, usually 20 years in the future. This practice assures a useful life for the facility before obsolescence. For sufficiency ratings, the 20 year projection does not apply. The standards are viewed as being currently applicable to the current functional and traffic classifications.

segments selected in the field. A segment should have fairly uniform characteristics with respect to geometrics, condition and traffic volumes. Note that raters need to be well trained. This can be accomplished by laying out a field course of representative road sections and letting a rater try his hand after initial "classroom" instruction. Then, the rater's evaluations are discussed with him and constructively criticized.

Roadway Ratings

Typical forms for road and bridge inventory are included in Chapter VII (see Figures 20 and 21) along with instructions for recording the inventory data and determining sufficiency ratings.

The ratings made in the office and the total rating may be determined by computer. It is a simple matter for an electronic computer to make comparisons of surface and shoulder types and actual measurements with table values, assign a corresponding rating, add up the results, combine these with the field-determined values, and arrive at the total adequacy rating.

The basic sufficiency rating may be modified by a traffic adjustment. This is appropriate when sufficiency ratings are used to select priority improvement needs. It actually is an economic adjustment -- it gives more importance to deficiencies on sections carrying relatively heavy traffic. The sufficiency rating adjustment formula is:

$$Y = X + \frac{X^2 - 100X}{70 \text{ Log } T_s} (\text{Log } T - \text{Log } T_s)$$

where $Y$ = Adjusted sufficiency rating

$X$ = Initial sufficiency rating

$T$ = Average daily traffic on the road section being rated

$T_s$ = Average daily traffic of the system (the average of all roads in the system, e.g. all major arterials)

Log = Common logarithm (base 10)

The traffic adjustment is normally taken from curves which are developed for different administrative or functional systems. Figure 12 provides a curve which is appropriate for a primary or major arterial system. In the example shown, a road with a basic rating of 75 carrying a volume of 3,000 vehicles per day would receive a final rating of 71. If it carried only 100 vehicles per day, it would be rated finally at 80.

## Structure Ratings

Structures must also be rated. Most sufficiency rating schemes provide for structures to be considered in two ways. First, they are considered independently to determine whether or not they should be included in a bridge improvement program. Second, they are considered as part of a road segment to see if they contribute to deficiencies in such a way as to make the entire section a candidate for improvement. Particularly when surface-width dimensions are being changed, there are advantages in letting contracts for roads and bridges at the same time. Note that space is provided on the road inventory form to reference bridges on the section.

The bridge evaluation can be very basic. Evaluation can amount simply to identifying deficiencies as indicated in Chapter VII. There are also more sophisticated methods of rating bridges which can be used. These are similar to those utilized in rating the roadway so that an actual bridge sufficiency rating is produced.

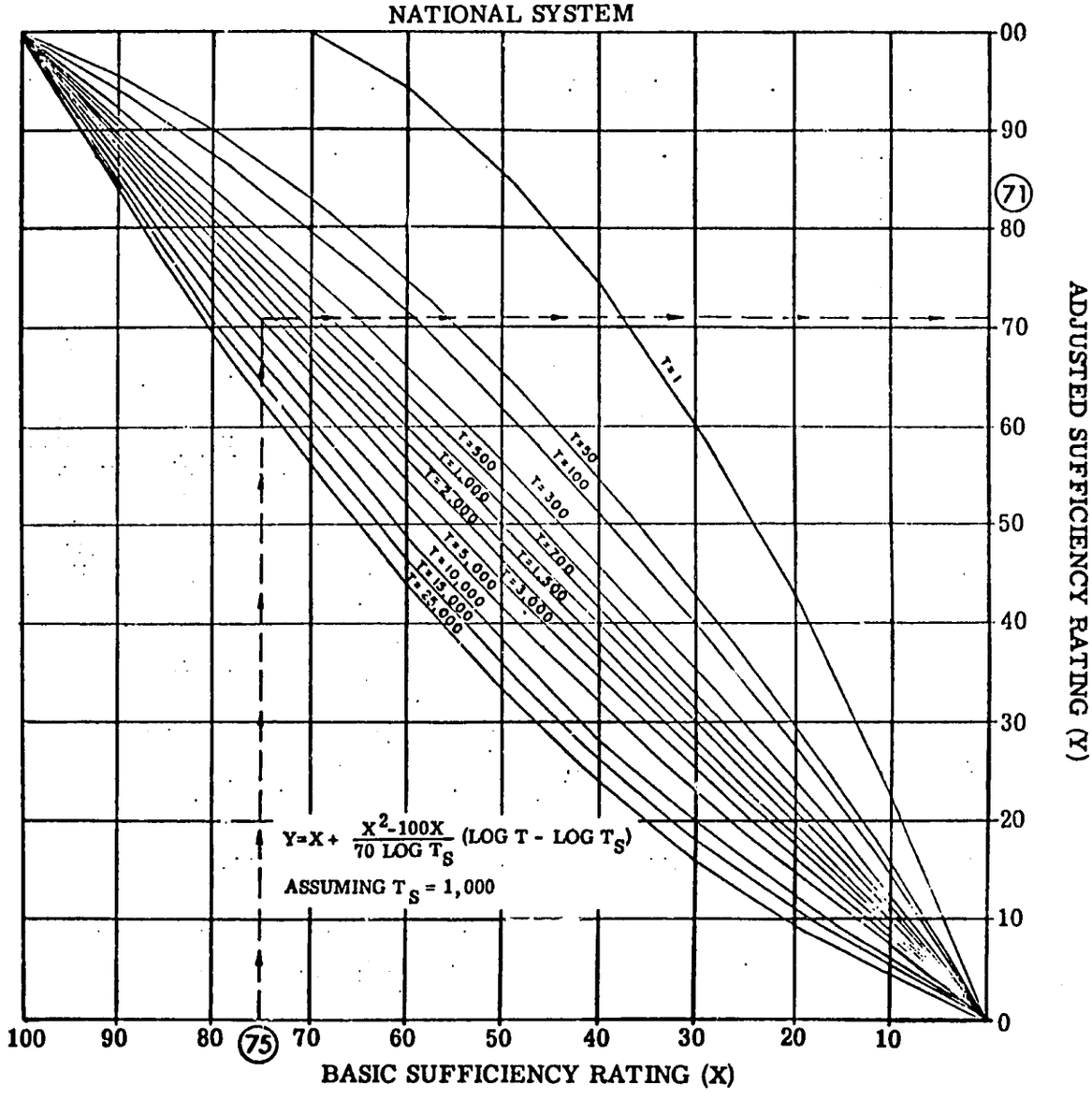
## Summary

The sufficiency rating method described is not as complex as some which make provision for such things as refined capacity evaluations, usually made on the computer. It has been designed so that evaluation of deficiencies, selection of improvements and determinations of cost can be done entirely by hand calculation or on the computer. Description of the computer methodology is beyond the scope of this Manual -- experienced experts should be consulted.

**FIGURE 12**

CHART FOR ADJUSTING BASIC SUFFICIENCY RATING FOR TRAFFIC VOLUME

NATIONAL SYSTEM



Sufficiency rating methodologies are also available for city streets in urban areas, both large and small. The procedures are more complex and do involve refined capacity analyses.

Determination of Improvement Needs

There are several ways of selecting a sufficiency rating cutoff value to delineate those segments of the system, rating less than this value, which will be considered critically deficient. After reviewing ratings in the field, engineers can make a professional judgment. Opinions on road adequacy can be solicited from appropriate representatives of the public -- community leaders and public officials. Highway accident comparisons can be made. Also, there is the economic consideration of how much it will cost to improve all highways below one sufficiency rating value as compared with another and as related to to relative benefits.

Once an initial cutoff value is selected for trial, each facility rating below the value is examined carefully to determine an appropriate improvement.

Initially, the traffic on the segment is projected to a design year, selected by agency policy. In a developed country where traffic is growing at a relatively low rate, it has been common to select a design year 20 years in the future. In developing countries where traffic growth is at a very high rate, selection of a design year so far in the future can indicate improvement requirements that are completely unrealistic in the existing situation. Requirements for multi-lane divided highways can be indicated on roads where present traffic is only a few hundred vehicles per day. Although traffic ultimately might grow to demand multi-lane facilities on the same routings, there also is the possibility of substantially different transportation demands developing over a period as long as 20 years because of unpredictable social, economic and land use development.

When this general traffic growth situation is occurring, it is better to select a design year no more than 10 years in the future. Traffic also can be

projected for 5 years to indicate the change in design requrements. This can be helpful in identifying stage construction potential.

Projections using general traffic growth trends and the same growth rate on all facilities should be avoided. There should be an attempt to relate traffic growths to actual developments expected to occur which will influence traffic demands on specific routings. Traffic interactance formulas, along with population changes, can be utilized to estimate specific growth factors in some cases.

Once traffic is projected to the design year, an appropriate design standard can be selected in accordance with agency policy. Then, comparison can be made with the inventory sheet.

If dimensions of surfaces and shoulders, or surface and shoulder types, are different from the design standard, an improvement to change the characteristics is indicated. The nature of an improvement will depend on (1) extent of deficiencies in dimensions and types between existing elements and those called for in design standards; and (2) condition of the existing facility. Ground rules can be set up for guidance:

1. If the surface plus shoulder width is less than the design standard by 3 m or more for an arterial, complete reconstruction or new construction is required.

2. If the difference is less than the amount specified above, the facility will require widening and resurfacing unless:

   - gradients rating less than 3, or
   - alignment rating less than 6, or
   - sight distance rating less than 4, or
   - average running speed less than 65 km per hour.

   In these cases, new construction will be required.

3. In any event, if alignment rates less than 6, or sight distance rates less than 4, or average running speed is less than 65 km per hour, new construction will be required.

4. If gradients and alignment together rate less than 12, selective reconstruction will be required.

5. If foundation rates less than 7, new construction will be required.

6. If surface type is less than design standards, new base and surface will be required.

7. If wearing surface rates less than 6 and foundation rates less than 10, new base and surface will be required.

8. If shoulder type is less than design standards or shoulder condition less than 2, reconstruction of shoulders will be required.

9. If wearing surface condition is less than 6, resurfacing will be required.

10. Note the types of improvements needed for structures on the road segment, based on structure ratings.

Although improvements are determined separately for each road segment, the effect of improving one segment of a route or its adjacent segments should be carefully examined. If the adjacent segments border on being deficient, or continuity of improvement is desirable for other reasons, it may be desirable to improve the adjacent segments at the same time.

## Determining Costs

Average costs per kilometer should be established for all types of improvement potentially called for in the analysis of improvement needs and should be related to the design standards and to different basic environmental situations. For example, average costs for new construction are not the same in mountainous or flat country, rocky terrain or gravel hills and right-of-way costs are not the same in urban and rural situations.

Average costs per kilometer should be determined from the cost experience records of the agency. In some cases in the past, where adequate records have not been available, attempts have been made to estimate costs on the basis of work quantities developed for typical sections and unit prices. Where this works well for surface and base costs which are relatively unaffected by terrain conditions, it does not work well for determining the average costs of complete construction.[1/] It is better to obtain cost experience from other countries and adjust the costs to the local situation. Average cost should be determined by design category under different average environmental category headings for:

- new construction or complete reconstruction,
- selective reconstruction,
- widening and resurfacing,[2/]
- new base and surface, and
- resurfacing.

---

1/ It is virtually impossible to identify a typical section in terrain that is not flat.

2/ Costs can be set up on a per unit width basis.

In developing costs, it sometimes is helpful to develop matrices as shown in Figures 13 and 14. This allows gaps to be filled in with some regularity where records do not contain sufficient average cost experience for all categories. Similar matrices can be developed for right-of-way costs and total costs. The latter are obtained by summation.

When average costs per kilometer have been established by improvement category, these can be applied to the identified types of improvement, segment by segment, using the segment length recorded on the inventory. A summation produces total "needs" for the sufficiency rating cutoff point chosen. Needs should be developed similarly for at least two other cutoff levels.

The described system for determining needs is designed for manual or computer application. Identification of improvement types, selection and application of average costs, and extension and summation of costs can all be done on the computer, saving considerable man-hours of office work. Figure 15 shows the general procedural flow diagram for computer analysis of inventory data.

Determining Benefits

Following improvement costs determinations, user benefits should be determined in relation to the improvements, to provide a basis for priority assignments. Virtually the same options are open in the case of processing benefit data as in the case of processing inventory and cost data. The computer can be used to make all of the calculations, or they can be done by hand. These are the same kinds of tradeoffs -- computer program writing versus manpower.

It is appropriate to consider what needs to be done in terms of an additional form to be filled out for each section, although this form would not be used under the computer programming technique. The form would contain the information shown in Figure 16 which would be recorded through entries and calculations prepared in the office.

## FIGURE 13

### MATRIX FOR GRADE AND DRAIN COSTS

| TYPE OF IMPROVEMENT | AVERAGE COST PER KM. BY TRAFFIC CATEGORIES* | | | |
|---|---|---|---|---|
| | 0-600 VPD | 600-2000 VPD | 2000-4000 VPD | Over 4000 VPD |
| NEW CONSTRUCTION | ↑ | ↑ | ↑ | ↑ |
| WIDEN AND RESURFACE | → | → | → | → |
| BASE AND SURFACE | → | → | → | → |
| RESURFACE | → | → | → | → |
| SELECTIVE RECONSTR. | 0 | 0 | 0 | 0 |
| | SPECIAL CASE → | | | |

* Arrows show matrix direction in which costs per km. increase with some regularity.

## FIGURE 14

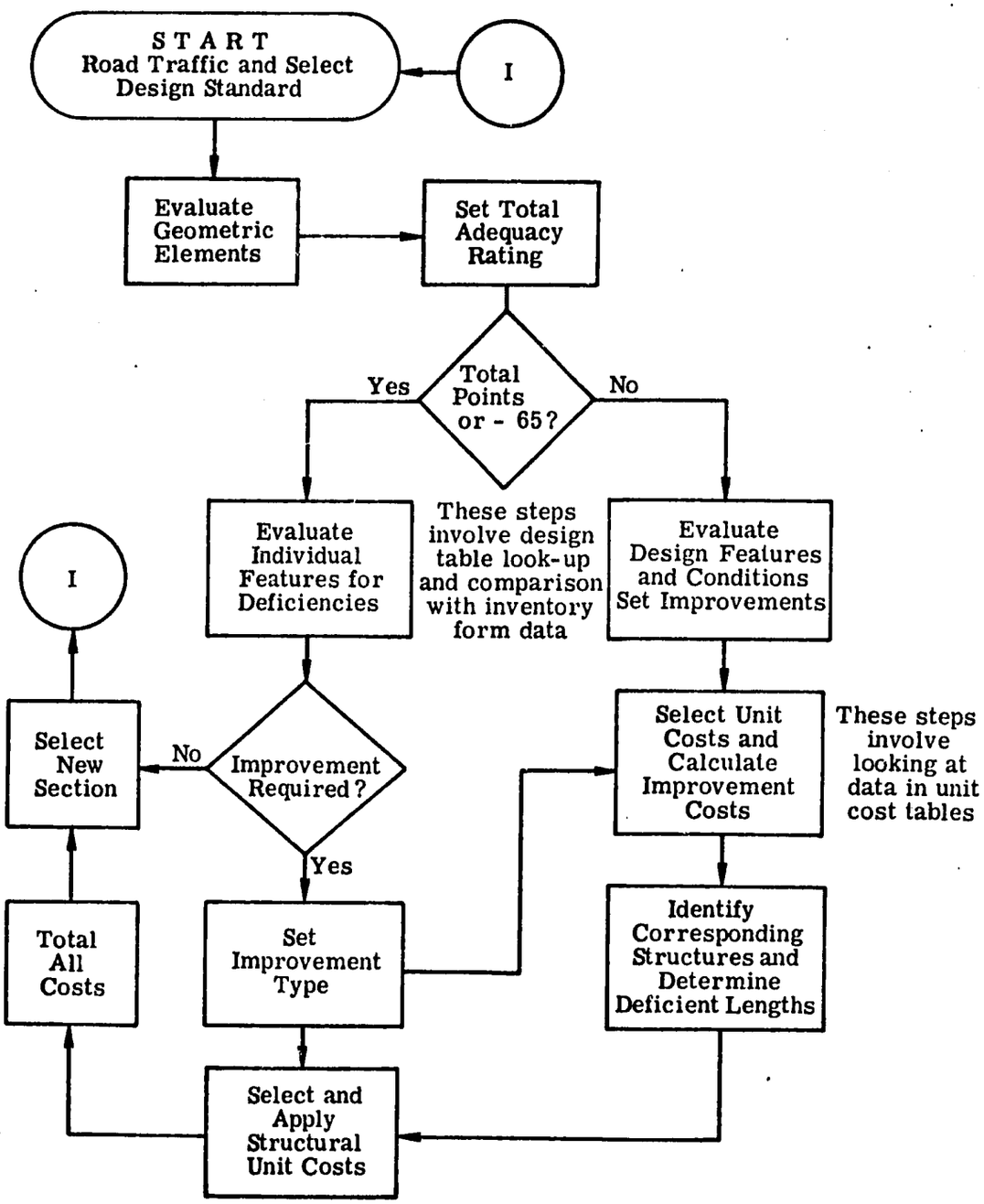
### MATRIX FOR BASE AND SURFACE COSTS

| TYPE OF IMPROVEMENT | AVERAGE COST PER KM. BY TRAFFIC CATEGORIES* | | | |
|---|---|---|---|---|
| | 0-600 VPD | 600-2000 VPD | 2000-4000 VPD | Over 4000 VPD |
| NEW CONSTRUCTION | ↑ | ↑ | ↑ | ↑ |
| WIDEN AND RESURFACE | → | → | → | → |
| BASE AND SURFACE | → | → | → | → |
| RESURFACE | → | → | → | → |
| SELECTIVE RECONSTR. | SPECIAL CASE → | | | |

* Arrows show matrix direction in which costs per km. increase with some regularity.

**FIGURE 15**

**GENERAL FLOW DIAGRAM FOR COMPUTER ANALYSIS OF INVENTORY DATA**



## FIGURE 16

## ORDER OF CALCULATIONS FOR ECONOMIC INDEX ANALYSES

(Each Section)

| Purpose | Item No. | Description |
|---|---|---|
| Identification | 1 | Card control number |
| " | 2-9 | Same identification as for corresponding sections on the inventory form |
| " | 10 | 1/ Existing percent passenger cars |
| " | 11 | 1/ 1975 AADT |
| " | 12 | 1/ 1975 percent passenger cars |
| " | 13 | 1/ 1975 diverted traffic (VPD) |
| " | 14 | 1/ Diversion distance saved |
| " | 15 | 1/ Diversion time saved |
| Cost Analysis | 16 | 2/ Interest rate |
| " | 17 | 3/ Construction cost per km. |
| " | 18 | 3/ Value of construction cost per km. in analysis year |
| " | 19 | 4/ Current maintenance cost per km. |
| " | 20 | 3/ Maintenance cost adjustment factor |
| " | 21 | 3/ Maintenance cost per km. adjusted to analysis year |
| " | 22 | 4/ Maintenance cost per km. after improvement |
| Benefits Analysis | 23 | 3/ Savings in maintenance cost per km. |
| " | 24 | 4/ Passenger car user cost per km. for existing surface type and operating speed (adjusted for poor road surface) |
| " | 25 | 4/ Commercial vehicle user cost per km. for existing surface type and operating speed (adjusted for poor road surface) |

(FIGURE 16 continued)

| Purpose | Item No. | Description |
|---|---|---|
| Benefits Analysis | 26 | 4/ Passenger car user cost per km. as related to improvement |
| " | 27 | 4/ Commercial vehicle user cost per km. as as related to improvement |
| " | 28 | 4/ Diverted distance savings per km. for passenger cars |
| " | 29 | 4/ Diverted distance savings per km. for commercial vehicles |
| " | 30 | 4/ Diverted time savings per km. for passenger cars |
| " | 31 | 4/ Diverted time savings per km. for commercial vehicles |
| " | 32 | 3/ Total user cost savings per km. |
| Benefits-Cost Ratio | 33 | 3/ Economic index for section |

1/ These items will be supplied for each section.

2/ These items are the same for every section.

3/ These items will be determined or calculated automatically by the computer for each section based on information in the inventory record, or information given elsewhere in the above format, or both.

4/ This information will be determined automatically by the computer from table look-up (immediate access tables) based on information contained elsewhere in this format or in the inventory form. Calculations using the table information and other recorded data are performed as needed.

Once more, a substantial amount of manpower would be needed to make the foregoing determinations for each section. However, through utilization of the full potential of the electronic computer, manpower requirements (once computer programs are written and cards are punched) can be reduced to the few persons needed to run the computer.

In performing the calculations, the computer virtually duplicates the human tasks. For example, there will be tables contained in the computer memory, or otherwise made available for immediate access, such as tables relating user costs to operating speed and road surface. The computer will examine the operating speed and surface type, look up the proper factor in the table, and apply the factor to traffic to determine user costs.

A flow diagram for a typical computer calculation is shown in Figure 17.

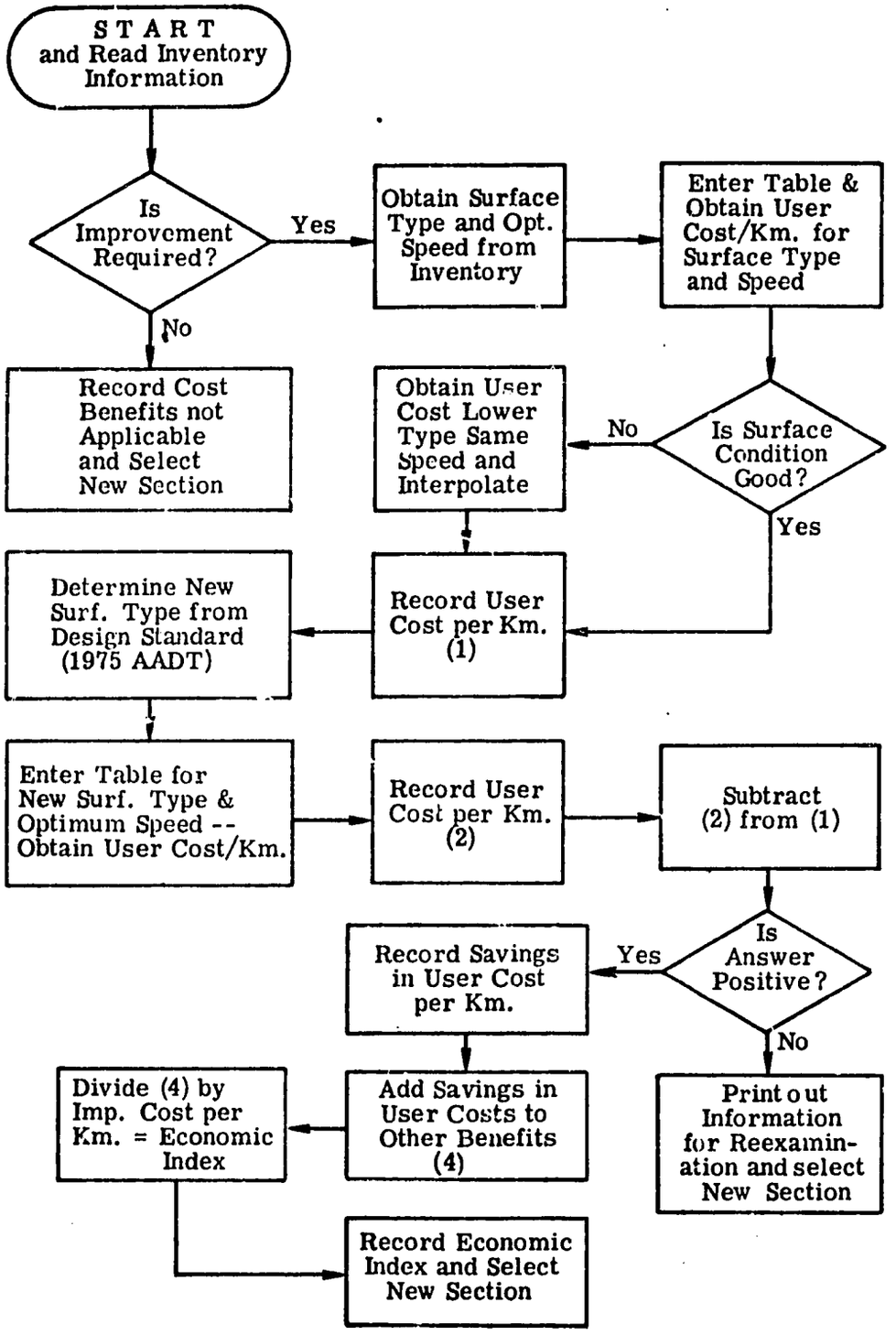
In addition to determining the benefits-costs ratios for each road segment improvement, there can be some overall costs of benefits versus the overall costs of improvements at different sufficiency rating cutoff points.

When it is possible to identify traffic accidents by category and by section, economic costs can be related to these accidents. Fatalities cause loss of lifetime earnings and productivity plus property damage and immediate costs as well as compounding effects. Serious injuries are likewise costly to individuals, families and society. Estimates are made in some countries of the costs of these types of accidents as well as property damage accidents.

If present annual accidents can be identified by road segment, present annual accident costs (accident losses) can be summed up for all segments above a selected sufficiency rating cutoff value. These costs can be adjusted to the analysis year to take advantage of calculations already performed for

**FIGURE 17**

**FLOW DIAGRAM FOR TYPICAL BENEFITS-COST DETERMINATION**



the user savings analysis. The adjusted costs can be expressed on a per kilometer (above cutoff) basis. [1/] Since it has been demonstrated that accidents usually reduce with increases in road quality as measured by sufficiency ratings, it would be expected that accident costs per kilometer above cutoff would reduce with higher cutoff values and this usually is the case.

If a cutoff value is selected, the inference is that the whole system will be improved to above that value. Therefore, if the cost per kilometer of accidents above the value is applied to the whole system kilometrage, the result should reflect total (annual) accident costs after system improvement. If this figure is worked out at a higher and lower cutoff value, the accident costs should be lower and higher respectively -- note the inverse proportion. The difference in costs from changing the cutoff, therefore, is determinable.

By applying annual construction cost per kilometer (analysis year) to segment lengths and aggregating for all segments below cutoff, the total annual cost of construction or improvement can be determined. This also can be done at different cutoffs corresponding to those used in the accident cost determination. The differences in construction costs can then be related to total accident savings in choosing one cutoff point over another. In some cases, it has been demonstrated that the increase in construction costs by selecting a higher cutoff value, within an appropriate range of such values, has resulted in a compensating or greater reduction of accident costs.

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1/ The value of construction cost already has been determined for the analysis year. This is accomplished by identifying the average road life associated with each improvement type in each design class. An average annual cost in present monetary units is determined which is adjusted by an appropriate interest rate to an annual value in the analysis year.

By another procedure:

- improvement kilometers are summed up below a selected cutoff point;
- user savings in the analysis year also are aggregated for improvements below the same cutoff by (1) multiplying savings per kilometer by length for individual segments and (2) adding;
- annual improvement costs in the analysis year are determined and aggregated as previously described;
- improvement costs per improvement kilometer are determined;
- user savings per improvement kilometer are determined; and
- an average benefits-costs ratio is established.

The same calculations can be performed at another cutoff point and comparisons can be made of the relative purchasing power of expenditures as related to benefits.

## Classification and Needs Planning Reports

The output of classification and needs planning is an annual report minimally providing:

- map showing recommended functional classifications;
- map showing deficiencies below selected cutoff;
- map showing recommended improvements by type;

- listing(s) of recommended improvements showing sufficiency ratings, benefits-costs ratios, and estimated improvement costs;

- cost summaries under appropriate headings; and

- documentation with respect to methods and results including economic or other justification for sufficiency rating cutoff value denoting critical deficiencies.

The output of classification and needs planning should be reviewed and commented on by management. After approval, it becomes an input to priority planning.

## PRIORITY PLANNING

The objective of priority planning is to formulate, recommend, obtain approval for, and develop a document supporting the long-range plan which constitutes the agency's current target objective towards which all of the agency's highway development efforts are directed. Inputs to priority planning come from system development planning and classification and needs planning.

Whatever organization is adopted, it is well to view these three aspects of the systems planning process as separate entities and see that the procedures for each are carried out regularly and, in some cases, continuously to provide a sound basis and thorough documentation for the current priority plan. More often than not, planners concentrate on one of these aspects -- classification and needs studies or traffic and land-use relationships (area developed) -- and give the others little attention.

The work of the priority planners basically consists of the following activities:

- Analyze committed and potential long-range funding and any requirements reducing the amount of these funds that will be available for planned improvements.

- Evaluate area highway development plans resulting from systems development planning.

- Evaluate the highway classification and needs analysis resulting from classifications and needs planning.

- Formulate a well-integrated and strongly beneficial plan of highway improvement and development, consistent with reasonable funding expectations, that can be accomplished within a reasonable period of time, thoroughly document and support the benefits expected to result from the plan, and establish and support priorities within the plan.

- Develop, for management review, amendment and approval, a document, suitable for publication, presenting and thoroughly supporting the official long-range plan of the agency.

Although some of these activities interrelate considerably, they can be grouped and discussed under three main headings, namely:

- financial planning,

- priority plan formulation, and

- Annual Plan Report.

## Financial Planning

Potential funding for highway improvements in a developing country can come from two or three main sources. First, following the example of some of the developed countries, the central government may provide dedicated taxes dependent on highway sources. Among these are motor-fuel taxes, motor vehicle registration fees -- often graduated by vehicle weight, mileage taxes, and driver's license fees. Second, there may be appropriations from general funds, both at national and local levels of government. Third, there may be regular and special property taxes which constitute a dedicated source. And, fourth, funds are made available to developing countries through aid programs of other countries and the United Nations or international bank or lending institutions who may make grants or loans.

Determination of potential funding from in-country tax sources requires: (1) research and careful examination of legislation pertaining to highway funding; (2) acquisition and examination of records showing taxes historically obtained for highways from various sources; and (3) projection of tax funds for the future.

Projections may be made on two possible bases. For funds made available from non-dedicated or non-highway related sources, trends in amounts provided for highways are established over a historical base period. These trends are projected into the future, usually on a straight-line basis. If the amounts of some of these funds have not varied regularly and seem to be dependent on a case being made for highway expenditures, judgment will be required to determine a reasonable expectation for the future. For funds which are dedicated and derived from highway related sources, the traffic projections discussed earlier in this Chapter provide the basis for tax projections.

When motor vehicle kilometrages are projected on the basis of population, motor vehicle ownership and average vehicle travel characteristics, it is relatively simple to determine fuel consumption from travel distances.

A trend of motor fuel consumption per vehicle-kilometer can be established by basic vehicle type -- average trucks rates are differentiated from passenger car rates. By applying current or projected taxes per liter of fuel, total annual fuel taxes can be projected.

Future motor vehicle registrations are projected on much the same basis. The proportions of truck registrations by weight group can be estimated from present proportions and change trends. Through application of the current schedule of fees, taxes from this source can be projected.

Usually, there are established unavoidable demands on funds available from tax sources. Foremost are highway maintenance cost and highway administrative costs. Total estimates of these must be subtracted before the amounts available for planned system improvement can be determined. Usually, these requirements are projected from present trends, necessitating a search and analysis of records from recent history.

The regulations and potentials for grant or loan funds must be obtained from each agency making such funds available. Through conversations with principals from these agencies, estimates can be obtained of the amounts of funds that might be made available for a justifiable long-range improvement plan. THESE EXPLORATIONS MUST BE CARRIED OUT BY, OR WITH SPECIFIC AUTHORIZATION FROM, THE HIGHEST RESPONSIBLE OFFICIALS IN THE AGENCY. Normally, planning division personnel would make recommendations to their superiors that these explorations be carried out.

Agencies making grants and loans are generally most receptive in cases where plans or proposed programs are well-conceived and economically sound. Eventually, they will insist on complete documentary support of a proposed program, including feasibility studies and economic justification, before funds are made available for expenditure. However, funds are often set up -- "granted" -- on a much more general basis to fund a complete plan or program concept sufficiently justified to show strong economic merit.

## Priority Plan Formulation

Priority plan formulation includes the evaluation of area development plans and highway classification and needs studies to arrive at a practical long-range highway development plan. The term "long-range" is relative. It infers completion of one or more specific goals or objectives over a period of years. The time frame should allow a reasonable expectation of accomplishing the objectives at least in essence. Thus, a fairly long planning period might be appropriate in a situation where changes occur slowly, whereas a much shorter period would be chosen in a very dynamic situation as in a developing country. With the traffic growths being experienced in many of these countries, it is impractical to plan national road development for 20 or even 15 years.

The target objectives should involve complete accomplishments such as development of a main stem primary system and a basic farm-to-market network. Ordinarily, for highways and other transportation systems, the concept of a long-range objective seems to imply an interconnected network of facilities. However, another type of objective, such as providing specific transportation services for a particular type of economic development, which could result in individual disconnected improvements, would also be reasonable.

Although the above examples might constitute principal objectives of a long-range highway plan, there almost necessarily would be other objectives. While concentrating on a particular goal, the public demand for reasonable transportation provisions, in general, will require accomplishments apart from the principal goals. For example, where primary goals may be development of a main-artery system and basic farm-to-market system, attention will need to be paid to other parts of the network to see that services provided by them will be satisfactory, and this probably will require some additional construction improvements. Provision should also be made for these in the long-range plan. There also needs to be provision for resurfacing and this can be planned.

Provision for maintenance may be included in the plan but this usually is a funding provision. 1/

Formulation of a plan is largely conceptual. First, there needs to be recognition of national or other goals and objectives toward which the final plan will be directed. To the extent possible, these objectives, which probably will not be specific with respect to highways, should be set forth in writing in advance of plan formulations. Then a set of sub-objectives, more specific with respect to highways, can be established. In practice, establishment of sub-objectives and plan formulation may go hand-in-hand. Often, recognition of highway program potential will result from examination of the benefits of specific improvements considered individually and collectively.

After analyzing benefits expected from recommended area development improvements and improvements recommended to overcome existing deficiencies and needs, the priority planners will put together alternative concepts of systems evolution which, with respect to expenditures over a sensible long-range period, appear to be within a range of reasonable expectations. The alternative plans then should be evaluated.

The evaluation should be made in a deliberate orderly manner. Principles of the PPBS 2/ concept are helpful in carrying this out. This calls for analysis to be carried out in the following way:

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1/ Useful long-range maintenance plans can be developed. However, discussion of these is not within the scope of this Manual.

2/ PPBS (Planning, Programming, Budgeting System) is a management concept designed for the objective evaluation of alternative expenditure "programs."

1. Objectives are specificaly identified. A few that would be listed are as follows:

   (a) optimum development of undeveloped areas;

   (b) optimum efficiency and economy for main line commercial and recreational travel;

   (c) maximum contribution to overall economic development;

   (d) optimum efficiency and economy from farm to market; and

   (e) optimum highway safety.

2. Desirable program outputs are identified that would contribute to these objectives. These could include:

   (a) new area development roads;

   (b) a well-developed main line highway system;

   (c) a selectively improved secondary system; and

   (d) early correction of outstanding critical deficiencies on all systems.

3. Candidate programs are postulated to produce the desired outputs. For example, alternative programs of selected area development roads might be formulated. This would provide output under 2(a) and 2(c) above. (The size of the programs would be limited by available funds.) Alternative programs of primary improvements similarly might be formulated.

4. The cost effectiveness [1/] of the candidate programs in producing the desired outputs is evaluated. For example, the area development road program producing the most benefits within a practicable expenditure range would be identified. Similarly, the most economically efficient program for main line highways would be identified. There also might be a "best" (most economically productive) program of critical deficiency improvements. Note that the identification of a "best" program usually requires a specific expenditure to be assigned. Since the ultimate priority plan will consist of a combination of programs in specific areas, the assignment of probable expenditures will be a repetitive process. Occasionally, a point of diminishing returns will indicate a maximum desirable expenditure program.

5. Once the most cost-effective programs are identified with respect to each desired output, the outputs need to be evaluated in terms of the achievement of each identified objective and the objectives need to be rated in terms of their relative importance. A weighting scheme can be devised as in the following example:

(a) Three objectives rate in relative importance (out of 20):

Objective 1 = 16
Objective 2 = 8
Objective 3 = 4

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1/ The term "cost effectiveness" is used because desired outputs are not always expressed in terms of economic benefits, but the results of most road programs are usually expressed in this way.

(b) Two outputs rate (out of 10):

Output 1: with respect to Objective 1 = 4
with respect to Objective 2 = 6
with respect to Objective 3 = 0

Output 2: with respect to Objective 1 = 2
with respect to Objective 2 = 0
with respect to Objective 3 = 10

(c) Each output may be given an overall rating by "weighting" the output rating for each objective by the importance of the objective, as follows:

Output 1 = 4x16 + 6x8 + 0x4 = 112
Output 2 = 2x16 + 0x8 + 10x4 = 72

(d) Two candidate programs -- from several -- rate (out of 10):

Program 1: with respect to Output 1 = 0
with respect to Output 2 = 5

Program 2: with respect to Output 1 = 10
with respect to Output 2 = 2

(e) The programs may be given an overall "weighted" rating as follows:

Program 1 = 0x112 + 5x72 = 360
Program 2 = 10x112 + 2x72 = 1264

The relationship of the program ratings provides a basis for allocation of expenditures among programs, based on one scheme of relative values for objectives, outputs and programs. Other "weighting" schemes could be utilized to obtain results which judgment indicates are acceptable. Good judgment is indispensible in these determinations -- no mathematical system will take its place. Nevertheless, the basic procedures are important in that they provide an orderly and reasonable process for intelligently analyzing several important considerations in a complex situation. For example, the orderly interjection of outputs, as a consideration between objectives and expenditure programs, is significant because programs commonly produce more than one output which relate to different objectives, although one output may be predominant.

## Improvement Timing

The background information provided by the system development planners and needs analysis planners, in recommending expenditure programs, will provide indication of appropriate timing for different elements of the priority plan. For example, some deficiencies on existing highways will be more crucial than others in degree and importance. Also, some developmental highways or main line highways can be expected to contribute to more rapid economic growth than others. From this background information, the priority planners will need to develop and recommend appropriate timing for elements of the priority plan.

Target dates for different "package" accomplishments should be established as well as indication of even more specific priorities with respect to important routes or projects. Using the fiscal projections and cost estimates, the priority timing scheme should be related to the appropriate use of available funds.

The timing established as part of the priority plan, when approved, will be the point of departure for more precise route and project studies described in Chapter IV.

## The Priority Plan -- Documentation and Reports

The priority plan is the final output of the system planning process. Other outputs may be produced from systems development planning -- area studies, and from classification and needs planning -- classification formats and deficiency maps. But, all need to be resolved into a practical long-range plan for undertaking highway development and improvement, with provisions for maintenance and administration.

The time period of the priority plan will follow the dictates of practicability with respect to financing, ability to accomplish, and reasonable foresight. The plan does not need to envision completion of an entire system to ultimate service characteristics at one time, or even at all. It should envision specific accomplishments within specific time periods and specific financial provisions for these accomplishments. It may also outline a future direction beyond the accomplishments which has figured in their selection. For example, the plan, basically developed for a ten year period, might provide an indication of ultimate developments to be accomplished sometime in the future beyond ten years. The particular time would not be important. These developments would be included only to support the ten-year recommendations that form the substance of the plan.

The plan should be set forth in a report containing full documentation. This report ultimately should be prepared in attractive form for dissemination to those on whom the highway department is dependent for support. This normally will include legislators, other national agencies, appropriate funding agencies, and public officials.

Initially, the report should be prepared in draft form and provided only to top management for review, request for amendment and, finally, approval. Publication would follow approval.

Acceptance of the report and appropriate action on its recommendations by those who hold the purse strings may well be dependent on the quality of documentary support for its recommendations. Documentary support should be specifically provided to justify all of the plan content under one or more of the following headings:

- economic justification -- benefits vs costs,
- social justification -- enhancement of life,
- service need justification -- reasonable service and safety, or
- environmental justification -- recognition of environmental impacts.

Economic justification will result from the systems development planning and classification and needs planning processes. To the extent possible, numerical relationships between benefits and costs as related to time should be provided for different elements of the plan, such as specific area development roads, specific improvements on main line highways, secondary program provisions, and general deficiency corrections. Otherwise, recognizable economic benefits such as more general effects on commerce and industry which cannot be quantified, possibly can be described in terms that appear to provide logical justification to the reader.

The social impacts of different aspects of the plan, as supportive information, should be described. How do elements of the plan provide for enhancement of rural or urban life, for society in general or specific segments of it? How do these processes relate to costs?

Service and justification can be handled similarly. Travelers have little difficulty recognizing where service is notably deficient. Appropriate maps of deficient sections, along with descriptive information and photographs, can be utilized. Safety deficiencies, by degree, can be described and shown on maps along with a clear presentation of the beneficial effects of the plan.

Presently, there is a growing need to assure that the plan, even at this stage, is designed to maximize beneficial effects and minimize detrimental effects. New and improved roads can be beneficial to the environment by providing access to protect the environment from natural scourges; by arranging use of the environment selectively; and by providing avenues for people to enjoy the environment without further degradation. Specific impacts of the plan in these and other respects can be effectively described.

The plan should contain a recommended complete plan for financing and phasing which may be a little beyond present resources but practically attainable if the funding sources can be properly motivated.

# CHAPTER IV

## ROUTE AND PROJECT PLANNING

Route planning consists of activities directed toward development of a specific plan for improving an existing route or developing a new route. Such activities include feasibility studies, corridor location studies, conceptual design studies, and environmental impact studies.

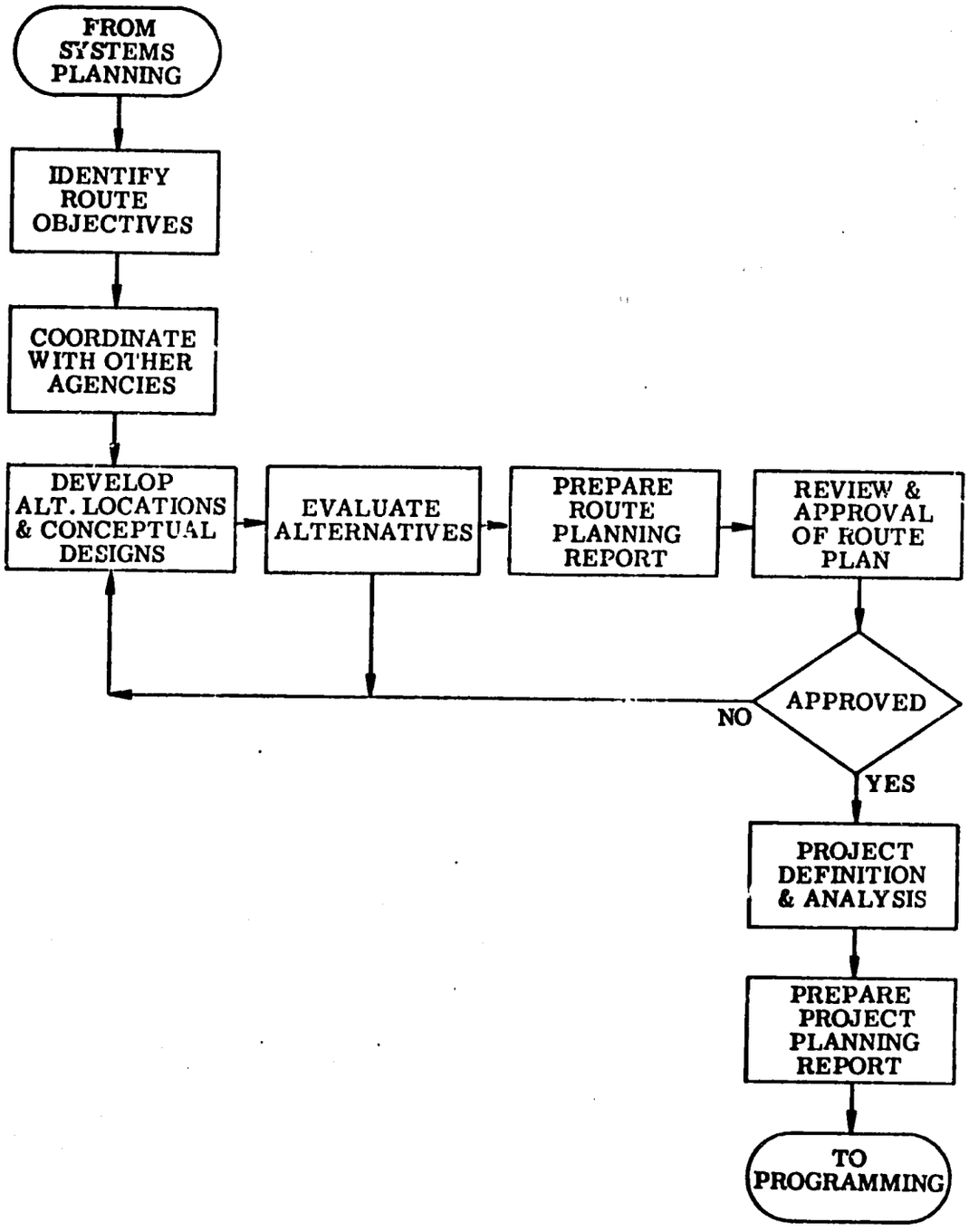
Project planning is performed for the purpose of defining the specific projects necessary to implement the route plan and analyzing the projects to provide the necessary data for programming, scheduling and controlling the work. Project definition and analysis provides information such as project limits, controlling design standards, traffic estimates required for design, preliminary estimates of quantities of work, and cost estimates by type of work.

The general process for conducting route and project planning studies consists of the following steps:

1. identification of route objectives,
2. initial coordination with other agencies,
3. development of alternative locations and conceptual designs,
4. evaluation of alternatives,
5. preparation of Route Planning Report,
6. project definition and analysis, and
7. prepare Project Planning Report.

These steps are illustrated in Figure 18 and are discussed in the following sections.

FIGURE 18




ROUTE AND PROJECT PLANNING PROCESS

## IDENTIFICATION OF ROUTE OBJECTIVES

At the outset of the route planning study, there must be a clear understanding of the transportation objectives for the specific traffic corridor being studied. Without this initial guidance, there can be no assurance that the resulting route plan will contribute to the accomplishment of the overall highway system plan.

General objectives were established during the system planning stage in terms of the purpose or function of the route (existing and proposed) and desired present and future desired service levels (volume, operating speeds, safety considerations). Also, current and anticipated future deficiencies were identified for the existing highway network. These results from system planning should be reviewed and, if necessary, updated to reflect any known changes that may have occurred during the elapsed time between the system planning study and the route study, such as new design standards or revised traffic projections. As the route planning study progresses, the objectives may be revised due to changes that are discovered in the study area, e.g., unanticipated changes in land use or population density.

## INITIAL COORDINATION

To insure that highway planning activities are coordinated with the activities of other governmental agencies in the study area, an announcement should be sent to other agencies early in the route planning stage. The announcement should indicate the general study area, desired objectives to be achieved, possible alternatives that may be considered, and a request for any information about the agency's interests or concerns in the area that might influence the conduct of the route study.

## DEVELOPMENT OF ALTERNATIVES

In most instances, there are a number of alternatives that can be considered by the highway planner to provide the desired service in the traffic corridor. These include alternative locations, improvement types and conceptual design.

If there is an existing route or perhaps more than one route in the corridor, improvements to, or replacement of, one or more of these routes can be considered. If no route exists at the present time, several alternative locations for a proposed new route can be considered.

Also, the alternative of not making a major improvement should be considered. In this case, the existing facilities will continue to be maintained, with such low-capital or non-capital improvements as necessary to provide an acceptable, if not the desired, level of service. The impact of this so-called "no-build" alternative on other elements of the highway system plan must be considered. The no-build alternative usually serves as the reference point, or baseline, for evaluating and comparing all other alternatives.

Initial concepts can be formulated in the office with the help of maps, aerial photographs and other information that may be available for the area. These initial concepts can then be examined in the field by ground and aerial reconnaissance, with attention given to topography, land use and other terrain and cultural features that may constitute constraints or otherwise influence the choice of alternatives. Route planning personnel are normally assisted by location and design personnel from the field offices nearest the study area.

The field reconnaissance will result in a refinement of the initially formulated alternatives and perhaps the addition or elimination of some alternatives. The refinements should provide a list of several reasonable alternatives that are worthy of further, more detailed examinations.

## EVALUATION OF ALTERNATIVES

The alternatives must be evaluated in sufficient detail to determine the most suitable one in terms of location, improvement type, and conceptual design for accomplishing the stated objectives. The evaluations should include engineering and economic feasibility studies, cost-effectiveness considerations, and assessments of social, economic and environmental impacts.

During the course of evaluations, additional refinements to the alternatives may become evident. The process of developing and evaluating alternatives should not be viewed as two separate steps in a one-way path but rather as a repetitive process resulting in several refined alternatives with well defined advantages and disadvantages.

### Engineering Studies

Engineering studies consist of preliminary investigations of topography, soils and geology, and hydrology to determine engineering feasibility and also to provide reasonable cost estimates for the economic analysis. A traffic analysis is necessary to determine anticipated traffic volume and traffic characteristics for the conceptual design, economic analysis, and impact assessments. A field reconnaissance, along with available maps and photography, will provide most of the data needed for this initial engineering analysis.

The conceptual design will consist of an approximate alignment shown as a line or band in plan view on a suitable base map. Also, typical profiles and cross sections should be shown.

The alternative locations at this stage of development should be viewed as representative, approximate alignments, identified only in enough detail to permit evaluation of the relative merits of the various alternatives. A precise alignment is not required at this stage. After the route plan has been approved and specific projects have been identified for implementation, a precise alignment will be established during surveys and design.

## Economic Studies[1/]

Economic studies are performed to determine whether or not the proposed alternatives are economically justified. The proposed improvements should provide a sufficient rate of return from economy of operations and from user taxes and tolls to justify the capital investment and amortize the cost within the useful life of the improvement.

In the case where alternatives will improve or replace an existing service, the existing service is used as the basis for comparison. The new service should show a definite advantage over the present service to justify making the change. The method commonly used for this analysis is called the "benefit-cost ratio" method.

In the case of an entirely new service which is not presently being provided, the rate of return should be sufficient to justify the capital investment and the operation and maintenance costs. The method used for this analysis is called the "rate of return" method.

### Benefit-Cost Ratio Method

The benefit-cost ratio is calculated as follows:

$$B/C = \frac{(U_1 - U_2) + (E_1 - E_2)}{(I_2 - I_1) \times CR}$$

where:

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1/ For a complete discussion of highway economics see: Robley Winfrey, Economic Analysis for Highways, International Textbook Co., Scranton, Pa., 1969, 923 pp.

B/C = Benefit-cost ratio

U = Annual road-user cost

E = Annual highway operating expense

I = Capital investment for construction

1, 2 = Subscripts referring to (1) existing condition or some other alternative used as a basis for comparison and (2) the proposed alternative, repectively

CR = Capital recovery factor = $\frac{i(1 + i)^n}{(1 + i)^n - 1}$

i = Interest rate

n = Number of years of the investment, usually the useful life of the project.

Annual road-user costs are determined by the following equation:

$$U = 365 \times V \times L \times C$$

where:

V = Average daily traffic volume

L = Length of route or route section being studied (kilometers)

C = Total unit operating and time cost per vehicle per kilometer (e.g. fuel, lubrication, tires, maintenance, depreciation, travel time).

Annual highway operating expense is calculated as follows:

$$E = A + T + M$$

where:

A = Annual administrative cost per kilometer

T = Annual traffic operations costs per kilometer (e.g. signal operation)

M = Annual maintenance cost per kilometer.

Capital investment cost (I) is the total cost of construction, including right-of-way, grading and draining, structures, paving, and appurtenances (e.g.,signs, guard rail). The investment cost must include an allowance for the time cost of money since the money could have been invested in something else to produce an interest income or could have been used to retire a public debt on which interest is being paid. This allowance is made by applying the capital recovery factor to the total investment to obtain an annualized investment cost including interest.

In the above B/C formula, the assumption is made that the terminal or salvage value of the facility is negligible. Where this is not the case, the salvage value should be reduced to an annual value and deducted from the annualized capital investment costs. The salvage value can be annualized by multiplying it by the sinking fund factor:

$$SF = \frac{i}{(1 + i)^n - 1}$$

For the proposed alternative to be justified economically, the B/C ratio should be greater than 1.0, meaning that the net gains exceed the net costs. If the B/C ratio is less than 1.0 (including negative values), the net benefits to be realized are less than the costs required to obtain the benefits.

When several alternatives are being considered, each alternative must be compared with each other alternative either by calculation or by logic. For example, if Alternative B is superior to A, and C is superior to B, there is no need to compare C with A since C is clearly superior.

## Rate of Return Method

The rate of return on an investment in a new facility, for which user taxes or tolls are charged, can be calculated as follows:

$$CR = \frac{R - E}{I}$$

and

$$R = 365 \times V \times L \times X$$

where:

CR = Capital recovery factor
R = Total annual revenue
X = Unit tax per vehicle per kilometer

Other terms in these equations have been defined previously in this Chapter.

For user taxes in the form of motor fuel taxes, the value of X can be determined by dividing the tax per liter by the kilometers per liter for the average vehicle.

After calculating the value of CR, and using the anticipated service life of the proposed improvement for n, the interest rate, i, may be determined from the CR equation presented in the benefit-cost discussion by trial and error or from interest tables. To be justified economically, the rate of return should be equal to or greater than current interest rates on public debts.

In some cases, the route may not appear to be justified in terms of road-user benefits or rate of return. Other considerations may enter into justification of the proposed route, e.g., military strategic importance or frontier development programs. However, as a general rule, the new route should be justified economically unless there is clearly some overriding consideration to indicate otherwise.

## Social, Economic and Environmental Impact Studies

The analyses described so far have addressed only the feasibility, justification, and requirements from an engineering and internal economic viewpoint. Equally important is the need to assess the social, economic, and other environmental consequences of the proposed route improvements during development and evaluation of alternatives. Good planning and engineering practice requires that all significant environmental[1/] impacts be considered to ensure that the proposed improvement is in the best overall public interest.

Environmental impact assessment consists of:

- Identification of anticipated environmental impacts that will occur as a result of implementing the proposed improvement,

- Evaluation of the degree of severity and importance of the identified impacts, and

- Recommendation of an appropriate course of action to avoid or mitigate any significant adverse impacts.

Identification of environmental impacts is greatly facilitated by starting with a framework of major land use categories and principal environmental concerns within these categories. Major land use categories include:

- Agricultural lands
- Commercial areas
- Floodplains
- Forested lands
- Historical sites
- Institutional sites
- Industrial areas
- Residential areas
- Waterways

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1/ The word "environmental" as used here includes the social and economic aspects of the environment as well as the physical aspects, i. e., the total human environment.

Within each of these land use categories there may be a number of different environmental concerns, such as:

- Ecological
- Economic
- Human interest
  - + Aesthetics
  - + Culture
- Physical
  - + Air quality
  - + Hydrology and water quality
  - + Land use and resources
  - + Noise
- Public services
- Safety
- Social

It should be noted that the land-use categories are not mutually exclusive, e.g., commercial and residential areas may overlap. Also, all of the above concerns will not be applicable to every category or at least not to the same degree, e.g., social concerns may not be applicable in unpopulated, forested areas, and economic concerns may differ among the various land-use categories. For a given area or region of the country a suitable matrix of categories and concerns can be formulated.

Environmental impacts can also be categorized by the time frame in which they are expected to occur. The time frame can be broken down as follows:

- preconstruction period,
- construction stage,
- post-construction -- short term, and
- post-construction -- long term.

Prior to construction, the proposed project may have an effect on residents because of the anticipation and uncertainty of when and how the project will affect them. Also, land speculation in anticipation of the highway improvement may affect the local economy.

During or immediately prior to construction, the relocation of residents and businesses occurs. During construction the area is physically altered by removal of vegetation and man-made objects and excavation and grading. The construction process itself may have a disruptive effect on activities in the area.

In the short-term post-construction period, there are adjustments in activities and life styles as a result of the new or improved highway service. In the long-term post-construction period, and to some extent also during the short term, there are changes in land use and population to take advantage of the new facility and of developments resulting from the new facility. These induced effects have their own impacts on the quality of the environment.

As implied above, environmental impacts may be:

- direct, or
- indirect (induced)

Direct impacts are those that occur in the path of construction, i.e., within the right-of-way or immediately adjacent thereto, and in the general corridor as a direct result of the physical presence of the highway, e.g., relocations, air pollution, soil erosion. Indirect or induced impacts are those which result from changes in land use and activities that were attracted to the area as a result of the highway facility.

Finally, the environmental impacts may be:

- favorable (positive), or
- adverse (negative).

It should be noted that a particular action may be both favorable and adverse depending on the point of view of the observer. For example, increased traffic volume may provide higher incomes for businesses adjacent to the new facility, but may result in lower incomes for businesses in the area from which traffic was diverted or attracted. The planner should point out the beneficial aspects of the proposed alternatives as well as the adverse effects so that decisions can be made which will provide the most benefits with the least harm.

### The Preferred Alternative

After the various evaluations described above have been performed, the results should be reviewed and an assessment made of the relative merits of the various alternatives. Consideration must be given to:

- the degree to which the objectives of the route are fulfilled, e.g., the level of service provided;
- the cost of constructing, operating and maintaining the proposed improvement; and
- the environmental effects anticipated as a result of implementing the proposed improvement.

In some cases, one alternative may obviously be superior in all respects and the choice will be clear. In many cases, however, there will be conflicting considerations. The route location which provides the desired service and greatest user benefits may include some unacceptable impacts. In such cases, a recommendation must be made which, in the planners judgment, represents a compromise that is in the best overall public interest.

## ROUTE PLANNING REPORT

The results of the route planning study should be documented clearly and concisely in a Route Planning Report. This report will serve several purposes. These are:

- to describe the proposed route plan, including objectives, alternatives considered, types of evaluations performed, and costs, benefits, and adverse effects;

- to present the findings and recommendations of the planning staff to decision makers and the public; and

- to provide needed data for subsequent stages of development.

The Route Planning Report should indicate the various considerations that were taken into account and should give adequate justification of the need for the overall improvement concept and for the particular alternative being recommended. The Report can also serve as the approval vehicle. A space for signatures can be provided for the approval authority within the planning organization and any other necessary approvals within the highway agency.

After the Report is completed, it is submitted to proper authority for review and approval. Approval of the route plan is indicated by signatures of the approval authority on the Route Planning Report. Revisions may be necessary in some cases prior to final approval.

Upon receipt of approval, the subsequent stages of project planning, described below, may be undertaken.

## PROJECT DEFINITION AND ANALYSIS

Route planning studies are normally carried out for entire routes or substantial route sections to ensure that the various proposed improvements to the route are consistent with overall route objectives and are compatible with each other. As a result, the proposed improvements are probably identified for sections that are longer than normal construction project lengths. During the project planning stage, the improvements identified in the approved route plan are examined from the viewpoint of breaking the work into reasonable section lengths which can be designed and constructed as individual projects.

Consideration should be given to logical breaks in the major features of the route, e.g., if the existing route has some sections which need reconstruction and other sections which need only minor widening and resurfacing, a logical separation may be made between these sections. Also, some sections of the proposed improvement may be on new location while other sections may follow the existing alignment.

Consideration should also be given to the time frame in which the improvements are needed. For example, portions of the route may carry heavy year-round industrial traffic, while other portions may carry seasonal traffic. Some of these sections may have a higher priority and therefore should be identified as separate projects for earlier implementation.

Additional considerations include logical breaks to take advantage of detour or bypass routes and to maintain existing traffic flows with as little disruption as possible.

The project description should indicate the route number (and name where appropriate), project number, project termini, and type of improvement.

Project termini should be clearly identified with respect to easily recognized features, such as crossroads, distance markers, and administrative or political boundaries.

Information needed for design of the proposed improvements should be clearly identified. This information consists of a description and map of the corridor location or approximate alignment of the proposed improvement, type of improvement, controlling design standards, and current traffic estimates.

For programming purposes, a reasonable cost estimate is needed. The cost estimate should be based on preliminary estimates of types and quantities of work, including preliminary engineering (surveys and design), right-of-way (acquisition, relocation assistance, utility adjustments), and construction

(project control and supervision, excavation, grading and draining, structures, paving, and incidentals). Some indication should also be given of the relative urgency of each project to assist in formulation of the work program.

The above information should be documented in a Project Planning Report. The Report should serve as a basis for programming and provide guidance to each unit manager having responsibility for implementing the project.

# CHAPTER V

## PROGRAMMING AND SCHEDULING

The process of arranging the planned projects in priority order over a period of time to make the best use of available funds and manpower is generally referred to as "programming." The specific listing of projects so organized is called a "highway improvement program." A separate unit in the planning organization usually has responsibility for carrying out the programming function.

The highway improvement program should cover a time period that will allow adequate lead time for conducting preconstruction activities, i.e., surveying, design, right-of-way acquisition, and preparation of contract documents, for the largest projects. Usually, a time frame of about five years is sufficient to span the period of preconstruction activities for major projects. Shorter time periods will place unnecessary restrictions on efficient time phasing of events and workload balancing. On the other hand, the time period should not be longer than needed for project lead time, in order to provide as much flexibility as possible in the long-range planning process. For example, projects programmed today for construction 10 years hence may turn out to be inappropriate based on future realities such as unanticipated changes in land use or travel patterns. This does not mean that planners should not try to anticipate future transportation needs, only that programming of specific projects should not be projected any further into the future than necessary for orderly project development.

An effective program will have the following characteristics:

- It will ensure the most effective use of all funds available for highway improvements.

- It will itemize proposed improvement projects for the program period, and show their time and funding relationships.

- It will reasonably follow priorities established in the development of the systems and route plans.

- It will coordinate highway project development with other provincial and local programs, including non-highway programs.

- It will remain relatively stable and provide a firm basis for scheduling the development of projects.

## PROGRAMMING PROCEDURES

The general procedures for developing and maintaining an up-to-date highway improvement program are:

1. review priority and route plans,

2. identify projects in priority order,

3. estimate project development time and resource requirements,

4. estimate funding availability and constraints,

5. formulate initial five-year program,

6. adjust program as necessary, and

7. update program annually.

Each of these steps will be discussed briefly in the following sections.

## Priority and Route Plan Review

The principal guides for program development should be the results of the priority planning and route and project planning processes described earlier. Results should be well-documented in the reports which describe the approved priority plan and the individual project planning reports.

Programmers should review these documents to obtain a clear understanding of the overall goals and objectives of the highway system, the contents of the priority plan for achieving these goals and objectives, and the specific route improvements called for in the project planning reports. In fact, the project planning reports should provide the basis for selecting projects for the highway improvement program.

## Project Selection and Identification

There are quite often more highway improvements needed than there are funds available to pay for these improvements. The needed improvements identified in the priority plan have been matched, to the extent possible, with revenue projections over a long period of time (perhaps 10 to 20 years). If the needed improvements accrued approximately uniformly over that period, the improvements could be grouped according to the year of obsolescence and the problem of funding would be somewhat less severe. However, in most instances, a substantial portion -- sometimes one-half or more -- of the needed improvements represent "backlog" needs based on deficiencies which exist at the present time. Therefore, it is necessary to establish some priorities for determining which projects to undertake in the immediate future and which to postpone for subsequent years.

The analyses performed in the system and route and project planning stages (e.g., needs analysis, sufficiency rating, benefit-cost analysis, traffic forecasts), provide programmers with information needed for arranging the

planned improvements in order of priority on a rational basis. The purpose of a priority ranking system is to provide an initial listing of a large number of projects on a uniform basis. Refinements to this initial ranking must be made to account for other non-quantifiable considerations, such as economic development and national security needs, and to accommodate budgetary or manpower restraints within a given time period.

The sufficiency rating technique, described in Chapter III, has been used effectively to rank projects in order of priority, with the lowest rating getting the highest priority. There are many variations of this basic method. More or less importance may be assigned to the various elements being rated and the rating may be adjusted in various ways for traffic volume, with higher than average traffic volumes resulting in lower ratings and, therefore, higher priorities. Other methods of determining priorities include use of benefit-cost ratios. But the sufficiency rating technique provides a simple and direct approach to start with. As experience with the method increases, refinements may be made to suit the requirements of the highway agency.

The projects to be implemented during the program period (5 years) should be ranked in order of priority. The list of candidate projects should include enough projects to extend a year or two beyond the five-year program period, because some of the projects may be delayed or eliminated for various reasons and there should be other projects available to take their place. There is no need to rank all of the projects anticipated over a 10 to 20-year period because their priorities will undoubtedly have changed by the time they are included in a five-year program due to changes in traffic, physical condition, and land use.

After the initial ranking is made for projects on existing routes, the ranking should be reviewed for consistency with the highway agency's goals and objectives and, if necessary, the ranking should be adjusted. Also, projects representing new facilities should be added to the listing at appropriate points based on their importance relative to the other projects in the list.

Care must be taken to ensure that the ranking does not cause an illogical separation of related projects. For example, a road widening improvement should not get a higher priority than a bridge widening improvement on the same section. On the other hand, a critically deficient bridge may need to be replaced before the road improvement is made, and the replacement bridge design should be compatible with the subsequent road improvement.

The priority listing should be formulated without regard to geographic area or political subdivision. An equitable distribution of projects across the country will occur as the projects are matched with funds available in the various subdivisions.

Each project to be included in the highway improvement program should be assigned a unique number for positive identification and ease of reference. Any unique number may be used. However, the numbering system should be designed to suit the needs of the highway agency and, as a minimum, should include a code number for highway district, province, route system, route number, sequence number of the project along the route, and type of improvement.

## Project Development Time and Resource Requirements

The program must provide adequate lead time for completing the various preconstruction activities necessary for project development prior to the desired contract letting date These activities include

- location surveys,
- design,
- right-of-way acquisition, and
- contract document preparation.

In order to formulate a meaningful program, the average time and estimated cost to complete each of these activities for a given type of project must be known. Time and manpower requirements vary with land use (e.g., rural or urban), type of highway (e.g., arterial or collector, national or provincial), and type of improvements (e.g., minor widening or new location).

Productivity rates may be developed for each activity and each type of project indicating estimates of the type and number of personnel and the time required per project, per kilometer, or per lane per kilometer. From these productivity rates, the total time and costs of all preconstruction activities can be determined. The time and cost required for preconstruction and construction of each project can be added to the information contained in the priority listing.

More specific detail, such as dividing the major activities listed above into individual tasks, is not needed during this stage of program development. This will be done when the first year of the program is broken down into a detailed work schedule.

## Funding Availability and Constraints

An estimate must be made of the total amount of revenues that are expected to be available over the five-year program period in quarter-year increments. The first step is to identify the various sources of funds, which may include:

- unappropriated surplus carried over from previous years,
- national tax revenues dedicated to highways (e.g., taxes on fuel, oil, tires),
- general fund appropriations,

- operating revenues (e.g., tolls, ferry fees),
- loans, and
- grants.

Methods for estimating the amount of funds that will be available in future years were discussed in Chapter III. For in-country funding sources, projections are generally made from the historical record of previous years, with allowances being made for current trends in population, vehicle registrations, tax rates, and other factors such as legislation that may affect revenues. The potential for loans and grants from outside agencies can be determined only through discussions with officials in those agencies.

The anticipated revenues should be summarized by category and by quarter-year of availability. If the use of certain funds is restricted, e.g., a loan, grant, or appropriation for a specific project, these funds should be listed separately.

The anticipated revenues are, in many cases, divided equitably among the provinces or geographic regions of the country. There are several good reasons for doing this. Suppose, for example, that an excessive number of high priority projects should happen to be concentrated in one area. If all of these projects were to be implemented in one year, the supply of contractors, labor and materials in that area may be exhausted to the point where additional resources may have to be imported into the area. This may increase the cost of projects unnecessarily. Also, from a political viewpoint, the public officials in other areas may expect some highway improvements in their jurisdictions in return for the taxes collected.

Various schemes have been used to ensure an equitable apportionment of funds over large areas. Apportionment formulas have included factors for area, population, road kilometrage, vehicle-kilometrage, and needs (as determined by highway needs studies). Generally, apportionment formulas are prescribed by law because of the social and economic importance attached to highway improvements. Within an apportionment area, projects should be undertaken in the order of priority.

All of the anticipated funds will not be available for highway improvement projects, due to various other obligations. These may include the cost of administration, operation, and maintenance of the highway system, collection of highway-related taxes, retirement of previously incurred debts, and highway aid to local governments. Estimates of these obligations can be made by examining records for previous years and making a projection for the program period.

After deductions have been made for these obligations, the remainder of the anticipated revenues are available for project development and construction. However, a small operating cash balance must be kept on hand each year to cover contingencies. Again, past experience will indicate the minimum cash balance required.

## Program Formulation

With the project priority listing and the estimates of costs and available funds in hand, program formulation can be undertaken. This would appear to be a simple matter of accumulating projects in priority order until the total accumulated cost is as close as possible to, but not in excess of, the available funds for the first year of the program. The process would be repeated for each successive program year. Although this is the general approach, there are a number of practical considerations which complicate the process.

First of all, projects that were undertaken previously, but not completed during the current year, should take precedence over new projects. Such projects are presumably higher in priority than new projects because they were undertaken earlier.

Any work of an emergency nature (e. g., repairs and replacements due to earthquakes, floods, bridge failures, etc.) must also take precedence over new projects. Consideration should be given to an appropriate type of repair. Present service could be restored, or a stop-gap repair could be made to

provide service until a major improvement is to be undertaken in accordance with the priority listing. Or, if the road was already high on the priority list for a major improvement, the major improvement could be undertaken instead of the stop-gap measure.

The timing and staging of projects must also be considered. If traffic service is to be maintained during construction and there is no suitable detour, the project or set of projects along a route may need to be constructed in stages (e.g., reconstruction of one lane at a time) which will permit continuity of traffic service. If there is a limited construction season, projects should be entered in the program in a time period which will permit construction to be completed within a construction season. This may result in a major project being postponed until the start of the next construction season and a shorter project of lower priority being moved up to take its place.

The highway improvement program should be coordinated with maintenance and traffic engineering programs. Sometimes, maintenance programs include projects for repairing road sections which are also included in the highway improvement program for a major improvement in the near future. By coordinating the two programs and making appropriate adjustments, unnecessary expenditures and duplications of effort can be avoided.

Another problem that must be considered is the in-house capability to carry out the necessary preconstruction activities and construction supervision associated with the projects. There may be sufficient funds available in a specific time period to undertake more projects than the highway agency can reasonably handle with available personnel. If this will be a continuing problem, additional staff may need to be added. If, on the other hand, there are a few peak workload and slack periods, the program can be adjusted to smooth out the peaks by postponing or rearranging projects so that the staff is not overloaded or under-utilized. An alternative would be to utilize consulting services during the peak workload periods.

Estimates must be made of the availabilities and capabilities of contractors and consultants and of the availability of various resources, such as equipment, concrete, structural steel, roadbed materials, and skilled and unskilled labor, to ensure that the projects may be undertaken in the desired time frame and carried through to completion without delay.

In order to successfully cope with all of these considerations, several different arrangements of projects will need to be examined. It may become apparent that a few projects of lower priority will have to be advanced toward earlier completion, while a few higher priority projects are delayed until later in the program period. After several repetitions, with fewer adjustments each time, a reasonably firm, well-balanced program will evolve.

The projects in the program should be grouped in a convenient order, e.g., by highway district, province, and priority. The program should be well documented for ease of reference by the highway agency, other governmental agencies, and the general public.

The program should be approved by top management in the highway agency and should represent a commitment by the agency to accomplish the work substantially as outlined in the program. The program should provide the basis for sound scheduling and monitoring of preconstruction and construction activities and should serve as a frame of reference against which overall progress of the agency can be measured.

## Program Adjustments

After the program is adopted and work is scheduled and undertaken on that basis, it is generally undesirable to make changes in the program. This is especially true for the first year or two of the program. If the program was well-balanced in terms of timing, funding availability and manpower requirements, any last minute substitutions or other changes in even a single project in the near-term portion of the program can have an adverse effect on the entire program. The program is somewhat more flexible in the last year or two and changes can be accommodated more easily.

There may be a need to adjust the program from time to time in spite of the best efforts of the highway agency to develop a stable program initially. For example, the funding picture may suddenly change and may represent a signficant departure from the initial projections. Or, a project that appeared to be justified may turn out to be inappropriate in the light of present realities. Also, unforeseen difficulties may be encountered during preconstruction activities which will delay the contract letting date.

For whatever the reason, program adjustments may need to be made. If so, alternatives available to the highway agency should be considered and the impact of various possible adjustments should be thoroughly examined prior to reaching a decision on changing the program. When the decision has been made to change the program, new program documentation should be developed to reflect the change. However, the changes may not need to be published more often than quarterly.

Annual Program Updates

The programming process must be a continuing effort if the program is to remain a viable, up-to-date document. As the first year of the program is accomplished, another year should be added to the end of the program. In this way, the program will always reflect a five-year future time period. Each year an annual update should be published to indicate the accomplishment during the current year and the needed additions to the fifth year of the program.

## SCHEDULING

To ensure that the highway improvement program is carried out efficiently and effectively, the highway agency will need to develop a plan of operations for optimum utilization of available equipment, materials, manpower and financial resources. The plan of operations to carry out the program is generally referred to as a "multiple-project work schedule" or simply a "schedule."

A schedule is a more detailed look at the near-term portion of the program. The process of developing the schedule involves breaking down each project into major activities, setting desired starting and ending times for those activities, determining the resources required for each activity, and adjusting the time as necessary to match the available resources.

A schedule should have the following characteristics:

- It should identify all the developmental activities to be completed on specific projects within a period of at least one year.

- It should establish target dates for the completion of developmental processes, including location surveys, soils investigations, roadway design, bridge design, right-of-way acquisition, and contract letting.

- It should correlate the activities on various projects to achieve workload balancing and efficient use of all resources.

- It should be adjusted during the year to reflect unavoidable project delays, substitutions, and other disruptions.

The usual format for a schedule is a bar chart or diagram. Time is customarily shown on the horizontal axis and project activities are listed on the vertical axis. Bars or lines are used to show work scheduled and work completed. The schedule format should be adjusted to show only the amount of detail needed for a particular level of management.

Top management, for example, does not need specific detailed information on the schedule of various design phases of a roadway or bridge. They should, instead, expect to see a chart which shows progress toward major

target dates and which illustrates the extent to which various projects are ahead of or behind schedule. On the other hand, a supervisor in charge of bridge design would want to know the schedule and progress of every activity necessary to complete the design by the target date. As a general rule, the closer the target date and the lower the management level, the more detail required on the schedule.

The schedule provides a framework for monitoring, reporting, and controlling project development. Supervisors responsible for the various work processes must monitor the work under their control, make a conscientious effort to ensure that target dates will be met, and report to higher management any exceptions, i. e., any dates which cannot be met, sufficiently in advance to allow for schedule adjustments and to minimize impacts on other projects. The reporting process should be "exception reporting." This means that no report is necessary if the work is being accomplished substantially in accordance with the published schedule. However, if it becomes apparent that a target date will not be met, a report of this fact should be sent to higher mangement with a brief explanation of the delay. It is also helpful to report work phases that are being completed far ahead of schedule.

With some advance notice of these exceptions, decisions can be made regarding adjustments in the schedule. For example, more resources could be allocated to preserve the schedule, or starting dates of subsequent activities could be delayed (or advanced).

In many organizations, the mechanics of developing balanced schedules, reporting progress, and making adjustments has been computerized. This greatly reduces the workload involved in initially formulating a schedule and keeping it up-to-date.

# CHAPTER VI

## AGENCY-WIDE PROGRAM PLANNING

Up to this point, the Manual has placed emphasis on those steps and procedures of a planning unit to define highway systems and to conceive and prepare highway construction and improvement programs. For most highway agencies, particularly in developing countries, the development and improvement of the highway network usually is considered the most important function.

But there are other essential activities of a highway agency which require funding and which must be considered in agency-wide financial planning. Funding is required for items such as maintenance, equipment, equipment shops, administration, new buildings, etc. And until these needs are defined and evaluated, there is no way to clearly identify the funding available for major construction programs.

### PURPOSE

Preparation of formal budgets for highway agencies usually is a responsibility of the accounting division. The format and procedures often are set forth by legislation or decree to be uniformly applicable to all government agencies. But seldom do these budgets define specific work accomplishment. They usually identify financial requirements by object of expenditure -- labor, equipment and materials. Similarly, the budget requests of individual organizational units within the highway agency are not related to specific accomplishments, and it is difficult to determine if the proposed allocation of resources is consistent with the overall objectives of the highway agency.

The purpose of agency-wide program planning is to prepare, review and evaluate "work program budgets" for each of the functional areas of the highway agency. Specific objectives will be defined, costs will be identified and evaluations will be made to determine how effectively this resource allocation

contributes to overall goals. The approved work program budgets will then serve as bases for preparing formal budget requests -- as well as for staffing and performing individual work activities.

## ORGANIZATIONAL RESPONSIBILITIES

Agency-wide planning obviously is a high-level responsibility. Although discussed in this manual, it is not necessarily a responsibility of the planning division of the agency. Responsibilities may be assigned to a special organizational unit reporting directly to the chief executive of the agency, or to some other organizational level. But quite often the planning division is the logical place for this responsibility because they are most experienced in the processes of data collection, economic analysis and evaluations.

However, the planning division should not be decision-makers. Final decisions probably will be made by the chief executive. But the planning division should gather data, conduct analyses and prepare initial recommendations.

A Budget Committee representing top management of the agency should be established to review and evaluate recommendations of the planning division and to make appropriate adjustments. The planning division should be represented on the Committee, along with heads of other divisions. The recommendations of the Committee should be submitted to the chief executive for approval.

The Committee will be responsible for review of all aspects of the work program budget to determine if the major objectives of the agency have been fulfilled, the necessary programs identified, and the funding levels for each program established in accordance with program priorities.

## THE BUDGET CONCEPT

The concept of work program budgets for a highway organization requires the determination of objectives which are considered essential to provide an acceptable level of service for the highway user within the constraints of available finance and resources. These objectives are the result of decisions made by top management of the organization. All program development, production scheduling, and the organizing, staffing and budgeting will be directed toward the fulfillment of the agency's objectives.

The budget concept ties the planning and programming tasks into an integrated operation that considers revenue and resource requirements necessary to achieve short- and long-range objectives. The budgeting task is in turn linked to the planning and programming tasks in order to allocate funds, programs, activities and projects that have been established to meet the objectives of the organization. All three tasks are linked together to support each other and act as a check to determine if each is oriented toward accomplishing the desired results established for the organization.

Performance-based budgets are related to specific work performance and accomplishments -- specific construction projects, specific betterment work, specific equipment acquisition, etc. Such a budget identifies by program the work the agency intends to accomplish during the budget period, and the level of funding recommended to accomplish the proposed work.

## PROGRAM OBJECTIVES

Clearly stated objectives are essential to a work program budget.

An example of an objective would be the statement that "each district headquarters will be furnished with new shop and office buildings constructed at new locations where suitable storage areas for equipment and materials are available." Purchasing the land and constructing these facilities is the means by which one moves toward the achievement of this objective. Providing every

district with a new site complete with new buildings and a storage yard represents total achievement of the objective.

Many constraints exist that prevent immediate accomplishment of objectives. It then becomes necessary to view objectives in terms of time.

Time Frame of Objectives

Objectives can be subdivided into three categories:

1. long range,
2. short range, and
3. recurring.

Short-range objectives are those that can be accomplished in a time frame of five years or less. This is generally considered to be reasonable from the standpoint of planning, programming and budgeting.

Objectives that require a longer time frame for complete achievement, or perhaps because of their complexity can never be completely achieved, are referred to as long-range objectives. Generally, long-range objectives can be subdivided into component parts which may fall into the category of short-range objectives.

Many work activities are of a repetitive nature and vary only slightly from year to year. They generally pertain to routine activities and are called recurring objectives. Recurring objectives should not be taken for granted but should be reviewed and analyzed during each budget preparation period in the same manner as new objectives. Otherwise, some activities may be continued long after the original objective has been revised or abandoned.

## Levels of Objectives

Another aspect of objectives is that they may have different meanings to different levels in the organization. What may be considered as an action towards an objective from one level of the organization may be the objective itself for another level.

For example, top management may decide that the organization must "generate cost information for use as a management tool." Then the chief of the administrative unit will say he will "operate a cost accounting system" in order to satisfy his objective "to generate cost information" as requested by top management. And the chief of the accounting unit will consider his objective to be "the operation of the cost accounting system."

Or, in the case of the highway improvement program, the chief of the engineering function may decide that in order to accomplish the assigned objective of "designing and awarding to contract those projects contained in the next fiscal year's highway improvement program" he will need a schedule for the design and monitoring of each project's progress. The chief of the programming unit will view his objective as the "implementation of the scheduling and monitoring system." But the designer himself will see his objective as the "completion of the projects assigned to him on schedule, and in accordance with design standards." And finally, the chief of the contract administration unit will consider his objective to be the "preparation of necessary documents for the advertising of bids and award of contracts in accordance with the schedule."

The above examples illustrate how objectives can be refined into smaller and smaller parts. In the refinement, the solutions or action for a larger objective become objectives in themselves for lower level organizational units.

## Organizational Objectives

It is thus possible to develop a hierarchy of objectives for the entire highway agency. The hierarchy would show how the action taken on objectives at one organizational level become objectives for a lower level. The organizational structure job descriptions and functional statements form the hierarchical core of the agency's objectives.

Long-range plans must be made more precise and specific for the shorter term. More current information, better forecasts, and current events permit more detailed planning. Often, long-range plans must be revised and time frames must be adjusted. Almost always, more detail in the regular or routine objectives must be identified. Also, new or special objectives will be defined. In particular, objectives are continually updated for the highway improvement and maintenance programs.

## DEVELOPING THE WORK PROGRAM BUDGET

Once the new or special objectives have been identified, the work program budget may be developed. The overall process is illustrated in Figure 19.

The basic steps are as follows:

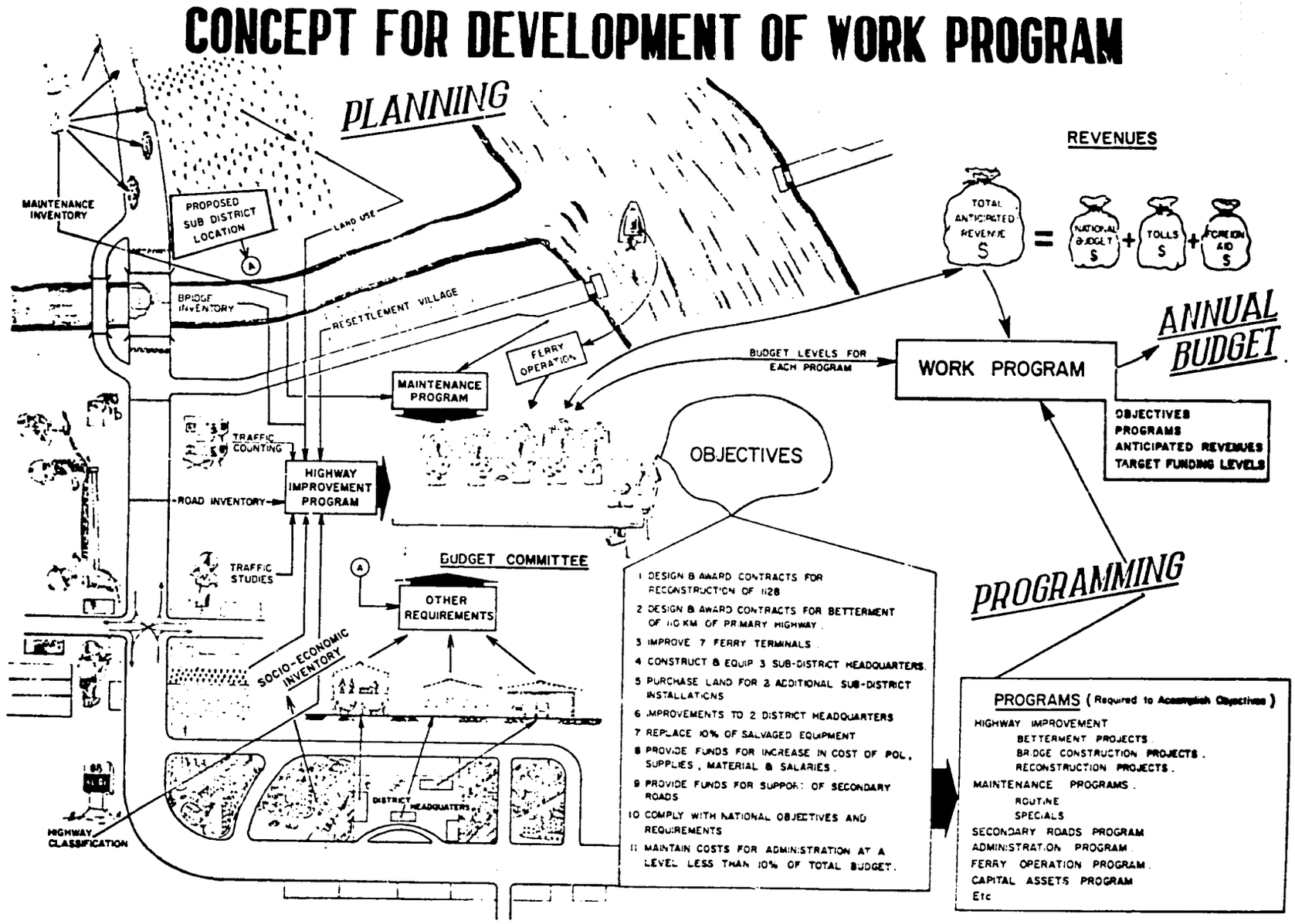
1. Analyze the new or special objectives. This involves:

   - structuring and relating them to the regular or recurring objectives,

   - determining their consistency with the regular or recurring objectives, and

   - identifying further objectives which result from the new or special ones just identified.

FIGURE 19


CONCEPT FOR DEVELOPMENT OF WORK PROGRAM
PLANNING
MAINTENANCE INVENTORY
PROPOSED SUB DISTRICT LOCATION
LAND USE
BRIDGE INVENTORY
RESETTLEMENT VILLAGE
FERRY OPERATION
MAINTENANCE PROGRAM
TRAFFIC COUNTING
HIGHWAY IMPROVEMENT PROGRAM
ROAD INVENTORY
TRAFFIC STUDIES
BUDGET COMMITTEE
OTHER REQUIREMENTS
SOCIO-ECONOMIC INVENTORY
DISTRICT HEADQUARTERS
HIGHWAY CLASSIFICATION
OBJECTIVES
1 DESIGN & AWARD CONTRACTS FOR RECONSTRUCTION OF 1128
2 DESIGN & AWARD CONTRACTS FOR BETTERMENT OF 110 KM OF PRIMARY HIGHWAY
3 IMPROVE 7 FERRY TERMINALS
4 CONSTRUCT & EQUIP 3 SUB-DISTRICT HEADQUARTERS
5 PURCHASE LAND FOR 2 ADDITIONAL SUB-DISTRICT INSTALLATIONS
6 IMPROVEMENTS TO 2 DISTRICT HEADQUARTERS
7 REPLACE 10% OF SALVAGED EQUIPMENT
8 PROVIDE FUNDS FOR INCREASE IN COST OF POL, SUPPLIES, MATERIAL & SALARIES
9 PROVIDE FUNDS FOR SUPPORT OF SECONDARY ROADS
10 COMPLY WITH NATIONAL OBJECTIVES AND REQUIREMENTS
11 MAINTAIN COSTS FOR ADMINISTRATION AT A LEVEL LESS THAN 10% OF TOTAL BUDGET.
REVENUES
TOTAL ANTICIPATED REVENUE $
NATIONAL BUDGET $
TOLLS $
FOREIGN AID $
BUDGET LEVELS FOR EACH PROGRAM
WORK PROGRAM
ANNUAL BUDGET
OBJECTIVES
PROGRAMS
ANTICIPATED REVENUES
TARGET FUNDING LEVELS
PROGRAMMING
PROGRAMS (Required to Accomplish Objectives)
HIGHWAY IMPROVEMENT
BETTERMENT PROJECTS
BRIDGE CONSTRUCTION PROJECTS
RECONSTRUCTION PROJECTS
MAINTENANCE PROGRAMS
ROUTINE
SPECIALS
SECONDARY ROADS PROGRAM
ADMINISTRATION PROGRAM
FERRY OPERATION PROGRAM
CAPITAL ASSETS PROGRAM
Etc

2. Establish estimated funding levels for all objectives.

3. Identify programs under which the objectives will be performed.

4. Document the programs and objectives.

Analyzing the Objectives

The following steps are to be used in analyzing the objectives used as the basis of the work program budget:

1. Using the organization chart as a guide, list the objectives of each functional unit. This listing provides the regular or recurring objectives for each unit.

2. List the new or specific objectives. Compare the recurring with the new objectives. This comparison will point out some interesting facts:

   - Some additional or new objectives will supercede old ones.
   - Some will be more specific statements of old ones.
   - Some will create new lower level objectives.
   - Most commonly, some objectives will not be new, but will be old objectives involving new quantities, limits, tolerances and quality ranges.

3. List the new or special objectives under the function and organization level where responsibility is vested.

4. Then, for each additional objective, ask the following question: "What must be done to accomplish this objective?" The answers to the question form the next lower level of objectives. In turn, this question is asked for all lower levels of objectives.

5. Also, for each additional objective, ask this question: "For what purpose is this objective?" The answer to this question should be the next highest objective. If it is not, then the objective is not consistent with the higher objectives.

6. The result is a hierarchy of objectives to be used as the basis for preparing the work program budget.

## Developing Funding Levels

Once the objectives have been identified and listed, it is necessary to determine funding levels for each objective in order to complete the work program budget.

The following guidelines indicate how funding levels may be determined:

1. It is important to recognize that the funding levels will be estimates. At this stage in the budget cycle the estimates are approximate and represent gross balances based upon expert judgment and historical cost data.

2. Recurring or routine objectives should be distinguished from new and specific objectives. The process of estimating funding levels differs between them.

3. The regular or routine objectives are usually similar from year to year. In this case, heavy reliance may be placed on historical costs adjusted by a general forecast of wage and price trends or other factors.

4. The new and specific objectives usually have little past history. Cost estimates prepared by lower echelon organizational units must be carefully examined if reliable funding estimates are to be

obtained. The Budget Committee should utilize the planning unit to review and analyze funding estimates and, in turn, temper results with their own expertise in the many areas covered by the new and specific objectives.

5. Estimates will be summarized and totaled to determine the funding level for all objectives associated with the various functional units of the highway agency.

## Identifying Programs

When all objectives have been identified, analyzed, and their funding level estimated, they may be grouped into programs.

Objectives having common "products" or "services" are combined to form a particular program. In this sense, a program is defined as the combining of similar objectives for the purpose of dealing with a major problem or meeting a major need. For the most part this is already accomplished by the functional organization and continually ongoing agency programs such as the highway improvement and maintenance programs. Other objectives relate specifically to other programs. All that remains is to classify the remaining objectives into programs.

An example of this procedure is shown in Table 1.

## Documenting the Work Program Budget

The procedures to document the work program budget follow directly from the previous discussion.

1. Based on the objectives grouped into programs (as shown in Table 1), write a descriptive narrative of each program. State concisely what the program is about and what areas it covers.

TABLE 1

RELATING PROGRAMS TO OBJECTIVES

| Program | | Objective |
|---|---|---|
| Highway Improvement | + | Prepare design for 20 bridges |
| | + | Supervise construction of 10 bridges |
| | + | Prepare designs for 10 Betterment projects |
| | + | Prepare design for 20 km of arterial highways |
| | + | Supervise construction of 10 Betterment projects |
| | + | Supervise reconstruction of 40 km of secondary highays |
| Maintenance | + | Continue routine operations |
| | + | Conclude Bridge Inspection program |
| | + | Conduct Crew Foreman training |
| | + | Construct and equip sign shop |
| Equipment | + | Continue routine operations |
| | + | Implement new schedules for echelons of repair |
| | + | Conduct advance training for heavy equipment mechanics |
| Administration | + | Continue routine operations |
| | + | Initiate computer needs study |
| | + | Implement new Personnel Classification Plan |
| | + | Implement a new Cost Accounting system |
| | + | Add new Internal Audit section |
| Capital Assets | + | Purchase 10 new dump trucks |
| | + | Purchase 2 new loaders |
| | + | Purchase land for new District 2-office complex |
| Engineering | + | Continue routine operations |
| | + | Staff and equip 2 additional bridge design teams |
| | + | Conduct feasibility study on urban highway system |

2. Then, write in the major and supporting objectives identified with each program. The regular, routine objectives may be condensed into one statement: "continue routine operations." Specific and additional objectives should be emphasized.

3. Clearly indicate those objectives which are subsidiary to larger, higher level objectives.

4. Transcribe the estimated funding levels.

Examples of budgets for two different programs are given in Tables 2 and 3.

## WORK PROGRAM BUDGET APPROVAL

The Budget Committee has the responsibility to consider all programs and make the necessary changes to eliminate work items that are not essential to the overall objectives of the agency.

It may be necessary to reduce either the size or number of programs to keep the budget estimate within the total amount of money the top administrators decide should be established for the budget year. This will be a difficult decision to make unless priorities are assigned to each objective. Priorities will enable the Committee to determine which objective can be eliminated from the program if such action is required to reduce the total work program budget request.

After several consultations, the work program budget will be submitted to the Budget Committee for final review. If approved by this Committee, the draft is sent to the chief administrator for final approval. In some cases, approval by authority higher than the chief administrator is required. Any corrections, additions or deletions resulting from this action will be resolved in the final report.

Finally, the report will be distributed as directed and used as the basis for preparing the annual budget.

TABLE 2

WORK PROGRAM — DESCRIPTION

CAPITAL ASSETS ACQUISITION PROGRAM

Description:

This program covers the purchase of all capital assets. Purchase of capital assets are distinguished from other costs because capital asset costs are large and relatively infrequent, and they do not reflect the anticipated regular performance of any activity or organization.

| Objectives or Work Item | Remarks — Performance Specification | Proposed Funding (000,000's) |
|---|---|---|
| Buy New Equipment | Amount to be purchased will not exceed 10% of the present value of equipment. | 2,400 |
| Purchase of Land and Construction Facilities for Districts | For equipment and materials yard only. | 50 |
| Improve Facilities of District and Subdistrict Headquarters | Eliminate all obvious signs of disrepair. | 100 |
| | TOTAL | 2,550 |

Note: Routine or regular objectives/work items do not apply to this program

TABLE 3

WORK PROGRAM — DESCRIPTION

ADMINISTRATION PROGRAM

FOR THE ACCOUNTING & FINANCE DIV.

Description:

This program covers the costs of supportive services to field operations. All costs that cannot be directly associated to other specific programs are included in this program. Frequently, this is called the overhead program.

| Objectives or Work Items | Remarks — Performance Specifications | | Proposed Funding |
|---|---|---|---|
| 1. Generate Management Cost Information | Report costs by "activity" | | |
| • Design new Cost Accounting System | | | 190,000 |
| - Payroll Subsystem | Pay based on attendance | 100,000 | |
| - Materials Usage Subsystem | | 50,000 | |
| - Equipment Usage Subsystem | | 40,000 | |
| • Additional personnel will be hired next year | | | |
| 2. Administer New Salary Plan | | | |
| • Adjust budget for new salaries | | | 10,000 |
| • Operate Payroll Revolving Fund | | | 30,000 |
| 3. Establish External Audit Office | Office will be staffed with minimum personnel this year | | 300,000 |
| 4. Continue Routine Operations | | | 2,600,000 |
| | | TOTAL | 3,200,000 |

# CHAPTER VII

## SUPPORTING FUNCTIONS

There is need for accurate and up-to-date information about the highway system in order to effectively perform the various planning functions described in previous chapters.

Much of this data collection becomes a routine procedure performed on a continuing basis. Because of the nature and volume of the work, most highway agencies have established a separate unit within the planning organization solely for the purpose of data collection and processing. The unit serves as a supporting function for other planning units. By removing this burden from the units responsible for system and route planning, these units can concentrate their efforts on planning rather than on data collection activities.

The principal types of data needs are related to:

- road and bridge inventories,
- traffic data,
- traffic projections, and
- origin and destination studies.

In the following sections, each of these types of data will be discussed -- as well as procedures for data processing.

## INVENTORY PRACTICES

The purpose of road and bridge inventory data is to provide reliable information on the current characteristics and condition of the existing road system. Inventories will provide one of the tools for defining improvement needs and priorities of improvements.

The road and bridge inventory is not a one-time work effort. There is need to update the information annually to assure that planners have reliable current information.

Responsibilities

The head of the planning organization will be responsible for all aspects of the road and bridge inventory. This responsibility includes:

- organizing the units and individuals to conduct the inventory,
- development of procedures (e.g., manuals and forms),
- training of personnel to carry out the procedures,
- organizing the resources required to conduct the inventories (e.g., transportation, equipment),
- determining the priority and schedule for the routes to be inventoried,
- controlling the quality of data obtained from the inventory,
- assembling, storing, and analyzing the data, and
- ensuring that the data, once collected, is kept up-to-date.

The inventory crews may be organized in either of two ways. Crews may be established at the headquarters office to cover the entire country and operate under headquarters supervision, or they may be district-based crews and operate under district supervision.

There are advantages and disadvantages to each method. A small number of centrally trained and controlled crews may produce more accurate and

consistent results due to the fact that there will be fewer individuals making measurements and judgments of conditions observed in the field. However, the inventory will take longer than if a large number of crews are involved. District crews, on the other hand, may have a better knowledge of local conditions. Also, they are in a better position to be familiar with construction and maintenance activities and to observe the changing character of the roads due to traffic.

## Pre-inventory Activities

Prior to sending the inventory crews into the field, certain preparatory activities must be completed. Procedures and forms for collecting and recording the data must be developed. Vehicles and equipment for conducting the inventory must be obtained. The inventory crews need to be trained. Also, it is desirable to develop a schedule for the route inventory to ensure that the information is collected in the most efficient manner and in the desired order. Each of these activities will be discussed in more detail in the following sections.

### Developing Procedures and Forms

Inventory procedures and forms are presented later in this chapter. They will have general applicability for a wide range of inventory needs, but special requirements may dictate a change in some of the inventory items. However, such requirements can usually be accommodated with minor changes in the forms and procedures.

Copies of the instructions should be made available to each crew member. The instructions should be suitably bound or protected to withstand field use.

## Preparation of Vehicles and Equipment

The inventory vehicle should be a passenger car or light truck with sufficient space for the inventory crew, equipment and personal baggage. In areas where roads are unpaved, the vehicle should have 4-wheel drive capability.

Distances along the road are normally measured by an odometer installed in, or mounted on, the vehicle. Three types may be found. These are (1) factory-installed odometers located on the instrument panel, which measure to the nearest one-tenth kilometer; (2) special odometers which measure to the nearest one-hundredth kilometer and are driven by the same cable that drives the factory-installed unit; and (3) special odometers which measure to the nearest one-hundredth kilometer and is driven by a wheel attached to the rear bumper and towed by the vehicle.

For most applications, the factory-installed odometer is not accurate enough for road inventory work. The second type should be used, if available, in preference to the third type which may be damaged if it is not raised while backing the vehicle.

Regardless of the type of odometer used, it must be calibrated before the inventory begins. Otherwise, the distance measurements may contain substantial errors. The odometer can be calibrated by driving the vehicle over a measured course of at least one kilometer in length. By comparing the difference in odometer readings between the end and starting points with the measured distance, a correction factor can be calculated which should be applied to all odometer-measured distances obtained during the inventory.

Accuracy of all odometers is affected by the amount of wheel slippage and bounce and by tire pressure. The non-towed types (see types (1) and (2) described previously) are also sensitive to substantial changes in the vehicle's total weight. On unpaved roads, the amount of wheel slippage can be significant depending on soil and weather conditions.

A separate calibration should be made for paved and unpaved roads if both types are to be included in the inventory. Also, the tires should be properly inflated during the calibration and during the inventory. (See vehicle manufacturer's tire pressure specifications.)

Inventory equipment for each crew should include:

- vehicle with odometer,
- odometer calibration chart,
- inventory instructions,
- inventory forms (road and bridge),
- clipboard,
- pencils and erasers or ballpoint pen refills,
- 15-25 meter tape measure,
- map showing route locations and designations, and
- tire pressure gauge.

## Training

Training the inventory crews is a very important step prior to the field inventory. The inventory crews must be completely familiar with each inventory item and how it is to be measured or determined. Otherwise, the inventory records will contain omissions, inaccuracies, and inconsistencies to the extent that the data will be useless or at least highly unreliable.

The training should consist of both office and field instruction. Office instruction should cover all procedures and forms to be used, map reading, route identification, vehicle odometer calibration, measurement and rating techniques, how to handle special cases or exceptions, and the importance of accuracy and neatness.

Field instruction should consist of an actual inventory of one or more short sections of roads that represent a wide range of conditions likely to be encountered on the job. The trainees should be divided into crew-sized groups (usually two people per crew) and should conduct the example inventory using the same types of vehicles and equipment that would be used on a regular inventory.

After the first sample section is completed, the results should be compared with the instructor's results. After a critical evaluation of each crew's performance, another sample section of road should be inventoried. The process should be repeated until the results exhibit an acceptable level of accuracy and reasonable consistency between crews. Usually, two or three repetitions are sufficient.

Inventory Scheduling

Initially, the routes to be inventoried should be listed in the order which will provide data on the most important routes first. Then, the routing of the inventory crews should be planned to provide for maximum productivity, i.e. with the least amount of unproductive travel such as returning on routes already inventoried.

Existing maps, even if not completely up-to-date, which show the route locations and designations will be very helpful in planning the route inventory. Where maps are non-existent, aerial photographs may be used as an alternative.

The routing for each inventory crew for each day should be laid out in advance. For planning purposes, a well-trained and experienced crew, consisting of one driver and one technician, should be able to cover 100 to 150 kilometers per day, depending on local conditions such as travel time to the area, complexity of road features, the road network configuration and the number of bridges. Usually, the inventory routes are laid out around or between bases of operations such as district offices or hotels. By planning the inventory route in advance, the crew can cover more distance with fewer repetitive trips and conclude the day's work near their desired destination.

In order to make the best use of the inventory crews, it may be desirable to cover some routes of lesser importance during the inventory of higher priority routes. Rather than return over a route that has just been inventoried, it may be possible to travel on a lower priority route and continue the inventory until the next desired route is reached. Also, if considerable travel would be required to return to an area to collect data on one or two low priority routes, it would be better to collect the data while the crew is in the area.

## Conducting the Inventory

A crew leader will be designated for each inventory crew. The crew leader will be responsible for performing the inventory in accordance with instructions and procedures established by the planning organization. Problems of a local nature regarding measurements or rating of specific features and crew management should be handled by the crew leader. However, problems which would affect the interpretation of results on substantial lengths of roads in the area should be coordinated with the head of the unit in the headquarters office with overall responsibility for the inventory.

There should be consistency in the direction of inventory. The beginning points should be the westerly end of routes that are generally east-west -- and the southerly end of routes that are generally of a north-south direction.

There will be at least one road inventory form completed for each inventoried route. In some cases, the route may be divided into sections, with one road inventory form for each section.

Routes should be divided into sections at points where any of the following conditions occur:

1. A provincial or highway district boundary, even if the route carries the same route number across the boundary.

2. A change in route number, even if road is continuous, e.g., a change in route number at a major route intersection.

3. A route intersects another route of the same route type.

4. A change in any of the following for a distance of more than one kilometer:

   - terrain type,
   - land use,
   - surface type,
   - surface width change of 30 cm or more,
   - shoulder type,
   - shoulder width change of 30 cm or more, or
   - number of lanes

5. A major change (20 percent or more) in annual average daily traffic.

Most route sections will probably be at least five kilometers in length. Where conditions are variable, i.e., numerous changes of less than one kilometer occur, an average condition may be assigned for each inventory item. As a general rule, the number of sections should be kept to a minimum. However, the inventory crews should not be discouraged from identifying new sections where conditions warrant a section break.

## ROAD INVENTORY FORMS AND INSTRUCTIONS

The inventory procedures have been developed to minimize the need for application of judgment by field survey crews. Field work will be limited to the collection of measurable data, except for a few condition ratings. All analyses will be conducted in the office where more experienced personnel are available and where a system-wide approach can be applied to the entire highway network.

## Road Inventory Forms

Field measurements and ratings will be recorded on Road Inventory Forms (Figure 20). The forms are designed to permit either manual or computer processing of recorded data. Items 1 through 19 on the form are basic inventory information -- items 20 through 30 are adequacy ratings.

The inventory and adequacy information will be recorded in the space provided on the right side of the forms. If the measured or observed value is not large enough to fill all the spaces provided, the numbers must be moved as far to the right as possible. For example, if the beginning log kilometer reading (Item 8) for a route section is 27.91 kilometers, the entry on the form must be _ 2 7. 9 1. For those items which involve decimal values, i.e., items 8, 9, 10, 15 and 17, the tenths or hundredths must always be recorded, even if zero. For example, a surface width (Item 15) of exactly 7 meters must be recorded as 7. 0.

## Road Inventory Instructions

### Identification

1. Card Control: Use the number "1" for road inventory records. (This number may be pre-printed on the inventory form.)

2. Highway District: Record the Highway District number as designated by the national highway agency.

3. Province: Record the code number for the province in which the inventory section is located. If no nationally recognized province numbers are in use, arrange the province names alphabetically and assign consecutive numbers.

**Figure 20**

**ROAD INVENTORY FORM**

Date _____

Crew Chief _____

ROAD INVENTORY

| Purpose | Item No. | Item Description | Card Columns | Record |
|---|---|---|---|---|
| Identification | 1 | Card Control | 1 | 1 |
| " | 2 | Highway District | 2-3 | __ |
| " | 3 | Province | 4-5 | __ |
| " | 4 | Route System | 6 | _ |
| " | 5 | Connecting Province | 7-8 | __ |
| " | 6 | Route Number | 9-11 | ___ |
| " | 7 | Connecting Route No. | 12-14 | ___ |
| " | 8 | Beginning Log Km. of Section (nearest hundredth Km.) | 15-19 | ___.__ |
| " | 9 | Ending Log Km. of Section (nearest hundredth Km.) | 20-24 | ___.__ |
| " | 10 | End of Route Indicator | 25-29 | ___.__ |
| Physical Features | 11 | Terrain -- (1) Flat (2) Rolling (3) Mountainous | 30 | _ |
| " | 12 | Land Use -- (1) Rural (2) Urban | 31 | _ |
| " | 13 | Traffic Volume -- latest ADT | 32-36 | _____ |
| " | 14 | Surface Type: (1) High (2) Intermediate (3) Low (4) Gravel (5) Unimproved | 37 | _ |
| " | 15 | Surface Width (meters & tenths) | 38-39 | _._ |
| " | 16 | Shoulder Type: (0) None (1) Paved (2) Stabilized (3) Earth | 40 | _ |
| " | 17 | Shoulder Width (meters & tenths) | 41-42 | _._ |
| " | 18 | Number of Lanes | 43 | _ |
| " | 19 | Average Running Speed | 44-45 | __ |
| Adequacy | 20 | Surface Type (20 pts.) | 46-47 | __* |
| " | 21 | Surface Width (18 pts.) | 48-49 | __* |
| " | 22 | Shoulder Type and Width (6 pts.) | 50 | _* |
| " | 23 | Gradients (6 pts.) | 51 | _ |
| " | 24 | Alignment (10 pts.) | 52-53 | __ |
| " | 25 | Sight Distance (6 pts.) | 54 | _ |
| " | 26 | Foundation (14 pts.) | 55-56 | __ |
| " | 27 | Wearing Surface (10 pts.) | 57-58 | __ |
| " | 28 | Drainage (6 pts.) | 59 | _ |
| " | 29 | Shoulders (4 pts.) | 60 | _ |
| " | 30 | Total Adequacy | 61-62 | __* |
| Structures | 31 | No. of Structures in Section | 63-64 | __ |
| " | 32 | No. of Deficient Structures | 65-66 | __* |

* to be recorded by office personnel only

4. Route System: Record the appropriate code for route system:

   1 = national route
   2 = provincial route
   3 = any other route

5. Connecting Province: If the route is a provincial route which is continuous from an adjacent province, record the code number of the province adjacent to the province boundary where the beginning log kilometer reading is recorded. (See earlier discussions of starting points rules.) If the route begins in the province where the inventory is being conducted, or if the route is a national route, record 99.

6. Route Number: Record the designated route number for the route being inventoried.

7. Connecting Route Number: If the origin of the inventory route is located within the province in which the inventory is being conducted, record the connecting route number at the origin of the inventory route. For routes which originate at the province boundary, record the route number of the connecting route in the adjacent province. If there is no connecting route at the origin, or if the inventory route is a national route which does not originate in the province in which the inventory is being conducted, record 999.

8. Beginning Log Kilometer: Record the odometer reading to the nearest hundredth kilometer at the beginning of the inventory section. If this is the origin of the route, the reading should be 00.00. If there is more than one section for the route, the beginning log kilometer of a subsequent section should be the same as the ending log kilometer of the previous section.

9. Ending Log Kilometer: Record the odometer reading to the nearest hundredth kilometer at the end of the inventory section.

10. End of Route Indicator: If the ending log kilometer reading in Item 9, above, for the inventory section represents the end of the route identified in Item 6 above, record 999.99. If not, record the odometer reading for the end of the route (note that this cannot be done until the last section of the route is inventoried.)

Physical Features

11. Terrain: Record code for appropriate terrain class:

1 = flat (local relief of less than 15 m)
2 = rolling (local relief of 15 to 150 m)
3 = mountainous (local relief of 150 m or more)

12. Land Use: Record code for appropriate land use class:

1 = rural (agricultural, forested, and other areas of low population density)
2 = urban (within city limits or residential and other areas of high population density)

13. Traffic Volume: Record the latest annual average daily traffic (AADT) based on actual counts (see Traffic Counting Procedures) or best available estimate of vehicles per day. This figure should be determined in the office and pre-recorded prior to conducting the field inventory. If recent counts are not available and field crews have reason to question the pre-recorded value, they should lightly draw a line through the estimated value and write in a new estimate above the old figure. Volumes may be estimated approximately as follows:

a. Over 4,500 vehicles per day on two-lane paved highway -- highway will appear crowded during all daylight hours, speeds over 60 kilometers per hour cannot be maintained for more than a short distance, and passing opportunities will be limited.

b, About 2,000 vehicles per day on two-lane paved highway -- highway will appear busy but there will be ample opportunity to pass and desired speed can usually be maintained.

c. About 600 vehicles per day -- during off-peak hours, intervals between vehicles will vary from 1/2 to 3 minutes.

14. Surface Type: Record appropriate code for existing surface type:

1 = High Type -- Portland cement concrete or asphalt pavements on a solid base suitable for frequent heavy axle loads.

2 = Intermediate Type -- Bituminuous surface at least 2.5 cm but less than 10.0 cm in thickness on a base suitable for moderately frequent heavy axle loads (a double bituminous surface treatment or better will qualify as intermediate).

3 = Low Type -- Bituminous surface of less than 25 cm in thickness.

4 = Gravel -- Surface of hard, durable particles of coarse sand, gravel, crushed stone, or a mixture of these particles and fine materials that provide a stable surface during rain.

5 = Unimproved -- Surface of native earth material unimproved except for removal of woody vegetation and, perhaps, shaping to improve drainage, usually passable during dry weather by moderately heavy loads but may be impassable by all except special purpose vehicles during wet weather.

15. Surface Width: Measure and record the width of paved or gravel surface, in meters and tenths, from inside edge of shoulder to inside edge of shoulder. If surface materials are not distinct from roadbed materials, record total roadway width as surface width and record "0" for Items 16 and 17.

For variations in width of less than 30 cm, record the average width. However, if the change in width is 30 cm or more, or if there is any change in surface type, for a distance of more than 1 km, a new section should be identified. For urban sections with curb and gutter, record surface width from curb to curb, and record shoulder width as "0".

16. Shoulder Type: Record appropriate code for shoulder type:

0 = none

1 = paved -- Portland cement concrete, asphalt, or bituminous surface treatment.

2 = stabilized -- gravel or sod which will support moderately heavy loads during most weather conditions.

3 = earth -- native soil with or without vegetative cover and and little or no stability when wet.

4 = curb and gutter

17. Shoulder Width: Measure and record shoulder width in meters and tenths. If the shoulder width varies along the route, an average value may be recorded. However, if the change in width is 30 cm or more, or if there is any change in width accompanied by a change in shoulder type, for a distance of more than 1 km, a new section should be identified. If Item 16 is "0" or "4", shoulder width must be recorded as "0".

18. Number of Lanes: Record the number of through-traffic lanes in both directions. Do not include turning lanes or parking lanes. If the number of lanes is not obvious from centerline stripes, lane markings, or traffic usage, the number of lanes can be determined by dividing surface width by 3.66 and rounding the answer to the nearest whole number. For curbed sections, deduct 2 m from surface width before dividing.

19. Average Running Speed: Measure and record average running speed in kilometers per hour. This item is determined by driving along a representative portion of the section being inventoried (between normal stops) at speeds which match the flow of traffic, i.e., passing or being passed only by cars which are moving slower or faster than the average. Note the distance traveled (from odometer readings) and the time required and calculate average running speed. The distance traveled should be at least 1 km and should include curves and grades that are typical of the section.

Adequacy

20. Surface Type (20 points): The adequacy of surface type will be determined in the office by a comparison of the existing

type with the type required for the present average daily traffic, using Table 4 as a guide.

21. Surface Width (18 points): The adequacy of surface width will be determined in the office, using Table 5 as a guide.

22. Shoulder Type and Width (6 points): The adequacy of shoulder type and width will be determined in the office, using Table 6 as a guide.

23. Gradients (6 points): Field crews will rate this item on a scale of 0 to 6, based on a judgment of the extent to which gradients cause traffic to be slowed down on the section being inventoried. Record 6 points for no gradient problem. Record 0 points where there are many bad grades. A bad grade is reflected in a line of passenger cars traveling at very slow speeds behind trucks, although this can be tolerated for short distances. Problems should be considered relative to traffic. On lightly traveled highways, gradient problems should be considered as less severe.

24. Alignment (10 points): Field crews will rate this item on a scale of 0 to 10, based on a judgment of the extent to which the curves cause traffic to be slowed down on the section being inventoried. Record 10 points for no alignment problems. Record 0 points where there are many bad curves. A bad curve is one that is sharp enough to cause a vehicle to substantially reduce speed. Problems should be considered relative to traffic. On lightly traveled highways, alignment problems should be considered less severe.

25. Sight Distance (6 points): Field crews will rate this item on a scale of 0 to 6. The evaluation is a measure of the availability of safe passing opportunities in relation to traffic volumes. A restriction may be caused either by vertical

## TABLE 4

### SURFACE TYPE RATING

| Design Type | Existing Type: High | Intermediate | Low or Gravel | Unimproved |
|---|---|---|---|---|
| High | 20 | 10 | 0 | 0 |
| Intermediate | 20 | 20 | 10 | 0 |
| Gravel | 20 | 20 | 20 | 10 |

## TABLE 5

### SURFACE WIDTH RATING

| TWO LANE RATING | | | | MULTILANE RATING* | |
|---|---|---|---|---|---|
| Existing Width | Standard Width 7.3 m | 6.7 m | 6.1 m | Existing Width | Standard Width (14.6 m) |
| 7.3 m | 18 | 18 | 18 | 14.6 m | 18 |
| 6.7 m | 14 | 18 | 18 | 14.0 m | 16 |
| 6.1 m | 6 | 14 | 18 | 13.4 m | 14 |
| 5.5 m | 0 | 6 | 14 | 12.8 m | 12 |
| 4.9 m | 0 | 0 | 6 | 12.2 m | 10 |
| 4.3 m | 0 | 0 | 0 | 11.6 m | 5 |
| | | | | 11.0 m | 0 |

* On divided highways where each side is rated separately, multiply the width on each side by 2 and apply the multilane table.

## TABLE 6

### SHOULDER WIDTH AND TYPE RATING

| Standard Shoulder | Existing Shoulder Type | Rating for Existing Shoulder Width (in meters) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3.0 | 2.7 | 2.4 | 2.1 | 1.8 | 1.5 | 1.2 | .9 | .6 | .3 | 0 |
| 3.0 m Paved | Paved | 5 | 5 | 4 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| | Gravel | 4 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Earth or Sod | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2.4 m Paved | Paved | 6 | 6 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 0 | 0 |
| | Gravel | 4 | 4 | 4 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| | Earth or Sod | 3 | 3 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1.8 m Paved | Paved | 6 | 6 | 6 | 6 | 6 | 5 | 4 | 2 | 1 | 0 | 0 |
| | Gravel | 6 | 6 | 5 | 5 | 4 | 3 | 2 | 0 | 0 | 0 | 0 |
| | Earth or Sod | 5 | 5 | 5 | 4 | 3 | 2 | 0 | 0 | 0 | 0 | 0 |
| 1.8 m Gravel | Paved | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 4 | 3 | 0 | 0 |
| | Gravel | 6 | 6 | 6 | 6 | 6 | 5 | 4 | 3 | 2 | 0 | 0 |
| | Earth or Sod | 5 | 5 | 5 | 5 | 5 | 4 | 3 | 2 | 0 | 0 | 0 |
| 2.4 m Earth | Paved | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 4 | 2 | 0 | 0 |
| | Gravel | 6 | 6 | 6 | 6 | 6 | 5 | 4 | 2 | 0 | 0 | 0 |
| | Earth or Sod | 5 | 5 | 6 | 5 | 4 | 3 | 2 | 0 | 0 | 0 | 0 |
| 1.5 m Earth | Paved | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 4 | 2 | 1 |
| | Gravel | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 4 | 2 | 1 | 0 |
| | Earth or Sod | 6 | 6 | 6 | 6 | 6 | 6 | 5 | 3 | 1 | 0 | 0 |
| 1.2 m Earth | Paved | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 3 | 0 | 0 |
| | Gravel | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 3 | 0 | 0 | 0 |
| | Earth | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 3 | 1 | 0 | 0 |

or horizontal sight distance limitations. However, when the cutting of weeds or brush within the right-of-way (maintenance) would correct the problem, the passing opportunity should not be considered to be restricted. Select points from Table 7 below for the average condition encountered on the section.

TABLE 7

SIGHT DISTANCE RATING

| Maximum Distance Without Passing Opportunities for every 10 Km Traveled | Traffic Volumes | | |
|---|---|---|---|
| | Over 600 AADT | 100-600 AADT | Under 100 AADT |
| 1 km or less | 6 | 6 | 6 |
| 1 - 3 kms | 3 | 4 | 6 |
| 3 - 5 kms | 0 | 0 | 3 |
| Over 5 kms | 0 | 0 | 0 |

26. Foundation (14 points): Field crews will rate the foundation condition on a scale of 0 to 14. Consider whether evidence of failure such as pavement breakup, dips and ruts result from underlying road materials and drainage conditions as distinct from surfacing materials. For no evidence of underlying failure, record 14. For a few failures limited to short lengths, use a lower rating. For extensive failures record 0. For earth roads of soils which will not support trucks during rain (plastic soils) record 0 points if there are over 25 vehicles per day or 7 points if under 25 vehicles per day.

27. Wearing Surface (10 points): Field crews will note the condition of the wearing surface on a scale of 0 to 10. Consider whether the wearing surface shows signs of distress such as pavement breaking up or insufficient gravel on gravel road. Do not rate down if surface condition can be corrected by maintenance, such as a few places which need patching on pavements or a rough gravel road where there is plenty of gravel. All earth roads where soils are plastic will be rated 0 under this heading.

28. Drainage (6 points): Field crews will rate the drainage condition on a scale of 0 to 6. Drainage condition is evaluated on the factors which influence the disposal of water, such as side ditches, culverts, or natural drainage away from road. If water can stand close in elevation to the road surface, even the best surfaces will break down. Rate the generality of the condition -- a few bad places would only lose a few points.

29. Shoulders (4 points): Field crews will rate the shoulder condition on a scale of 0 to 4. Shoulder condition is measured in terms of stability and regularity. Shoulders that appear soft, rutted, and irregular in width due to erosion and lack of grading should be rated down. For gravel and earth roads, apply this principle to edge of roadway to obtain rating.

30. Total Adequacy (up to 100 points): The total adequacy will be determined in the office by summing up all the ratings for Items 20 through 29.

## Structures

31. Number of Structures in Section: Record total number of structures on the section. Structures are defined as the following: (1) overpasses of railways or other highways; (2) bridges 6 meters or more in length; (3) all multiple culverts 10 meters or more; and (4) underpasses of railways and other highways.

32. Number of Deficient Structures: This item is to be left blank by field crews. The number of deficient structures will be recorded in the office.

## BRIDGE INVENTORY FORMS AND INSTRUCTIONS

The inventory crew is to stop and briefly inspect each structure on the section being inventoried. Structures are defined as any of the following: (1) overpasses of railways or other highways, (2) bridges 6 meters or more in length, (3) all multiple culverts 10 meters or more in length (along highway centerline), and (4) underpasses of railways and other highways.

For grade-separation structures which carry a road over another road, the structure should be inventoried during inventory of the route which passes overhead unless the overhead route is on a system which will not be inventoried. Otherwise, the structure would be inventoried twice, once while on the route which passes overhead and once while on the route which passes underneath.

### Bridge Inventory Forms

Field measurements and ratings for bridges will be recorded on a Bridge Inventory Form (Figure 21). Items 1 through 18 are basic inventory information. Items 19 through 24 are adequacy ratings.

**Figure 21**

**BRIDGE INVENTORY FORM**

**Date** _____

**Crew Chief** _____

BRIDGE INVENTORY

| Purpose | Item No. | Item Description | Card Columns | Record |
|---|---|---|---|---|
| Identification | 1 | Card Control | 1 | 2 |
| " | 2 | Highway District | 2-3 | __ |
| " | 3 | Province | 4-5 | __ |
| " | 4 | Route System - (1) National (2) Provincial (3) Other | 6 | _ |
| " | 5 | Route Number | 7-9 | ___ |
| " | 6 | Kind of Structure - (1) Bridge 26m. (2) multiple culvert 10m. (3) overpass over road (4) overpass over railroad (5) underpass under road (6) underpass under railroad | 10 | _ |
| " | 7 | Log Kilometer (nearest hundredth) | 11-15 | ___._ |
| Physical Features | 8 | Structure Length (meters & tenths) | 16-20 | ___._ |
| " | 9 | Surface Width (meters & tenths) | 21-23 | __._ |
| " | 10 | Number of Lanes | 24 | _ |
| " | 11 | Superstructure Material (1) Steel (2) Concrete (3) Timber | 25 | _ |
| " | 12 | Deck Material (1) Steel (2) Concrete (3) Timber | 26 | _ |
| " | 13 | Substructure Material (1) Steel (2) Concrete (3) Timber | 27 | _ |
| " | 14 | Vertical Clearance (meters to nearest two hundredths) | 28-30 | _._ |
| " | 15 | Horizontal Clearance (meters & tenths) | 31-33 | __._ |
| " | 16 | Vertical Underclearance (meters to nearest two hundredths) | 34-36 | _._ |
| " | 17 | Horizontal Underclearance (meters & tenths) | 37-39 | __._ |
| " | 18 | Load Capacity (metric tons) | 40-41 | __* |
| Adequacy | 19 | Width | 42 | _* |
| " | 20 | Clearance | 43 | _* |
| " | 21 | Structural Conditions (0 = inadequate, 1 = adequate) | 44 | _ |
| " | 22 | Deck Conditions (0 = inadequate, 1 = adequate) | 45 | _ |
| " | 23 | Safe Load Adequacy | 46 | _* |
| " | 24 | Overall Adequacy | 47 | _* |

*** to be recorded by office personnel only**

A separate Bridge Inventory Form is to be filled out for each structure. Bridges less than 6 meters in length or multiple culverts less than 10 meters in length (along centerline of roadway) are to be considered in determining the roadway drainage rating, but are not to be evaluated separately.

## Bridge Inventory Instructions

### Identification

1. Card Control: Use the number "2" for bridge inventory records. (This number may be pre-printed on the inventory form.)

2. Highway District: Same as Item 2 on Road Inventory Form.

3. Province: Same as Item 3 on Road Inventory Form.

4. Route System: Same as Item 4 on Road Inventory Form.

5. Route Number: Same as Item 6 on Road Inventory Form.

6. Kind of Structure: Record the kind of structure according to the following code:

   1 = Bridge 6 m or more in length.

   2 = Multiple culverts 10 m or more in length, measured along highway centerline.

   3 = Overpass over road (Inventory section passes over another road).

   4 = Overpass over railway.

5 = Underpass under road (Inventory section passes under another road) -- note that this type of structure should not be inventoried during inventory of the underpass route unless the route passing overhead is on a route system which will not be inventoried.

6 = Underpass under railway.

7. Log Kilometer: Record the odometer reading as the inventory vehicle crosses over the low kilometer end of the bridge or overpass when traversing the route in the standard inventory direction. For underpasses, record the odometer reading when the inventory vehicle passes under the approximate center of the structure.

Physical Features

8. Structure Length: Measure and record the overall length of the structure in meters and tenths. The length is measured from the outside edge of one abutment to the outside of the other abutment, i.e., the points where the roadway and structure meet.

9. Surface Width: Measure and record the surface width in meters and tenths. For structures which carry highway traffic (Item 6 = 6), measure from curb to curb (or from edge to edge of roadway surface if no curb). For structures which carry rail traffic (Item 6 = 6), record the overall width.

10. Number of Lanes: Record the number of traffic lanes carried by the structure. If the number of lanes is not obvious, deduct 2 m from structure width (Item 9), divide by 3.66 and round to the nearest whole number. If the structure carries rail traffic (Item 6 = 6), record "9."

11. Superstructure: Record the predominant type of material for the superstructure using one of the following codes:

1 = Steel
2 = Concrete
3 = Timber

12. Deck Material: Record the predominant type of material for the deck using one of the following codes:

1 = Steel
2 = Concrete
3 = Timber

13. Substructure Material: Record the predominant type of material for the abutments, piers, or piles using one of the following codes:

1 = Steel
2 = Concrete
3 = Timber

14. Vertical Clearance: For structures with a through-truss, measure the minimum vertical clearance between the roadway surface and the lowest overhead structural member. Record the clearance to the nearest two hundredths of a meter. For structures with unlimited overhead clearance or for railroad structures (Item 6 = 6), record "999."

15. Horizontal Clearance: Measure the minimum horizontal clearance width, i.e., the width that determines the maximum width of an object that can cross the bridge. This will normally be the distance between side rails or structural members. Record the clearance in meters and tenths. For railroad structures (Item 6 = 6), record "999."

16. Vertical Underclearance: For underpasses (Item 6 = 5 or 6), measure the minimum vertical clearance between the roadway surface and the lowest overhead structural member. Record the clearance to the nearest two hundredths of a meter. For other types of structures, record "999."

17. Horizontal Underclearance: For underpasses (Item 6 = 5 or 6), measure the minimum width of the opening which would restrict vehicular movements and record the clearance in meters and tenths. Normally the clearance width is determined by width between walls, columns or revetments. For other types of structures, record "999."

18. Load Capacity: This item is to be determined in the office by a qualified bridge engineer prior to the field inventory. The load capacity should be based on design load, with an allowance for age and condition, and recorded in metric tons. If field crews have reason to question the pre-recorded load capacity, e.g., posted load does not agree with the recorded load capacity, or there is obvious structural damage such as broken or badly deflected structural elements, or scouring of footings by water, etc., they should lightly circle the recorded value and make an appropriate notation on the inventory form to indicate that load capacity of the structure should be re-examined.

Adequacy

19. Width: The existing surface width is to be rated in the office as adequate or inadequate. To be adequate, the actual roadway width on a bridge or overpass less than 10 meters in length should equal the width of the normal traveled surface of the roadway (not exceeding 7.3 meters) plus one additional meter. For bridges or overpasses 10 or more meters in length, the roadway width on the

structure should at least equal the traveled surface of the approaching roadway. The rating should be recorded using the following code:

0 = inadequate
1 = adequate

20. Clearances: This item will be rated in the office as either adequate or inadequate. To be adequate, horizontal clearance (Item 15) and underclearance (Item 17) should be at least equal to the approaching traveled surface width plus two meters. For vertical clearance (Item 14) and underclearance (Item 16) to be adequate, each should be at least equal to the maximum allowable vehicle height plus 15 cm (In general, vertical clearances for structures on national routes should be at least 4.9 m). Record adequacy using the appropriate code listed below:

0 = inadequate
1 = adequate

21. Structural Condition: Field crews will rate this item. Observe the condition of superstructure and substructure elements, such as beams, columns, joints, bolts and welds. Look for cracking, rusting, looseness of parts, and foundation damage due to erosion by surface runoff or scouring by stream flow. If the structural members appear basically sound - - damage to minor members which can easily be replaced should not be considered -- rate the structure as adequate. If there is evidence of basic structural damage which affects the load-carrying capacity, rate as inadequate. Record adequacy using the appropriate code listed below:

0 = inadequate
1 = adequate

22. Deck Condition: Field crews will rate this item. Observe the general condition of the deck. If the deck appears to be sound, rate as adequate. If there is evidence of deterioration, such as holes, cracks, depressions, looseness or excessive deflections under traffic, rate as inadequate. Problems which can be corrected with routine maintenance should not be considered. However, if replacement or extensive repairs are needed, the deck should be rated as inadequate. Record adequacy using the appropriate code listed below:

0 = inadequate
1 = adequate

23. Safe Load Adequacy: This item will be rated in the office as either adequate or inadequate. The safe load recorded for Item 18 should be at least equal to the maximum allowable gross vehicle weight established by the highway agency for that type of road. If not, and if there is no suitable detour route within a reasonable distance, the structure should be rated inadequate. Record as follows:

0 = inadequate
1 = adequate

24. Overall Adequacy (up to 5 points): This item will be determined in the office by adding up the ratings for Items 19 to 23 and recording the total.

If the overall adequacy rating is less than 5, i.e., if any item is inadequate, then the structure should be considered inadequate. The rating will provide an indication of the relative inadequacy of the various structures in the country and will be useful in determining priorities for improvement.

## TRAFFIC DATA

Throughout the processes of highway planning and development, factual information is needed on traffic and traffic flow characteristics. Traffic studies include traffic counts, classification studies, traffic forecasts, origin and destination surveys and truck weight surveys.

The primary purpose of a traffic counting program is to obtain factual data concerning the movement of vehicles at selected locations (counting stations). Traffic volume data are expressed in relation to time. The base year is determined by the type of information desired and the use to which it will be applied.

### Types of Data

1. Annual Traffic (Vehicles per year):

   Used for:
   a. determining annual travel in a particular area, and
   b. indicating trends in traffic volume changes.

2. Average Annual Daily Traffic (AADT, Average Annual Vehicles per day):

   Used for:
   a. measuring the present demand for service,
   b. evaluating present traffic flow,
   c. developing classification of highway system,
   d. determining need for improvements, and
   e. developing improvement program.

3. Average Daily Traffic (ADT): Same as for AADT, except expressed as an average value for a period of less than one year. ADT may be adjusted for weekly and seasonal variations to obtain AADT.

4. Vehicle Unit Average Daily Traffic (VUADT): Same as ADT, except converted to vehicle units equivalent to a passenger car, jeep, pick-up or small bus, used to express the capacity of a highway in terms of a standard-sized vehicle.

5. Hourly Traffic (Vehicles per hour):

   Used for:
   a. determining length and magnitude of peak traffic periods,
   b. evaluating capacity deficiencies,
   c. establishing traffic controls, and
   d. geometric design and re-design of intersections.

## Types of Traffic Counts

The type of data collected from traffic counts depends upon the application for which the information will be used. Several different kinds of traffic counts are made, as outlined below.

1. Road Counts (total volume without regard to direction):

   Used for:
   a. developing daily volumes,
   b. preparing traffic flow maps,
   c. determining trends, and
   d. programming highway improvements.

2. Directional Counts:

   Used for:
   a. capacity analysis,
   b. planning improvements, and
   c. determining signal timing.

3. Turning Movement Counts:

Used for:

a. determining movements at intersections to compute capacity,
b. evaluating congestion,
c. determining traffic desire,
d. design of intersection channelization, and
e. design of signalization.

4. Classification Counts:

Used for:

a. determining types of vehicles and percentage of total for each type,
b. determining correction factors for machine counts,
c. computing capacity (percentage of commercial vehicles), and
d. establishing structural and geometric design criteria.

5. Occupancy Counts:

Used for:

a. determining distribution of passengers per vehicle, and
b. determining usage of transit facilities, e.g. buses.

6. Control Counts: Taken at selected locations throughout the highway system and used as the basis for developing factors to adjust "coverage counts" taken at satellite stations.

7. Coverage Counts: Short term counts taken at secondary or satellite stations and adjusted in relation to the counts taken at "control count" stations to reflect an accurate and factual ADT at the satellite station.

## Counting Techniques

There are two basic methods of determining traffic volumes. The type of data required usually determines the method of counting to be used.

1. Machine Counts: This is the most common method for obtaining traffic volume data. Total volumes, directional volumes, or lane volumes can be obtained depending on the type of equipment available.

   a. Permanent Counters: These are installed at limited and selected locations to obtain "control counts" on a permanent basis. Permanent counters operate 24 hours a day and 7 days a week for as long as they are in operating condition.

   b. Portable Counters: This type of counter, because of its versatility, is recommended for general use in collecting data for both "control counts" and "coverage counts." Portable counters can also be used to record traffic counts 24 hours per day for extended periods of time. This type of counter has an advantage over permanent counters because they can be easily moved from one counting station to another.

   Portable counters consist of an electrically operated counter that is usually actuated by air impulses from a pneumatic hose (road tube) stretched across the highway. Since each axle crossing the road tube gives a pulse, the counters are designed to give one count for each two pulses. If a significant number of multi-axle trucks are present an error is introduced. A correction factor to reduce the error may be obtained by a simple classification count made manually and applied to the machine total, as illustrated below:

| | 2-axles | 3-axles | 4-axles | Total |
|---|---|---|---|---|
| Vehicles by Manual Count | 33 | 27 | 4 | 64 |
| | x 2 | x 3 | x 4 | |
| Number of axles | 66 | 81 | 16 | 163 |

Count from portable counter = 330 vehicles/day

$$\text{Corrected vehicles/day (ADT)} = \frac{2 \times 64}{163} \times 330 = 259$$

There are two types of portable counters. The recording type that provides a permanent record of volumes on a paper tape. The other is a non-recording type which has a visible counter that must be read by an observer at regular intervals. Regardless of the type used, readings must be recorded at the counting station, on forms prepared for this purpose, by the recorder at regularly prescribed periods of time. The forms will be reviewed by the traffic counting supervisor to detect any apparent errors. If errors of serious consequence are found, and the reason for the error cannot be determined and the correction made, the count must be disregarded.

2. Manual Counts: Manual counts are made by an observer with a tally sheet or manually operated counter. These counts are necessary for certain studies when data cannot be obtained by using portable counters. They are also used to determine the correction factor for portable counts as described above.

Other uses for manual counts are:

a. counting turning movements,
b. counting pedestrians,
c. classifying vehicles by type,
d. occupancy studies, and
e. counting in multiple lanes which are difficult to count with machines.

## Selecting the Counting Stations

This is an important aspect of the traffic counting program. The collection of accurate and factual data is dependent upon the location of counting stations. Before choosing the location of counting stations, a study of the highway system should be made. This study should include but not be limited to the following items:

1. Preparation of maps: The following information will be indicated on maps prepared for the purposes of aiding in the selection of counting stations:

   a. Highway District and other boundaries.

   b. The highway system, including all roads regardless of administrative responsibility.

   c. The location of all projects that are listed in the Priority Plan.

   d. An indication of the comparison in traffic volumes by varying the thickness of lines representing the highways. This must be based upon the best available information until an ongoing counting program can provide more factual data. Adapt a scale that will differentiate between highways having volumes of, say, less than 500, 500-2000, 2000-5000 and over 5000 ADT.

   e. Finally, when the location of a station has been determined it will be shown on the map.

2. Station Selection: After preparing the maps as described above and an analysis of the traffic patterns and the proposed priority improvement plan has been made, the process of selecting the counting stations can begin. Two types of counting stations are recommended. These are "control stations" and "coverage stations."

a. Control stations will be established for each classification of the highway system. These stations will be the main source of data relating to traffic volumes and classification throughout the highway system. They will also serve as the basis for developing factors that will be used to "adjust" counts taken at coverage stations.

Control stations are the most important and should be implemented first. These stations should be located on the more heavily traveled highways and on those sections of the highway system that are included in the priority improvement plan.

Control stations should be located between cities, towns and road intersections. Traffic volumes on any road will change whenever it intersects another road or passes through a city or town. Control stations should be located only where these changes are significant. It is not necessary to establish stations at frequent intervals on a highway if the traffic is relatively constant. Select locations where, percentage-wise, there is a significant change in volume, e.g., over 10%.

The counting plan should be prepared so that portable counters can be used at all control stations.

b. Coverage Stations: Coverage stations are used to supplement control stations in determining traffic volumes throughout the system. Counts of a much shorter duration are used at coverage stations. These counts are adjusted on the basis of the volumes recorded at control stations to allow for daily, weeky, monthly, or seasonal variations. Coverage stations will be implemented as the traffic counting program is expanded. The locations will be selected in a similar manner as for control stations.

The selection of both control and coverage stations will be at locations where counts can be repeated on an annual basis. The percentage of different types of vehicles using a particular highway can be determined by manual counts taken at either the control station or coverage station.

## The Reporting System

All records of counts taken at designated control stations and coverage stations or other special counts taken to determine traffic volumes will be maintained by the planning organization.

Three basic forms are used to compile the traffic data. Form No. 1 (see Figure 22) is used by the field counting crews to record the hour by hour count by vehicle type and by classification. This form can be used to record results of the automatic counter as well as for the manual counts.

For manual counts, two forms are used at each station, one to record the travel from one direction and the other to record the travel from the other direction. The direction of travel is noted in the heading of the form on the line "From_____to_____." Since the automatic counter does not identify the direction the traffic is moving, only one form is required for recording these results.

**Figure 22**

## RESULTS OF TRAFFIC COUNTS

ROAD _____ DISTRICT _____
FROM _____ TO _____ PROVINCE _____
LENGTH _____ DATE _____
PLACE _____ CREW CHIEF _____
WEATHER _____ SIGNATURE _____

| COUNTING TIME | | TYPE OF VEHICLES | | | | | REMARKS |
|---|---|---|---|---|---|---|---|
| FROM | TO | 2-WHEEL | 3-WHEEL | SEDAN SMALL BUS P.U. TRUCK | TRUCK BIG BUS | TRUCK TRAILER COMBINATION | |
| 0600 | 0630 | | | | | | |
| 0630 | 0700 | | | | | | |
| 0700 | 0730 | | | | | | |
| 0730 | 0800 | | | | | | |
| 0800 | 0830 | | | | | | |
| 0830 | 0900 | | | | | | |
| 0900 | 0930 | | | | | | |
| 0930 | 1000 | | | | | | |
| 1000 | 1030 | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| 1700 | 1730 | | | | | | |
| 1730 | 1800 | | | | | | |
| 1800 | 1830 | | | | | | |
| 1830 | 1900 | | | | | | |
| 1900 | 1930 | | | | | | |
| 1930 | 2000 | | | | | | |
| 2000 | 2030 | | | | | | |
| 2030 | 2100 | | | | | | |
| 2100 | 2130 | | | | | | |
| 2130 | 2200 | | | | | | |

TRAFFIC COUNT % COMPARED WITH TRAFFIC VOLUME ESTIMATED IN 24 HOURS: _____

In order to apply the correction factor to the automatic counters as described earlier, it is desirable to differentiate betweeen two-axles and three-axle trucks. This is accomplished by dividing the fourth column of Form No. 1 (see Figure 22) in two parts. One part will be used to record two-axle vehicles and the other part for three-axle vehicles.

Vehicles with four axles and over will be recorded in the column entitled "Truck-Trailer Combination."

Form No. 2 (see Figure 23) is a summary of the form used by the field crews. The total number of vehicles in both directions are shown in the appropriate columns of this form.

Copies of Form No. 1 and Form No. 2 are sent to the central planning office where Form No. 3 (see Figure 24) is prepared. This is a recapitulation of the traffic count results for a specific counting period at each station. It contains all the necessary data that is required from a traffic count.

## Classification of Vehicles

In most countries, there is a wide variety of vehicles using the streets and highways. This use ranges from ox-carts and bicycles to heavy truck-trailer type vehicles with up to nine axles. A large percentage of the usage may be two- and three-wheeled vehicles -- bicycles, motorcycles and three-wheeled motorized and non-motorized vehicles.

In studies of traffic volume and highway capacity, it is necessary to classify the various types of vehicles into groups that have similar sizes and operating speeds. With knowledge of the number of vehicles in each group, the total traffic volume for a highway can be expressed in terms of an equivalent number of vehicles of a standard type, usually passenger cars. (Passenger cars are desirable for the standard group, because highway design standards are categorized by passenger car volumes.)

**Figure 23**

## ANALYSIS/RESULTS OF TRAFFIC COUNTS

ROAD _____ DISTRICT _____

FROM _____ TO _____ PROVINCE _____

LENGTH _____ DATE _____

PLACE _____ CREW CHIEF _____

WEATHER _____ SIGNATURE _____

| COUNTING TIME | | TYPE OF VEHICLES | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| FROM | TO | 2 WHEEL | 3 WHEEL | SEDAN SMALL BUS P.U. TRUCK | TRUCK BIG BUS | TRAILER HALF-TRAILER | TOTAL | NUMBER VEH./HOUR | REMARKS |
| 0600 | 0630 | | | | | | | | |
| 0630 | 0700 | | | | | | | | |
| 0700 | 0730 | | | | | | | | |
| 0730 | 0600 | | | | | | | | |
| 0800 | 0830 | | | | | | | | |
| 0830 | 0900 | | | | | | | | |
| 0900 | 0930 | | | | | | | | |
| 0930 | 1000 | | | | | | | | |
| 1000 | 1030 | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| 1700 | 1730 | | | | | | | | |
| 1730 | 1800 | | | | | | | | |
| 1800 | 1830 | | | | | | | | |
| 1830 | 1900 | | | | | | | | |
| 1900 | 1930 | | | | | | | | |
| 1930 | 2000 | | | | | | | | |
| 2000 | 2030 | | | | | | | | |
| 2030 | 2100 | | | | | | | | |
| 2100 | 2130 | | | | | | | | |
| 2130 | 2200 | | | | | | | | |
| GRAND TOTAL | | | | | | | | | |
| % | | | | | | | | | |
| V.U. EQUIVALENT | | | | | | | | | |

TRAFFIC COUNT % COMPARED WITH TRAFFIC VOLUME ESTIMATED IN 24 HOURS _____

**Figure 24**

## RECAPITULATION/TRAFFIC COUNT RESULTS/PLACE

ROAD _____ DISTRICT _____

FROM _____ TO _____ PROVINCE _____

LENGTH _____ DATE _____

PLACE _____ CREW CHIEF _____

PHASE _____ SIGNATURE _____

| DESCRIPTION | COUNTING DATE | | | | AVERAGE | REMARKS |
|---|---|---|---|---|---|---|
| | | | | | | |
| Counting Time | | | | | | |
| Q'ty of Vehicles counted | | | | | | |
| Veh./AM/Highest hour | | | | | | |
| AM/Related hour | | | | | | |
| Veh./PM/Highest hour | | | | | | |
| PM/Related hour | | | | | | |
| Veh./Lowest hour | | | | | | |
| Related hour | | | | | | |
| Veh./Average hour | | | | | | |
| V.U/Average hour | | | | | | |
| % 2-wheel vehicles | | | | | | VU = 02 |
| % 3-wheel vehicles | | | | | | VU = 0.5 |
| % Sedans | | | | | | VU = 1.0 |
| % Trucks | | | | | | VU = 2.0 |
| % Trailers | | | | | | VU = 3.0 |
| % Outgoing Vehicles | | | | | | FROM |
| % Incoming Vehicles | | | | | | FROM |

The concept of equivalent passenger car volume can be illustrated by considering a traffic flow composed of two-wheeled vehicles and passenger cars. Assume that ADT is 5,000 vehicles per day, of which 3,000 are passenger cars and 2,000 are two-wheeled vehicles. If as many as four two-wheeled vehicles can occupy the same area of a roadway as one passenger car, then 2,000 two-wheeled vehicles would be equivalent to 500 passenger cars (2,000 x 0.25). The multiplier to convert to equivalent passenger car units is called the vehicle unit coefficient. The equivalent number of passenger car units per day is 3,000 plus 500, or 3,500 VUADT.

Considerations for vehicle classification are listed below:

1. Special consideration must be given to the type of vehicles actually in use on the highway system prior to establishing a classification system. A suggested grouping is as follows:

   a. Two-wheeled vehicles with and without motors (bicycles and motor bikes.)

   b. Three-wheeled vehicles without motors (ox-carts, pedi-cabs and horse carriages) and with motors (tricycle-type vehicles).

   c. Passenger cars, small buses, jeeps and pick-ups.

   d. Single unit trucks (two and three axle) and inter-city buses.

   e. Tractor-trailer combinations.

2. At least twice a year, vehicle classification counts will be taken at each control station and each coverage station. Special classification counts may be taken as required at any location on the highway system.

3. The variation in vehicle types must be equalized for planning and design purposes by applying a coefficient to each group which will relate each group to a standard group. The categories listed in Item 1, above, are used as an example of this procedure. Coefficients are applied to all five groups. Par value of 1.0 is given to the standard group, which in this case is group "c." The other four categories are assigned a coefficient that will equate each category to the standard group based on the impact each has upon the capacity and volume of the highway in relation to the standard group. An example of such a procedure, using the classification shown in Item 1, above, is as follows:

| Vehicle Type | Vehicle Unit Coefficient |
|---|---|
| 2-wheeled vehicles | 0.2 |
| 3-wheeled vehicles | 0.3 |
| passenger cars (base) | 1.0 |
| single unit trucks | 2.0 |
| truck-trailer combinations | 3.0 |

## Truck Weight Surveys

Truck weight surveys are conducted to determine the weights, types, and numbers of trucks using various routes in the road network. Also, information may be obtained on origin, destination, trip length, purpose and routing of truck trips. Weight survey information is useful for pavement design, highway cost allocation and economic feasibility studies, identification of routes carrying heavy truck traffic, and traffic studies.

The procedure for conducting truck weight surveys is to set up a temporary roadside weighing station on each route to be surveyed. The station should

be located on a wide, level area along the route where trucks may park for a few minutes without impeding traffic flow. Each truck that approaches the station is stopped and weighed. The weight data and other needed information is recorded. Signs should be placed along the route near the weigh station to alert truckers to stop at the station for weighing and to alert other drivers about the roadside activity.

The weighing is done with a portable scale, known as a loadometer, especially designed for this purpose. The scale is placed in front of a wheel, the truck is moved forward until the wheel is on the middle of the scale, and the weight is recorded. This process is repeated until all wheel loads have been determined. (Dual wheels are weighed as a single unit.) The individual meaurements are summed up to obtain total axle weight for each axle and gross vehicle weight. For loads with approximately equal lateral distribution, wheel weights may be measured on one side only and doubled to get axle loadings.

## TRAFFIC FORECASTING

The traffic counting program enables the highway planner to determine the number and types of vehicles that pass a counting station during a specified time period. The data collected can be processed to provide such information as the total annual traffic, the average daily traffic, the average daily traffic converted to equivalent passenger cars, and the peak traffic. This information can be determined for each counting station. It can be expanded to cover a particular part of the highway system or for the entire system.

After several years of compiling data collected at each counting station, it will be possible to determine trends in highway use. The trends may be expressed as a percentage of increase or decrease in traffic for a specified period of time. The traffic volume (AADT) for any future year can then be forecasted based upon the historical trend.

The following is a typical problem in traffic forecasting:

Given: Current ADT = 1250 vehicles (determined by actual count)
Growth Rate = 5% per year (determined by historical data)

Find: ADT for the year 20 years from current year

The solution to this problem requires the use of the compound interest equation:

$$P_1 = P_o \ (1 + 1)^t$$

where:

$P_1$ = future ADT in time t

$P_o$ = present ADT

t = time in years

i = growth rate

By substituting the given values in the above equation, the following result is obtained:

$$P_1 = 1250 \ (1 + .05)^{20} = 1,250 \times 2.6533 = 3317 \text{ ADT}$$

It should be recognized that this projection is based upon a constant growth factor of 5 percent for each of the 20 years for which the traffic is forecasted. Certain conditions may occur during this period that will influence the traffic flow to such an extent that the 5 percent growth factor is no longer applicable.

If traffic forecasting is to be meaningful, procedures must be developed that will enable the planner to anticipate these influences and the extent to which they will affect existing growth trends. Major changes in land use or shifts in population can result in significant variations to the growth trends for a specific section of highway. Without the benefit of good planning processes, these variations can have a serious effect upon the highway user and the agency responsible for operating the highway system.

The foregoing example is a simple method of forecasting travel demands. A more sophisticated approach is to determine the travel patterns which are a measure of traffic flow from a point of origin to a point of destination with respect to the travel desires of the highway user.

It is from a tabulation and description of complete travel patterns that traffic assignments on existing highway networks and traffic assignments for the development and evaluation of future alternate networks are based. A true picture of travel desires cannot be obtained by manual and machine counting methods alone. A comprehensive origin and destination survey must be made to determine the existing travel desires and traffic characteristics on a nation-wide or area-wide basis. A thorough knowledge of the desires and characteristics of the highway user are necessary in order to properly evaluate the needs of the present system. To properly evaluate the future needs, land use and socio-economic data will have to be developed.

In summary, the forecasting of future traffic is one of the more important aspects of the planning operation. Accurate forecasts are needed not only by the highway planner but also by the designer. The geometric and structural design of a highway is dependent upon the amount and type of traffic that will be using the highway at a specific future date which is called the design year. If forecasts are not reasonable it is highly likely that the result may be an over design or under design of the highways.

## ORIGIN-DESTINATION STUDIES

An origin-destination study provides data on the origin, destination, length routing and purpose of all trips in an area (usually an urban area) or on a specific route. This information is useful for estimating future traffic volume and flow patterns, functionally classifying routes, determining which of several routes should be improved, and determining suitable location and design. For example, an origin-destination survey may determine that much of the traffic in a badly congested city street is actually passing through the city and is in the city only as a consequence of route location. In this case, the need for a by-pass route is indicated to handle present and anticipated future pass-through traffic.

Origin-destination surveys may be conducted in several ways, depending on the type of trips to be identified. Trips may be classified in three groups: external trips (those made by personal and commercial vehicles into, out of, or through the study area); internal commercial trips (those made by commercial vehicles within the study area); and internal residential trips (those made by residents within the study area).

### External Trips

The customary procedure for determining the characteristics of external trips for an urban area is to circumscribe the urban area with an imaginary line, called a "cordon" line, and collect information on all trips which cross this line. The cordon line should be at the edge of urban development, far enough out to intersect a minimum number of roads, but not to include much rural area. Each point where a road crosses the cordon is a sampling point or station. At each point, drivers are stopped and interviewed to determine where they are going, where they are coming from, and the purpose of the trip (e.g., business, pleasure, shopping, etc.). Also, other information may be obtained, such as vehicle type, travel time and time of day. The information should be recorded on a suitable form such as the one shown in Figure 25.

FIGURE 25

ORIGIN-DESTINATION SURVEY FORM

I. IDENTIFICATION

A. Route _____

B. Location (Station) _____

C. Date _____

D. Time _____

E. Crew Chief _____

F. Trip Direction (Circle one)

| | | |
|---|---|---|
| NW | N | NE |
| W | | E |
| SW | S | SE |

II. VEHICLE CHARACTERISTICS

A. Registration Number _____

B. Type of Vehicle (Check one)

1. 2-wheeled vehicle ☐
2. 3-wheeled vehicle ☐
3. Passenger car ☐
4. Small bus ☐
5. Large bus ☐
6. Small truck ☐
7. Large truck ☐
8. Trailer truck ☐

C. Number of Persons in Vehicle (including Driver) _____

III. TRIP ORIGIN AND DESTINATION

A. Origin _____

B. Intermediate Stops _____

C. Destination _____

IV. PRINCIPAL PURPOSE OF TRIP

A. Personal Trips (Check one)

1. To and from work ☐
2. Personal business ☐
3. Recreation ☐
4. Other ☐

B. Business

1. Passenger transport ☐
2. Commodity transport ☐
3. Other business ☐

On heavily traveled roads, the survey should be conducted for a 24-hour period on a typical working day. For less heavily traveled roads, a 10 to 16-hour period is usually sufficient. The period should include the peak travel periods and be sufficiently long to include at least 90 percent of the daily trips.

It is not necessary to collect data on every vehicle that passes a sampling station. On busy roads, say 10,000 ADT or more, a 4 percent sample will suffice. However, as the traffic volume decreases, the sample size must increase substantially to obtain reliable results. For example, an 8 percent sample of a traffic volume of 5,000 ADT will provide about the same level of accuracy as a 40 percent sample of a traffic volume of 1,000 ADT. For volumes of 500 ADT or less all vehicles should be interviewed.

The survey team may find some difficulty in getting vehicles to stop for the survey, unless there is substantial advance publicity. Care should be taken to avoid undue delays to traffic and to avoid creation of a traffic safety hazard. It may be helpful to enlist the help of the local police force during the survey.

Internal Trips

Due to the number of streets and vehicles inside the cordon line, internal origin-destination surveys are not usually conducted by stopping drivers for interviews. Personal or telephone interviews in homes and offices or mail questionnaires are more appropriate for obtaining data on internal personal and commercial trips. The internal trip survey provides the same type of information that is collected in the external survey, i.e., origin, destination, purpose, trip length, time of day that trips are made, and type of vehicle.

Data collection is done on a sampling basis, usually 1 to 5 percent, depending on the size of the city. The larger the city, the smaller the sample size. Home interviews should include a representative sampling of people with various backgrounds, ages, and occupations in order to determine travel habits and transportation requirements of residents in the area. Office interviews should be limited to those organizations involved in trucking, taxi and transit services and other activities where a significant number of commercial trips originate.

## Analysis of Results

The data from origin-destination surveys are usually summarized in charts or flow diagrams to illustrate the characteristics of traffic in the area. Various summaries can be compiled to illustrate the types of trips (e.g., work, personal business, shopping, recreation, other types, and total), and volume of trips (e.g., number of trips, vehicle-miles).

A "desire line" map may be compiled to show the origins, destinations and volumes of trips between various parts of the urban area or between various cities in a region. Lines are drawn between the various points of origin and destination. The width of each line is proportional to the number of trips between the two points. Separate maps may be compiled to illustrate home-to-work commuter trips, personal trips, and commercial trips. Also, present trip and projected future trip desire lines may be mapped and compared with existing road networks. An example of a desire line diagram is shown in Chapter 3.

# DATA SYSTEM

It is evident that good planning requires a considerable amount of basic data. Although most of the data is related to planning of highway systems and highway improvement programs, various types of data frequently are needed and utilized by other functional areas of highway agencies. And most agencies have found that data gathering and processing for all purposes can most effectively be handled by a single organizational unit -- usually within the planning division.

With the complexity of data needs, it becomes necessary to develop and implement a "data system." The system may range from simple manual processing of data to very complex computerized systems. But in any case, the basic criteria remain the same and the systems must be clearly defined to assure orderly processes and reliable data bases as needed.

There are five principal elements of data systems:

- defining data needs,
- data collection,
- data processing and reporting,
- data storage and retrieval, and
- data updating.

These are briefly discussed in the following sections.

Defining Data Needs

A first step is to clearly identify the types and formats of information needed by the various units of the highway agency. Some data may be used by several units -- some units may have unique data needs.

It is essential that data needs be known before developing procedures for data collection and processing. This is important for two reasons.

1. If needed data is overlooked in the initial data collection process, it will be more costly and time-consuming to repeat the process.

2. When there is uncertainty about what data is needed, there usually is a tendency to gather and process excessive data because "it might be needed." This also is costly and time-consuming.

The users of the data are the ones who can best identify their own needs and establish specifications relating to accuracy and characteristics of the data. There must be effective communication between those responsible for data systems and those who will be using the data.

## Data Collection

Based on the defined data needs, the data collection processes should be designed to assure the most effective utilization of manpower. When field trips are required, they should be coordinated to gather more than one type of data, whenever practical.

Forms should be carefully designed to fit the data needs -- and criteria should be established for accuracy and scheduling of data collection. Manuals should be prepared and personnel should be trained to assure both accuracy and consistency.

## Data Processing

Raw data, as collected in the field, has little meaning to planners. It must be processed and summarized in ways to effectively guide decision making. The data users should identify the content and format of needed information. The unit responsible for data collection then can design processing techniques and output reports to satisfy the needs of all users.

Data processing may be performed either manually or with an electronic computer. The techniques and procedures will be quite different -- but the end result should be the same. The computer provides greater versatility and expedites processing of large volumes of data. But for relatively small agencies, computer processing may not be economically practical.

When data is to be processed manually, there is need for carefully designed worksheet forms, clearly defined procedures and instructions, and adequate training of clerical personnel.

## Data Storage and Retrieval

An accumulation of data over a period of years is virtually useless unless it is readily retrievable when needed.

Most basic data originates on some type of worksheet forms. If computers are used, the basic information is usually punched on cards and eventually stored on magnetic tapes or other devices. Large volumes of data can be stored in quite a small space, and computer programs readily facilitate retrieval of information. After a reasonable period of time, the original worksheets and punch cards may be destroyed.

When data is processed manually, the problem of storage and retrieval becomes a little more difficult. The original data sheets are summarized on various intermediate worksheets. To minimize errors, each computation and summary is performed by one person and checked by another. Each worksheet must be clearly identified and manual filing systems must be designed to facilitate retrieval of specific kinds of information.

Required filing and storage space for manual processing is considerably larger than for computer processing. And when facilities are not available to transfer all of the original source data to the computer, there usually is need to retain the original source documents for longer time periods.

Data Updating

Some of the data collection may be one-time undertakings for special purposes. But a large portion of the data collection is of a recurring nature at periodic intervals. Criteria should be established for the frequency of updating each of the various kinds of information and the data system should assure regular scheduling of the operations. Data users should be confident that the data they need will be available.

As a part of the updating process, there should be periodic review and evaluation of all data services to avoid needlessly continuing practices and developing information no longer needed.