PRELIMINARY EVALUATION FOR ROAD NETWORK IMPROVEMENT ALTERNATIVES IN LESS DEVELOPED COUNTRIES

by

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ABSTRACT

An approach is developed to provide the decision makers in a Less Development Country with a tool for selecting an investment program and operating policy best suited to its development criteria and the existing Economic and political conditions. Using the Highway Cost Model, which provides a detailed, accurate framework for assessing the costs and benefits associated with the operation and development of links in a low volume highway network, it generates and presents the consequences of potential investment alternatives in a concise form, based on the input of Highway Cost Model link strategies. The choice and relative timing of these link strategies may vary within bounds, and patterns of network strategies, which do not satisfy the investment constraints are eliminated. For those remaining, year by year benefits may be determined considering the users' consumer surplus, maintenance and construction costs. The net present value is computed for these network strategies, and used to rank them.

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INTRODUCTION

1.1 Objectives for Planning a Transport Network

The planning of a transport network is fundamental, not only for the transport of goods and people, but for the country's economy as well. As stated by the Harvard Transport Research Program (1):" any change in the Country's transportation network has obvious repercussions throughout the entire economy". The goal of transport network planning is to achieve balanced and sustained economic growth. In numerous developing and less developed countries, the expected impact for transportation investment is so significant that the investments on network improvements have accounted for over 25 percent of the total public investments (2).

Planning of transport network improvement is usually undertaken in a hierarchical fashion. Regional economic goals are identified, then transport needs. Projects or sets of projects may be identified to satisfy these needs and then strategies consisting of their implementation sequences in specific years are generated. Project improvements to the network are then made following a chosen strategy, and projects designed in more detail.

The objectives of the transport network planning are the economic growth of the country and the improvement of the existing social conditions (i.e. education, way of life). These are accomplished with the increase of mobility throughout the country, resulting from the improvement of the transport network's level of service. These objectives are:

i. To decrease the transport costs and travel time between the production and consumption centers;

- To create access roads to remote areas or potential production centers;
- iii. To enable the free movements of men and material resources all over the country.
- iv. Finally, since all improvements must be accomplished by allocating resources (material, manpower, capital) to projects, improvements should be undertaken so as to attain the most effective consumption of resources.

In achieving the above objectives, carefull planning of links improvement is of great importance including their engineering and design characteristics and the choices among alternatives.

The output of transport planning are: (1) The proposal of the improvements and their consequences, (2) which links it is worth improving, when and by which strategy. (3) What are the resulting benefits and the costs, (4) Appraisal of the proposed alternative in comparison with others.

Lansing (3) has summarized these objectives even more broadly by writing:

"Among these goals (of economic policy) are economic efficiency, economic growth, a high level of employment and freedom from pronounced cyclical flunctuations, and a degree of equity in the distribution of the products of economic activity which avoids the juxtaposition of extreme poverty and extreme wealth. Transportation (network) planning is directly involved in the attainment of these objectives".

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1.2. Planning process

The transport network planning process consists of the following phases: (1) Definition of objectives, (2) Generation of alternatives for the accomplishment of the objectives, (3) Feasibility of the alternatives and/or screening, (4) Network analysis, (5) Determination of impacts, (6) Evaluation of alternatives, (7) Choice and (8) Implementation (The whole process is represented in figure 1.1).

The definition of objectives is undertaken by the government as part of a proposed Development Plan for the country. They must contribute to the attainment of the broad objective "economic and social development".

The generation of alternatives is done by a transportation planner. He considers all the possible alternatives, that might accomplish the objectives. During the generation, two broad classes of variables are recognized:

(i) options related to transportation itself, and (ii) activity system options .

Transportation options are those items that can be controlled directly by the analyst or the agency for which he works. They are the decision variables, which range from such broad items as alternative technologies and modes to specific items such as vehicle types, links (to be improved), type of improvement (at this point either detailed engineering studies about each improvement strategy or models that simulate the activities of construction and maintenance as needed). Activity system variables are the social, political and economic variables

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which determine the demand for the transportation options. They include variables such as spatial patterns of population, economic activity, agricultural and industrial policy and the like, all of which can influence in one way or another the demand for transport services. In most instances these options are taken as major exogenously specified factors, non-maniputable in the direct sense.

The feasibility of each alternative will be examined in the next phase: To be feasible, all the constraints introduced by the analyst must be verified. (Only the feasible alternatives will be considered in the next phases). For each feasible alternative, the analysis of the resulting transport network is done. The analysis may be performed by simulation of all network activities or using direct mathematical procedures. With the analysis, the impacts of each alternative to different groups (users of transport network, producers, consumers, government) will be found. Then, the evaluation of the alternatives will be done.

The next phase is the choice: The alternative that contributes more to the accomplishment of the set objectives is chosen as the one to be implemented. In some cases, the analyst through the screening process may eliminate some alternatives without a detailed evaluation. This will make the task of evaluation easier and faster. The screening is based on criteria set by the analyst and derived from the objectives.

The final phase is the implementation of the best alternative on a proposed time schedule.

1.3. Role of an evaluation model

The role of an evaluation model is to develop the impacts of alternative plans and compare and rank them with each other and the do-nothing

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alternative. Most of the evaluation models introduce formulae which enable the analyst to compare the different and often irregular, series of benefits and costs that are associated with alternative plans.

The evaluation model can be compared with other types of network programming tools (e.g. screening): It can rank plans by productivity, by returns, and the like, it enables the analyst to consider numerous alternatives, it gives him a more accurate picture of the impact of each alternative and it takes into consideration the goals and objectives directly and realistically in the evaluation.

Thus, the evaluation model broadens the horizons of the transportation planner during the process of planning transport network improvements.

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BACKGROUND

2.1 Evaluation measures and objectives

Several measures for evaluating the consequences of the implementation of an alternative may be identify. The consequences may be measurable in monetary terms (costs, users savings) or non-monetary terms (level of service, environmental impacts). Most studies are concerned only with monetary impacts, using economic or financial costbenefit analysis exclusively.

The benefits of transport network improvements (or planning in other sectors of the country's economy), will result from a reduction in the consumption of resources. It will impact the economy by altering the interactions between resources, production and transport in such a way as to improve (or deteriorate) the welfare of inhabitants. If an evaluation measure is based on economic analysis, it seeks that alternative which consumes the minimum resources while providing significant economic growth. A number of planning models have been developed which employ the economic analysis in the evaluation of alternative plans. Among them are the Harvard-Brookings Macroeconomic model for evaluation of network alternatives in Colombia (4) and Taborga's work with the Chilean Transport Network (⁵). (Explained in § 2.2.2). If financial analysis is employed, this would imply that the value of a plan is specified independent of any detailed study about how it may alter the economy, and focuses instead in the investments' consumption of resources; its purpose is to determine the best way to allocate resources to

projects of presumed known value. That is, it is primarily concerned with budget constraints, and not with the economic relationships, which determine an investment's impacts.

The evaluation measures may be classified into four types of analysis according to their objectives. (Based on a classification system introduced by R. de Neufuille and D. Marks (6)).

i. Type I: Standard Benefits Cost Analysis

This is the simplest case. The future costs and benefits are discounted to a common point in time (usually the present) and compared. Several criteria exist to the comparison: (1) Benefit-cost criterion, computing the ratio of the present value of all benefits to the present value of all costs, (2) the internal rate of return criterion, that is **the discount rate at which** the net present value of the benefits equals to the net present value of the costs, (2) net present value criterion, that is the difference between the present value of all benefits and present value of all costs. The underlying assumptions are:

(i) the value of a benefit or cost, increases linearly with the amount of benefits or costs at any time.

(ii) As long as values are linear in the amount of benefits, uncertainty can be introduced with the use of expected values.

(iii) Money is taken to be the measure of all things. If it is not feasible or practical to qualify a benefit or cost, such as an aesthetic one, it does not get considered.

(iv) All parties interesting in the investment must agree upon a single criterion of evaluation. This assumption is reasonable so long as groups accept that it is meaningful to measure all benefits and costs,

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Figure 2.1: Consumer's Surplus

such as loss of life on a common basis and with the same weight on each kind of benefit and cost.

The objective of this type of measure is to maximize the monetary profits (benefits minus costs) over the time horizon.

ii. Type II: Consumer's Surplus

It recognizes the non-linearity of the values in terms of benefits and costs. The real value of any benefit is known as its utility, and the utility function describes the real value of the benefits. The nonlinearity of the utility function, which contradicts the first assumption on which the standard benefit-cost is based, is a pervasive phenomenon. As a general rule, both individuals and the public have a diminishing marginal utility for benefits. As it appears in figure 2.1, someone would be likely to demand more of a good until, at the margin, was equal to its costs. This would occur at Q* in the figure. It follows that someone's utility or value for less than Q* of a good is greater than its price. The sum of the utilities over all quantities used will result in the willingness to pay for the good. The difference between the willingness to pay and what actually has been paid to a certain price is the consumer's surplus. This type of analysis attempts to incorporate consumer's surplus into the measurement of benefits. It employs the benefit-cost analysis to accomplish its objective, the maximization of profits. Basically, it recognizes that benefits often have a real value much greater than their price.

iii. Type III: Decision Analysis

This approach includes procedures to quantify any individual's own

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utility over risk, usually nonlinear functions. Unlike the utility functions over quantity, however, the utility functions over risk are not expressed in terms of common units, such as money, which different groups might be willing to pay for any specified number of goods.

The process of decision analysis consists of the following steps: (i) all possible sequences of decisions and their consequences are laid out. This is represented as a decision tree, since there can be several choices at any stage and since each choice may branch into several consequences. (ii) All possible outcomes are indicated together with the a priori probability of occurrence. (iii) The utility function of the decision maker is assessed and the utility or real value of each outcome is calculated. Finally, (iv) the optimal choice at each choice at each stage, and thus the optimal sequence of choices, is calculated on the basis of maximizing the expected value of utility.

The objective of the Decision Analysis is to find the optimal sequence of choices of alternatives over time aimed at maximizing the expected value of utility, since uncertainty is incorporated.

Pecknold (7) employ Decision analysis measuring all consequences in monetary terms, as profits or losses.

iv. Type IV. Multiattribute Analysis

This approach attempts to account for the non-linear, nonadditive nature of any individual or group's utility function over several attributes. Once the multiattribute utility function is encoded, it can be used in the evaluation just like a utility function of type I.

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Therefore the objectives are the same as of type I.

v. Type V: Multiobjective Evaluation Analysis

So far we have had only one objective. This analysis attempts to lay out explicitly the preferences of the different groups concerned with a project for the set of possible consequences. In this way, it intends to allow the analyst to estimate those choices which are preferable to the several groups, according to their objectives and how these differences might be resolved. It does not define the best alternative, but rather leaves the selection to judgement.

It is important to note that the existing procedures of multiobjective evaluation do not propose clear, analytic methods for determining the preferences of any group. The most cogent descriptions of the theory and proposed practice have been presented under the auspices of the United States Water Resource Council. It has not yet been applied to transport network planning. However, it would be interesting, if it could be applied, since transport network planning implementation affects several groups: the users of the network, the producers and consumers of goods, industry and the government itself.

2.2. State of the art

2.2.1. Link evaluation models

These models deal with the evaluation of the several alternatives for link improvements. It is assumed that (1) the alternatives are mutually exclusive, (2) any improvement of one or more links in the network does not affect the others and (3) the budget allocated to each link-for its improvement- is fixed; thus, links to be improved are not competing for the same funds.

Wohl and Martin (8) deal with the evaluation of link improvements taking into account present and future impacts of the improvement. Tarplay and Drake (9), Thygeson (10) and Marglin (11), all develope fairly simple evaluation models, incorporating the timing (the improvements to be done in stages, and may be postponed for one or more years). They showed that substantial benefits can be achieved with the appropriate timing. Winfrey (12) is concerned with the optimal staging of an improvement (namely an expansion of a 2-lane highway to a 4-lane one, given that some increased capacity is needed now), and not when the improvement should start. Thus, he ignores the impacts of delaying the starting time and the supply-demand dependencies. Cole (13) develops a model with a probabilistic demand structure but, once the sequences of improvements is decided it would remain unchanged over the economic life of the link, no matter what changes in demand might occur. Howard and Nemhauser (14) introduce dynamic programming for the evaluation of alternative link improvements considering supply-demand dependencies in a fairly theoretical work. Other models simulate the activities which take place on the link during a development and operating time horizon, considering construction, maintenance and vehicle operation. The Highway Cost Model (15) and, the Project Analyzer of the Harvard Brookings Transport Model (16) are such models, calculating economic consequences with a sequential simulation of events over time for the evaluation.

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The main characteristics of the above mentioned models are the following:

(1) demand is exogenuously given and independent of the alternative selected,

(2) link capacity is merely additive; to meet increasing demands, we need only to widen the link to carry the new volume,

(3) costs are very simple in structure: fixed and variable ones, with the only exception the ones simulated by the HCM,

(4) the problem is one of minimizing total costs only, and simple techniques are used to produce the optimal sequence of the improvements.

2.2.2. Network Evaluation Models

The network evaluation models can be divided into four categories (expanding Pecknold's (7) classification) which become progressively more complex:

(1) capital budgeting models

(2) Network flow models

(3) Stochastic Models

(4) Activity growth models.

The latter are the most complex, introducing the constraints of long-run supply-demand dependencies in addition to normally using a complicated network flow simulation procedure. Surprisingly enough, little work has been done on the use of such models. The reason is their complexity. The most significant studies which employ macroeconomic model in conjunction with a transport model are Taborga (⁵) work

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with the optimal transportation policy in Chile, the Northeast Corridor Study (NEC) (1^7) and the Harvard Brookings study on Colombia (4).

2.2.2.1. Capital budgeting models

Capital budgeting models generally assume all benefits are exogenously specified, single valued and independent of the sequence chosen. They incorporate the combinatorial mathematics to select the best sequence of improvement activities subject to capital (budget) constraints. Marglin (11) deals with the network problem in finding the optimal strategy of network improvement, although, he deals with dependencies caused by budget constraints only. The optimal strategy is one that allocates the budget among the links in such way as to maximize the sum of the net present values of the alternative and the net present value of slack subject to the condition that the sum of alternative outlays in each period not exceed the period's budget. Weingartner (18) uses mathematical programming to solve the capital budgeting problem. Consad (19) proposes several models to find the optimal sequence of improvements of a transport network, still in terms of abstract projects (i.e. projects, although intended to be transport projects, are represented solely by a set of costs and benefits). One of the proposed models for the Northeast corridor project was a quadratic programming model, which can handle project dependent costs and benefits quite easily.

Mori (20) uses dynamic programming for the selection of these link improvement strategies to produce the optimal network improvement alternative subject to capital budget constraints. The optimal alternative

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is the one that maximizes the benefits (B_i) from all link improvements in each period, for P periods.

maximize

$$Z = \sum_{i=1}^{P} \sum_{j=L}^{N} g_{ij}(x_{ij}) = \sum_{i=1}^{P} B_{ij}(x_{ij})$$

s.t.

$$\mathbf{x}_{i} \geq \sum_{j} (\mathbf{x}_{ij})$$

where:

 x_{ij} : the amount allocated for each link j in period i x_i : the budget available in period i $g_{ij}(x_{ij})$: the benefits of each link (j) improvement

N: number of improved links.

The technique permits: (i) Examination of many stages for each link alternative proposed as an addition to the road network, however, this technique can handle only two or three stages; (ii) analysis over multiple time periods; (iii) inclusion of budget limitations; and (4) consideration of situations where system costs, and benefits change over time.

Meyer and Straszheim (21) present a fairly concise and clear treatment of the dual problem of the capital budgeting primal problem, the shadow prices and internal (vs. external) opportunity costs of the alternatives.

2.2.2.2. Network flow models

The network flow models are an extension of the capital budgeting models. The cost and benefits are not exogenously specified, fixed quantities, but depend on some prediction mechanism. In some cases, it can be internal (as in linear flow models) and in others, it is a completely separate model. They all deal with a deterministic and fixed demand structure. They have been generally limited to linear flow models, however. Additionally, they usually ignore the dependancy of supply- demand. Recently, developments in branch and bound techniques have placed fewer constraints on the form of the flow model. Hershdorfer (22) applied a branch and bound algorithm- developed by Land and Doigto the single period, link addition problem developing a linear programming flow model to determine the measure of effectiveness of network changes. He sets up a general network with nodes i=1,2,...,N and directed arcs. Demands are specified between groups of origin-destination pairs. Each "commodity" may be the flow from a single origin to several destinations or from several origins to one destination. There are the flow constraints and capacity constraints for existing links and additional ones. The objective function searches for the minimum additional construction necessary to reduce travel costs.

Roberts (²³), at the same time, although independently, was using the same branch and bound algorithm coupled with heuristic backward stepping, time-sequencing algorithm for the multiperiod problem.

Bergendahl (24), in a similar approach to Roberts, used a linear programming flow pattern of any improvement plan at each period, but

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employed dynamic programming to search for the optimal sequence of improvements in time. Roberts in Meyer and Straszheim (21) developed a model which minimize the sum of costs for both constructing link additions and operating vehicles over the entire system, subject to the following constraints: (i) all supplies and demands of each commodity type must be met by flow over the network, in which the sum of flows into each node must equal to flows out; (2) if a link is not built, then there can be no flow over it; (3) the amount of funds committed to building new links must not exceed the available budget; and (4) the partial construction or improvement of a link is not permitted. He comesup with the optimal improvements and their timing. It is assumed that the network in any given stage n is a subset of the network which will exist at the next stage n+1. Therefore a dynamic programming approach was introduced. However, there is a shortcomming in the approach traffic patterns in the last planning period are the only ones that affect the selection of the highly important final or Nth-stage plan. Today's volumes merely determine which links of this final plan to build early. There is, therefore, an element of commitment to the Nth-stage plan, once it is determined. Morlok (2^5) has proposed a dynamic programming procedure to define the optimal timing and strategies in the Northeast corridor context, ignoring the network effects of multiple and overlapping paths.

Another interesting approach to find the optimal time-staged sequence of improvements is to solve the combinatorial problem using the

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discrete optimization technique of branch and bound programming. Ochoa and Silva (26) apply a branch and bound algorithm and a branch backtrack algorithm to the network improvement (single period) problem, using a traditional assignment model as a flow prediction mechanism.

Also, there are a number of heuristic approaches for the network improvements, which concentrate mainly on the link addition or capacity expansion, only in one period, using a simulation model. Barbier (27), Stairs (28), Spenser (29) and Bhatt (30), all propose ways to select improvement plans for testing in a simulation model, which corresponds to a form of direct search procedure. Allman (31), Fisco (32) and others have developed simulation models mainly serving the needs of the railroad in North America.

Carter and Stowers (33) develop a model to find the optimal allocation of funds for network improvements. A general transportation network is specified with n nodes and m arcs with arbitrarily chosen directions. Associated with each arc is a capacity $b_{ij} \geq 0$ and a travel cost $c_{ij} \geq 0$. Each distinct flow or "commodity" is defined as the flow from a single source with supply r_k to various destinations. The non-linear relation between link volumes and construction costs is handled by means of a piecewise approximation- one **constant** user cost is associated with relatively free flow conditions and another constant user cost is charged to all vehicles volumes above a critical "practical capacity". This is easily incorporated into the model by representing each link by two "artificial links", with respectively low and high user costs.

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The low cost link will have a capacity equal to the "practical capacity" of the link. The other higher cost link will have a capacity equal to the difference between the possible and practical capacity of the actual link. The optimization algorithm will load the low cost branch first and if its capacity is exceeded the high cost branch will then be loaded. In this way an actual link with nonlinear travel costs will be simulated. The introduced objective function aims at minimizing the sum of transport costs and cost of improvements, keeping them within the budget limits. The program developed can use a standard linear programming procedure for its solution, but for a relatively large network this might overcome the computer capacity.

Quandt (34) has developed a model having as objective the minimization of user costs. This model is based upon the classic Hitchock-Koopmans transportation network problem: There are N sources and M destinations and all sources are initially connected to all destinations. Each source has a fixed supply k_i and each destination a fixed requirement R_j . He equals the total supplies with the total requirements. Also, he introduces as constraints, the total outflow from source i to be less or equal to its supply k_i and the total inflow to destination j to be greater or equal to its requirement R_j . The objective function aims to minimize the total transport costs, provided that the cost of improvements does not exceed the available budget. He associates with each link ij the decision variable k_{ij} , the amount of capacity to be added. This variable is continuous and a small positive increase in its value may

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well correspond to the widening of a road or the installation of a better signal system; a large value of k_{ij} may well be indicative of the need for provision of an additional link. Though k_{ij} will be restricted to values greater than or equal to zero, links may be taken entirely out of the network or added if their initial capacities b_{ij} are set to zero. Therefore the total traffic flow on the link must be less or equal to the sum of the initial capacity and the capacity to be added.

2.2.2.3 Stochastic Models

Pecknold's (⁷) work is the most important in this area. He recognizes that improvements are usually implemented as a series of staged sequential improvements to a fairly extensive existing system and that there is substantial uncertainty over the future demands. He has developed a basic stochastic time-staying model, which is capable of handling supply-demand interdependencies, network connectedness, budget constraints and system dependencies on the type of improvements. The use of a descriptive non-analytic simulation model for transport flows, which recognizes both uncertainty and the multi-stage nature of investment alternatives results in an extensive multi-stage decision tree of extreme dimensions. He introduces approximating procedures, called pruning rules and terminal evaluation functions to heuristically reduce the computations and make application of his sequential decision model feasible forlarge networks.

2.2.3. Traffic assignment approaches

Numerous approaches have been developed for the assignment of the

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traffic on the links of the network. Here we will mention the ones more relevant to our work.

Beckman (35) considers a transport network consisting of N nodes and directed arcs, with a single type of homogenous traffic flowing on it. He solves the problem using an algorithm which:

(1) starts with an initial demand $D_{\ell,k}$, on each origin-destination pair ℓ,k and the flows x_{ij} over the links ij;

(2) computes the travel costs or time c_{ij} associated with using the link and the flow x_{ij} :

$$c_{ij} = a+b \cdot x_{ij}$$
 where: a,b constants.

(3) finds out the minimum path for each origin-destination piar l,k with the help of the expression:

$$c_{l,k}^{*} = \min - path \sum_{ij} c_{ij}$$

which gives the minimum travel time between l,k,

(4) now, a new demand is generated:

$$D_{l,k}^{\dagger} = f - gc_{l,k}^{\star}$$
, where: f,g are constants

(5) a weight sum of the new and the old demand is generated:

$$a \cdot D_{l,k} + (1-a)D_{l,k}$$
, where 0 a 1

(6) the assignment of the flows on the links is done through the imposed conservation conditions:

$$\sum_{j=1}^{N} x_{ij}^{-x}_{ji} = \begin{cases} D_{\ell,k}: & (at origin) \\ -D_{\ell,k}: & (at destination) \\ 0 & (elsewhere) \end{cases}$$

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-36-(7) the same calculations are repeated,

(8) the flows between each 0-D pair will oscillate within a. $D_{l,k}^{i}$ and if a is progressively decreased during the iterations, convergence will be satisfactory.

Manheim and Martin (36) propose an algorithm, which requires as inputs: interzonal transfers, network description, volume- delay characteristics and a specification giving a volume increment and a generation rate characteristic. The algorithm works in five basic phases:

(i) The random selection of a zone pair,

(ii) The determination of the minimum time path between the zone pair,
(iii) The use of a generation rate characteristic to determine the potential volume to be assigned between the zone pair,
(iv) The addition of a small increment of the potential volume to the minimum path,

(v) The use of volume- delay characteristic to update the travel times of the links in the minimum path due to the increase in volume.

The produced output consist of link volumes out travel times, interzonal potential volumes. Isard (37) develops a model handling aggregatively the shipment of commodities between regions; shipments are considered to be direct between origins and destinations; rerouting and transhipment possibilities as well as capacity constraints on the links are not considered. The model defines the shipment of commodities
is such a way as to maximize the regional income subject to the conservation rule of supply and demand.

Tomlin (38) develops a model defining the flows over the links according to the minimum costs of transport. A network is specified with nodes 1,2,...,N and directed arcs 1,2,...,M. Associated with each arc is a capacity $b_{ij} \ge 0$ and an average user cost c_{ij} . The objective function is the one minimizing the overall user costs:

$$z = \sum_{k=1}^{q} c_k \cdot x_k$$

where:

minimize

c_k: the vector of the transport costs of the k^{th} commodity over each link.

 x_k : the flow vector for the kth commodity over each link. The introduced constraint is the one of flow conservation at node i:

$$\sum_{j=1}^{N} x_{ij}^{k} - x_{ji}^{k} = \begin{cases} r_{k} \text{ (origin)} \\ -r_{k} \text{ (destination)} \\ 0 \text{ (elsewhere)} \end{cases}$$

The arc-node formulation leads to a basis of large size. The program can be handled by means of the decomposition principle developed by Dantzig (39).

2.3. Conclusions

After reviewing a number of models, we can conclude the following: - The evaluation of alternative network improvements and the choice of the optimal one is a problem which is complex in theory and depends largley on whose point of view we are concerned with;

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- the problem has been approached from a variety of different perspectives, each emphasizing a certain commitment to a profession, to a mode, or a philosophy which emphasizes some aspects and largely ignores others;

a number of computational techniques have been used to solve the problem, not recognizing the non-linear status of the problem, or introducing assumptions to transform the non-linearity to linearity;
none of these techniques or algorithms can be used satisfactorially in all of these basic problems of transport investment planning.

Furthermore, reviewing the models with the perspective of being applied in a less developed country we may find some that are inappropriate for couple of reasons:

- They are too sophisticated, thus they need large computer facilities (usually unavailable in a less developed country) to be implemented, - the data requirements are such that it is impossible to meet them with the available resources and facilities in a LDC. (most of the data does not even exist, thus making those models which are highly sensitive to accurate data obsolete).

Summing up our conclusions for the type of evaluation model needed for the improvements of the transport network in a LDC we may recommend: a model which is easily applied, straightforward, with few data requirements. Finally, it must be able to serve in the best possible way the needs of a LDC for better transport.

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-39-CHAPTER THREE

THE APPROACH: PROBLEMS FACED AND THEIR SOLUTIONS

3.1. The approach

3.1.1. Definitions

Before describing the approach itself, the definition of the words, expressions and concepts employed should be done. A transport network is composed of links and nodes. It is assumed that all economic activity takes place within nodes, cities or villages, rather than being continuously distributed over space and that transport is confined to links, routes between these nodes. A point where two or more links join must also be a node, even if not a point of economic activity. Each commodity is produced at one or more supply nodes. Demands for these commodities exist at other nodes within the network. Commodities are shipped from supply nodes (origin) to demand nodes (destination) over the links of the network. Similarly, people are moving from the origin node for the destination node over the links. A transport network is composed by links of several modal types: highway, rail, waterway and air. In this study only the case of the highway mode is considered.

Network improvements denote the construction of new links, the upgrading or widening of parts of others, or better maintenance for the road surface, aimed at lowering the vehicle operating costs. Network improvements are executed according to a proposed plan called a network improvement strategy. Network improvement strategy, or network strategy (N.S), is composed of one improvement strategy for one or more linksthe link improvement strategy, which is a time sequence of projects or changes on the link, is chosen from among alternatives. It is obvious that the number of network strategies possibly considered depends on the number of links to be improved and the number of tentative link improvement strategies. With the timing of a link strategy left as a variable, one network strategy may be identical to another except for the time when one link strategy is implemented.

A link improvement strategy, or link strategy (L.S.), may denote one or more of the following: (i) the timing of the construction projects for a new link, staged or not; (ii) the maintenance of policy to be followed overtime; (iii) the time-sequence of the upgrading (e.g. the year that an earth road will be improved to a gravel one, and, possibly, to a paved road) to part or all of the link; (iv) the time-sequence of widening the road or adding a new lane; or (v) no improvement at all. It should be pointed out a link strategy is a sequence of activities with a fixed relative timing. The entire sequence may be shifted in time.

3.1.2. Overview of the logic

The approach, advanced here, generates alternatives network strategies from proposed link strategies, simulates the network performance over the time horizon for each feasible network strategy, and finally, evaluates it.

The consequences of a network strategy are evaluated as follows: First, the alternative is checked to see whether it satisfies the imposed constraints on budget, foreign exchange and skilled labor. Then, during the simulation of the network, the annual costs and benefits are computed.

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The cost are those associated with construction and maintenance activities. The benefits are defined as the difference between the price a user is willing to pay or was paying before the implementation of an incremental cost change due to a change in transport cost and the price actually paid. To estimate the transport cost for each trip from its origin to its destination, the routes of the vehicles must be determined and the cost of time and congestion added to the operating costs. The evaluation of the alternative is based on the net present values of these incremental costs and benefits produced by the simulation for each alternative when compared to a base network solution. The approach proposes as the optimal network strategy for implementation the one with the highest net present value. The figure 3.1 shows the several steps of the approach.

3.2. Constraints on the feasibility of an alternative

The constraints imposed to each network strategy are of three types: 1) those related to the costs of improvements, 2) those related to the timing of each strategy and 3) those economic weightings associated with each strategy which determine its importance in the economic improvement of the country. The feasibility of a network improvement strategy is based on whether it satisfies constraints introduced to prune the generated network strategies. An annual budget is allocated for highway construction and maintenance, and distributed among the regions of the country. Each network strategy may not have costs of construction and maintenance activities for each region higher than the

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Figure 3.1.: Flow Diagram of the Approach



Figure 3.1.: (continued) Flow Diagram of the Approach



Figure 3.1 (continued) Flow Diagram of the Approach

annual regional budget.

Two other constraints are closely related to the economic conditions: Most of the money available for initial construction comes from abroad either as direct aid in foreign exchange or low interest, long term loans. The balance of payments usually constraints the growth of the country; therefore the available money for purchases of machinery, materials, etc. is limited to the aid or loan money or to specific allocations to the transport sector as a whole. Therefore the model allows foreign exchange allocations in each region to be constraint. Similarly, there is often a scarcity in skilled labor. This may be a deterant to development or imply the use of labor instead of capital intensive techniques, the latter using mostly skilled labor. It may be specified as a regional constraint.

3.3 The Costs

3.3.1. The cost of construction and maintenance activities

An improvement may be any continuation of upgrading or construction of part or all of a link. The costs are those resulting from the construction or upgrading that occur during the improvement phase as well as those associated with the maintenance of the link.

The cost may be specified exogenously or computed by the Highway Cost Model (HCM) after simulation of the activities of improvement. Construction costs may be computed directly and accurately by the HCM; maintenance costs can only be approximated because they vary with the traffic on the link, which is not known until the entire network is simulated. Maintenance costs are computed for an approximate expected

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volume. Although fairly insensitive to volume, these costs could be adjusted if the volume turns to be significantly different.

The cost of construction and maintenance activities may be distinguished as financial and economic costs, the economic costs being those obtained by deducting from the financial costs the percentage resulting from indirect taxes and import duties. This is an estimate of the "cost of the improvement" to the country's economy net of the payments of taxes. It is this cost that is used to measure national objectives. The financial costs, perceived by the user, as the costs that influence his behavior. Budgets are stated in these terms. Similarly, budget constraints may also be stated in terms of other critical resources, such as foreign exchange and skilled labor, since their allocation to other sectors of the economy than in the transport sector, could influence the country's economic growth.

3.3.2. Vehicle operating costs

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Since the model will be integrated with the HCM, it adopts some of its characteristics and constraints. One of these is that, seven vehicles types may be handled. They are usually designated as: passenger car, bus, pick-up truck, 5-ton truck, 10-ton truck and two types of tractor-trailers.

Vehicle operating costs are dependent on the design and the surface as well as on the traffic volume on the road. The operating costs resulting from the road conditions can be exogeneously specified or computed by the HCM through the simulation process. The costs due to the introduced monetary value of the travel time are computed by the

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evaluation model. The vehicle operating costs are computed as both financial and economic costs. Economic costs are these derived from fuel and lubricants consumption, tires usage, vehicle depreciation and interest on capital, maintenance and repairs and wages (in the case of trucks and busses). The financial costs are the economic costs plus the costs of insurance and taxes. The financial costs are used to determine the routing of the traffic between Origin and Destination (O-D) and changes in demand due to operating costs, and the economic costs used to compute the benefits resulting from the improvement.

3.4. Definition of demand and the generated traffic

The traffic on the network originates from the supply nodes, its destination being the demand nodes. The demand is given by O-D pairs (origin-destination nodes). A supply (origin) node represents a production region, where one or many crops are produced, a mine, a place where animals are raised, or a city or industrial area, where manufactured goods are produced, ready to be consumed locally or shipped to other places. A demand (destination) node represents a city, a town or a village where the goods are consumed.

The annual based demand is a function of the population and its growth rate, the average income and its increase, the price of the commodity etc. The changes in transport costs will shift the demand up or down due to price elasticity. The number of vehicles moving on the links of the network is based on such demand of the commodities between each O-D pair. The model handles seven different vehicles types, each with different capacities. It is assumed that for one O-D pair, one vehicle type carries one commodity type or at least ones with similar handling and transporting characteristics. Thus, the model limits the number of substantially different commodities which can be transport between each O-D pair to five, not including passengers. Demand can be measured in two ways: in number of vehicles per day (according to vehicle type) for each O-D pair; or in tons per day. (From the volume of commodities in the vehicle capacities and the load factors, the number of vehicles for each O-D pair is easily computed). Each vehicle type will follow that sequence of links which connect the O-D pair and minimize its total operating costs. As the network characteristics change, so may be the routing.

3.5. Impacts of the Improvement on Demands and Traffic

Any change in the operating characteristics of a link in the network will affect the distribution of traffic on the links. Changes may induce greater demands, divert traffic from other links, or create congestion on the link due to the traffic increase.

The demand of commodities and passengers between origin and destination pairs is influenced by changes in the transport costs. This sensitivity to demand is denoted as the price elasticity. Price elasticity is the percentage change in demand that results when the transport costs have changed by one percent. Elasticity may vary from O-D (inelastic demand, i.e. no change in demand) to values as high as O.1 to

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Freight



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o.4 (elastic demand).

Several approaches have been developed to estimate the demands of the O-D pairs. Their general scheme is protrayed in the flow chart in figure 3.2 It begins with land use or spatial location characteristics, derive trip demands and trip destinations and then follo this with an assignment or allocation of these trips to a network. When the demand is elastic any change in the transport costs, resulting from the route assignment, will change the demand.

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Route assignment provides specific estimates of demand placed on various links in a network summed from the individual O-D demands. Since there may be a number of alternatives paths that can be used for connecting the O-D pairs, the assignment selects the least costly route. These costs vary with travel time, which varies with link (not O-D) volume. If links capacities were infinite, and the travel time therefore did not vary, the assignment would be relatively simple. However, as flows on a transportation network change, the cost-performance characteristics on the network also change. Real world users adapt their behavior to local capacity shortages. If a shorter, faster route becomes congested (and thereby slower), users will shift to a less congested and formerly slower alternative route. The result is a complex equilibrating process of travel demands, travel speeds and link volumes. There are numerous solution approaches and assumptions introduced to solve such problem. For LDC's, where alternatives are fewer, we will assume away this problem by assuming that congestion costs do not alter the routing, determined ignoring congestion.

3.6 The Assignment of Traffic on the Links

The assignment of traffic follows the assumption that each vehicle will travel the sequence of links that connect the O-D pair and minimize its total operating costs. No reassignment of the traffic on the links is considered for changes in transport costs due to the increased travel times caused by congestion. This limitation is not considered to be significant since most links in LDC's are uncongested and usually there is only one reasonably feasible route connecting most O-D pairs, which the vehicles must follow regardless of congestion. Congestion, however, it it exists, is considered by computing the costs resulting from the time value of the commodities and the passengers.

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Initially the assignment is done for the first year of the simulation. It is then repeated during the time horizon if any change occurs in the network (identified by changes in user costs in any link) or if specified by the analyst.

3.6.1. The Routing Algorithm

Numerous algorithms have been developed which search a sequence of links to find minimum cost routes.

The Algorithm developed by Floyd (40), which can treat efficiently a general network and multiple O-D pairs, and been applied.

The Floyd procedure builds optional paths (routes) by inserting nodes, when appropriate into more direct paths. The algorithm starts with a NXN matrix C of transport costs, and N matrices are constructed sequentially, where N is the number of nodes. The K^{th} such matrix can be interpreted as giving the minimum transport costs of all possible routes between all node pairs (i j), where only routes with intermediate nodes belonging to the set of nodes 1 through k are allowed. The (k + 1)st matrix is constructed from the K^{th} using the formula:

 $C_{ij}^{(k+1)} = \min (C_{ij}^{(k)}, C_{i,k+1}^{(k)} + C_{k+1,j}^{(k)}), C_{ij}^{(0)} = cij$ (3-1) Here, K, which is initially zero, is incremented by 1 after i and j have ranged over the values 1,...,n; and K=N-1 at termination. If two nodes are not connected directly by a link, the assigned transport costs for this link is a large number. Also a time matrix T is introduced being the same as, C, but with travel times on the links as its elements. The label matrix has as elements in the initial stage the nodes denoting the beginning of each link; i.e. the element aij is i, if i is the beginning node of link ij. Note that all matrices have elements defined by node pairs, not by O-D pairs.

The algorithm proceeds as follows: It pivotes on every node of the network, i.e. it obliges all traffic between O-D pairs to pass through this pivot-note for each O-D pair, it compares the resulting transport costs with the previous ones and saves the leasts ones as the transport costs of the O-D pair under consideration.

If the traffic has to pass through the pivot node, the algorithm updates the label matrix and the time matrix as well. The pivoting had ended, for each O-D pair the cost matrix C would come up with the minimum transport costs the time matrix T with the resulting travel time and the label matrix L with the previous node of any node, both nodes defining a link of the minimum costs route.

Finally, the set of links of which the route is made up may be found.



Figure 3.3.: Minimum Cost Route Algorithm

The steps of the algorithm are shown in figure 3.3. An example of the algorithm application is presented in Appendix $\mathbf{1}$ of this chapter.

Using the routing so determined, the transport costs by O-D pair may be computed. To the total operating costs found by the algorithm, we add the costs associated with the time lost in travelling, determined without taking in to consideration any costs resulting from possible congestion.

3.6.2. Congestion

If congestion occurs during anytime period, it will cause vehicles to lower their speeds, thus increase the travel times and transport cost. If the average traffic volumes on a link are given on a daily basis, which is usually the case, we must translate them to a distribution of volume levels, but on an hourly basis to determine whether congestion will occur or not. If one sampled the hourly volumes at many points in time, the result would be a distribution of hourly volume levels for the whole day. If speeds are determined at each volume level and the resultant ravel times weighted by the number of vehicles traveling at that volume level, the estimate of "average" conditions is much improved. The distribution of hourly volumes varies for different types of roads. In general, heavily traveled roads tend to have distributions in which the "peak volume" is skewed towards the higher volume levels, while the distributions of volumes on less traveled roads are heavily skewed toward very low volume levels. Roberts (16), introduced a probability mass function, which is analogous to the one resulting from the "binomial distribution". There are 4 Bernouilli trials, the

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sucess Y_k being whether the hourly volume will fall in the kth volume level. Therefore, he measures the probability of each hourly volume level to be the same as the hourly volume on the link-which is unknown, the volume given on a daily basis. Thus without knowing the hourly volumes on a link, he comes up with an approximation of them, sufficient to help solving the congestion problem. His approach has been applied, as described belows.

3.6.2.1. Measuring the Traffic in Passenger Car units (PCU)

The traffic on the links is given in numbers of vehicles by vehicle type (cars, busses, trucks). A common unit of measure for traffic is needed in order to represent it. This is taken as one passenger car, all other vehicles are represented by passenger car units (CU). Factors are introduced for each vehicle type for this transformation.

The Highway Capacity Manual (41) considers a truck or a bus displacing several passenger cars in the flow on the road. The number of passenger cars that each truck or bus represents under specific conditions is termed the "passenger car equivalent" (PCE) for those conditions. Note that the passenger car units (PCU) for a truck is equal to its PCE. (Passenger Car Equivalents) In level terrain where trucks can maintain speeds that equal or approach the speed of passenger cars, it has been found that the average truck is equivalent, in a capacity sense, to between 2 and 3 passengers cars on 2-lane highways depending on the level of service. These values are appropriate for most downgrades as well. On upgrades, the passenger car equivalent of trucks may vary widely, depending on steepness and length of grade and number

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of lanes. For approximate analyses of operations on a given road, section it may be sufficient to apply an overall approximate equivalency factor to the road as a whole.

According to Highway Capacity Manual, for the case of two-lane roads, the difference, between truck speeds and passenger car speeds on grades, is what causes trucks to reduce the traffic volume carried by a road at any given level of service. The greater the speed difference, the greater is the reduction in any given volume, with corresponding increase in the passenger car units. Roberts (26) developed a formula to compute the PCE, for each vehicle type.

PCE (IV) =
$$\frac{\text{ROC x SPEED (1)} - \text{SPEED (IV)}}{10} + 2$$
, (3-2)

Where:

IV: the vehicle type

SPEED (1), SPEED (IV): the speeds of passenger car and vehicle type

IV respectively (in km/hr)

ROC: is the increase in PCE for each kilometer per hour difference in speed

Roberts computes ROC taking into account factors such as the number of lanes (LANES), the type of surface (SURF), and the sight distance, using the rise and fall, in m/100m, (RFF) as a surrogate: Thus:

$$ROC = \frac{SURF \times RFF}{LANES-1}$$
(3-3)

and for the case of a two-lane road, it turns out to be:

$$ROC= SURF \times RFF$$
(3-4)

For the surface types, Roberts uses indices from 1 to 3; 1 being paved or surface treated road, 2 being gravel and 3 being earth road. Considering only the surface type and the rise and fall of the road, this does not take into account the impact of the design standards of the road. Since, the other important factors in the road design standards are, besides the surface type and the sight distance, the horizontal alignment and the width of the road, it would be appropriate the introduce these as factors to determine the ROC. This is done with a road design index, RDI, taking values from 1 to 3, combining the roads surface type, the road width and the horizontal alignment. Since all these factors may be reflected in the design speed of the road, the RDI may be calculated if the design speed of the road is known. In our approach a formula is developed according to which RDI equals to 1, when the design speed is 100km/hr and to 3 if it is 25km/hr. Other values may be found through interpolation or applying the developed formula:

$$RDI = 3.67 - 0.027 \times V$$
 (3-5)

where:

V: the design speed of the road.

and, thus:

 $ROC = RDI \times RFF = (3.67 - 0.027 \times V) \times RFF$ (3-6)

Thus the RFF and the design speed of the road or the RDI must be inputs. In case that RDI is given, the design speed may be computed applying the equation:

$$V = 137.5 - 37.5 \times RDI$$
 (3-7)

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Thus, using the above approach the traffic (ADT) is measured in PCU/day. Given is also the capacity of the road (CAP) in PCU/hr both directions. Assuming the movement will take place only 16 hours per day the daily capacity of the road is computed:

$$DCAP = 16 \times CAP \tag{3-8}$$

3.6.2.2. Determining the Congestion Speeds

The ratio of the daily traffic volume and the road daily capacity

$$\frac{\text{VOLCAP}}{\text{DCAP}} \tag{3-9}$$

may be used as a measure of congestion. According to Roberts (16), if VOLCAP turns out to be less than 0.1, no congestion is likely to occur in any hour of the day. Otherwise the variable RVOL is computed as a function of VOLCAP:

$$RVOL = 1.25 \times (VOLCAP - 0.10)$$
 (3-10)

Where, RVOL represents the probability in the Bernoulli trials of and hourly volume level to be equal to the hourly volume on the link. It is assumed that the probability is the same for all volume levels. The proposed probability mass function will be applied for 4 Bernoulli trials. The levels of hourly volumes are 5, represented by VOL (IP) (IP taking values from 1 to 5).

Each volume level is defined as a percentage of the hourly capacity of the road (CAP). Thus:

$$-59-$$
VOL (1) = 0.10 x CAP
VOL (2) = 0.30 x CAP
VOL (3) = 0.50 x CAP (3-11)
VOL (4) = 0.70 x CAP
VOL (5) = 0.90 x CAP

The proposed probability mass function of the hourly volume level IP to be equal to the actual hourly volume on the link is given by:

$$VOL(IP) = \binom{4}{x} RVOL^{X} \cdot (1 - RVOL)^{4 - x}$$
(3-12)

where:

X= IP-1, the index numbers for the hourly volute levels, as used in the probability mass function.

The f(IP) is represented in figure (3-4)

The resulting frequency distribution f(IP), is used to determine the equivalent number of vehicles VEHNO (IP), travelling at each volume le-vel, (IP), according to the following equation:

VEHNO
$$(IP) = \frac{2* IP - 1}{10} * f(IP) * DCAP$$
 (3-13)

The speeds of vehicles traveling in each volume level can now be determined by the relationship (a simplified linear version of the volumespeed curves so frequent in the literature):

$$VEL = V^{*} \left(1 - \frac{VOL (IP)}{CAP}\right)$$
 (3-14)

where: V is design speed of the road.

3.6.2.3. Costs of Congestion

Having defined the VEL for each vehicle type IV, the weighted additional travel time is computed by the equation for each type IV:



Figure 3.4: Comparison of Artificial Traffic Distribution and Binomial Distribution

$$AAT(IV) = \underbrace{\frac{5}{IP=1} \left((AT (IP) * VEHNO (IP) \right)}_{ADT}$$
(3-15)

where:

AAT (IV) = weighted additional travel time of vehicle type IV AT (IP) = the additional travel time of vehicle type IV, if it was in volume level IP, given by the equation: (T being the travel time on the link without congestion):

AT (IP) = $\frac{V - VEL (IP)}{V} * T$ (3-16)

TRAF (IV) = number of vehicles of type IV

ADT = average daily traffic in PCU/day

VEHNO (IP): equivalent daily volume of level IP, in PCU/day The additional travel time is multiplied by the value of the time, to give the costs of congestion for each vehicle type.

An example of the approach is presented in Appendix 2 of this chapter.

3.7. Benefits resulting from the Improvement

Using total transport costs for the vehicle movement form origin to destination, the benefits attributable to changes in the network can be defined. They are computed by comparing the transport costs of each O-D pair after the improvement and before. The benefits are the savings, in transports costs, accruing to the network users underneath the demand curve. If the demand curve is unavailable an approximation that can be made is given by the equation:

$$BEN= \Delta \Theta \cdot T^{\circ} + 0.5 \cdot \Delta \Theta \cdot \Delta T \qquad (3-17)$$

where:

- $\Delta \Theta \cdot \mathbf{T}^{\circ}$: benefits to normal traffic (\mathbf{T}°) , after unit transport cost reduction,
- **0.5.** $\Delta \Theta \cdot \Delta T$: benefits from the induced traffic (ΔT); after the unit transport cost reduction, $\Delta \theta$

This equation is another expression of the "consumer surplus" resulting from the improvement. The induced traffic, ΔT , is the difference between the traffic before the improvement (T^{O}) and the traffic after (T').

$$\Delta T = T' - T^{O}$$
(3-18)

and thus equation 3-17 will be transformed to:

 $BEN= 0.5 * (T' + T^{\circ}) * \Delta \Theta$ (3-17a)

the familiar form of the "consumer surplus". The increase in O-D traffic will result if the demand is elastic with respect to ransport costs. Thus, if ELA is the elasticity of demand with respect to costs and Θ° , the transport costs before and after the improvement:

$$T' = T^{\circ} \cdot \left(\frac{\theta}{\theta^{\bullet}}\right)^{\circ} \qquad (3-19)$$

This is resulting from the definition of the demand function:

$$T_{i} = \mathbf{A} \cdot \boldsymbol{\Theta}_{i}^{-\mathbf{ELA}}$$
(3-20)

where:

T₁: the traffic (demand) at unit transport cost

O₁: the unit transport costs

ELA: elasticity of demand with respect to costs (positive)

A: a constant









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Figure 3.5 represents the benefits by the shaded area. It will be proved that these benefits are equal to the benefits accruing to the consumers and producers of the transported commodites, considering an one commodity transport between two regions (represented by the O-D pair), with no other transport made to share the transport. Another assumption is the indifference with respect to benefit distributions between the two regions and between producers and consumers. Furthermore, it is assumed that the commodity is produced in region B and consumed in region A.

The two regions are connected by a single road and due to the assumed abscence of competitive transport, all the volume of the commodity has to use the road-therefore the transport costs are common for each alternative improvement strategy of the road. The equilibrium between supply and demand (see figures 3.6, 3.7) before any improvement sets the per unit price of commodity in A equal to the per unit cost of production in B plus the unit transport costs (which in this case is assumed to be invariant with respect to the volume of transport measured in units of commodity). Similarly, the equilibrium between A and B equal the difference between the per unit price of the commodity in region A and the per unit cost of production of the commodity in region B. (Again the transport costs are assumed to be invariant).

Thus,

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Where:

• the unit transport costs between A and B P_A : unit price of commodity in A P_B : unit cost of production of commodity in B

Denoting by (•) the case before the improvement, and by (') the case after the improvement, we have:

$$\Theta^{\circ} = P_{A} - P_{A}^{\circ}$$

$$\Theta' = P_{A} - P_{B}$$
(3-22)

The change in unit price of commodity is A due to the improvement is:

$$\Delta \mathbf{P}_{\mathbf{A}} = \mathbf{P}_{\mathbf{A}} - \mathbf{P}_{\mathbf{A}}^{\mathbf{O}}$$
(3-23a)

since P_A° a greater than P_A^{\prime} (price reduction after the improvement), ΔR_A is negative.

The change of the unit costs of commodity in B is:

$$\Delta P_{B} = P_{B} - P_{B}^{O}$$
(3-23b)

Since P_B^{\prime} greater than P_B° (cost increase), ΔP_B is positive.

Then change in unit costs of transport are :

$$\Delta \Theta = \Theta^{\bullet} \Theta^{\bullet} \qquad (3-24)$$

since Θ' less than Θ'' (trnasport cost reduction), $\Delta \Theta$ is positive. Substituting the ϑ' and ϑ'' in the equation 3-24 from equations 3-22 the outcome is: $\Delta \Theta = \Delta P_{\Phi} - \Delta P_{\Delta}$ (3-25)

To prove that equation 3-17 gives the benefits to the consumers and producers of the two regions, figures 3.6 and 3.7 are required as reference. The price of commodity in an A falls but the cost in B rised when the transport costs fall. At the same time the volume of traffic increases from T° to T'. The increase equals the excess demand in A plus the excess supply in B. In region A, the consumers surplus $\begin{bmatrix} T^{\circ}_{+}T' \cdot \Delta P_{A} \end{bmatrix}$ is offset by the producers losses $\begin{bmatrix} -\Delta P_{A} \cdot (T^{\circ}_{+}T') \end{bmatrix}$ Therefore the benefits of region A (shown in the shaded area of Figure 3.6) are: **BENA=** $-\Delta P_{A} \cdot \frac{T^{\circ}_{+}T'}{2}$ (3-26) Similarly, in region B, a part of the producers surplus $\begin{bmatrix} \Delta P_{B} (T^{\circ}_{+}T') \end{bmatrix}$ is offset by the consumers losses: $\begin{bmatrix} -\Delta P_{B} \cdot \frac{T^{\circ}_{+}T'}{2} \end{bmatrix}$ Therefore the benefits of region B (shown in the shaded area of Fig. 3.7) are:

$$BEN_B = \Delta P_B \cdot \frac{T^0 + T'}{2}$$
(3-27)

The toal benefits for both regions are:

which is the same expression as in the one in 3-17.

These are the benefits observed when we improve a route connecting two regions. What about constructing a new road that will connect two regions, previously unconnected? It is obvious that before the construction no demand of the commodity was existed. However, a potential demand would be up to a maximum of T^{O} units of commodity; where $T^{O} = A \cdot (\Theta)^{CLA}$

 θ° being the difference between the price of commodity in region A (consuming region) and the cost of production in region B (producing region). That is: $\theta^{\circ} = R^{\circ} - R^{\circ}$ (3-21a) The new road will reduce the transport costs to and the new prices will be R^{\prime}_{a} and R^{\prime}_{a} as a result the new volume would be $T^{\prime} = A^{\circ} (\theta^{\prime})^{\circ} \in \mathbb{R}^{A}$ and the benefits will be measured as previously.

3.8 Evaluation Criterion

Using the costs and benefits computed for every alternative improvement strategy, they must be ranked as the next step is the evaluation process. There are four principal economic evaluation criteria: annual costs, benefit cost ratio, rate of return, and net present value. It must be stressed that each of these techniques has associated with it, in one way or another, an interest rate and a period of analysis, or time horizon. The net present value criterion has been introduced to the model as the evaluation criterion. With this method, present and future costs and benefits are discounted to the present and summed and the difference between the two sums in computed. Strategies having a net present value less than zero is unacceptable and that strategy with the highest net present value will be most desirable, when chossing among mutually exclusive alternatives. The reasons why the net present value is chosen as criterion instead of another, due: (i) the NPV method will always give single valued results; (ii) allows inflation costs to be considered as a component of the discount rate; (iii) provides good relative ranking among alternatives with similar cash flows. It requires, however, a reasonable choice of a discount rate, being the critical issue of the evaluation.

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-70 APPENDIX L: Example about Assignment

The following example will illustrate the effectiveness and the simplicity of the minimum cost route algorithm (3.6.1). In the figure 3.8 a network is represented with the associated vehicle operating costs on the links (it is assumed vehicle type 1) and travel times. We construct the matrices C, T, L, as follows for the different itterations.

			С								т		
	1	2	3	4	5			_	1.	2	3	4	5
1	-	4.5	107	12.0	7.0	Ī		1	-	20	107	60	30
2	4.5	-	8.0	10 ⁷	10 ⁷			2	20	-	40	10 ⁷	107
3	10 ⁷	8.0	-	5.0	10 ⁷			3	10 ⁷	40	_	25	10 ⁷
4	12.0	10 ⁷	5.0	-	5.0			4	60	107	25	-	25
5	7.0	107	10 ⁷	5.0				5 .	30	107	107	25	-
						1	2	3	4	5			
					1	1	1	1	1	1	1		
				т.	2	2	2	2	2	2			
				_	3	3	3	3	3	3			
					4	4	4	4	4	4			

5

5

5

5 5

5





1 st	st										
	1	2	3	4	5		1	2	Т З	4	5
1	[_	4.5	107	12	7		<u> </u>	20	107	60	30
2	4.5		8.0	16 5	11 5	2	20	-	40	00	50
-	7		•••	10.0		2		-	40	80	50
3	10'	8.0		5.0	10'	3	10'	40	-	25	10'
4	12.	16.5	5.0		5.0	4	60	80	25	-	25
5	7.0	11.5	107	5.0		5	30	50	107	25	-

L

	1	2	3	4	5	
1	1	1	1	1	1]
2	2	2	2	1	1	I
3	3	3	3	3	3	
4	4	1	4	4	4	
5	· 5 ·	1	5	5	5	

5

30

50

10⁷

25

2 ^{nc}	2 nd iteration: Pivot on node 2									
	1	2	3	4	5		1	2	3	4
1	-	4.5	125	12.0	7.0	1	-	20	60	60
2	4.5	-	8.0	16.5	11.5	2	20	-	40	80
3	12.5	8.0	-	5.0	10 ⁷	3	60	40	-	25
4	12	16.5	5.0	-	5.0	4	60	80	25	-
5	7.0	11.5	107	5.0	-	5	· 30 ·	50	107	25
(Co	ont.	2 nd	ite	rati	on)					
-----	------	-----------------	--------	------	-----					
	1	2	L 3	4	5					
1	1	1	2	1	1					
2	2	2	2	1	1					
3	2	2	3	3	2					
4	4	1	4	4	4					
5	5	1	5	5	5					

3rd iteration: Pivot on node 3

С

	1	2	3	4	5	
1	-	4.5	12.5	12.0	7.0	1
2	4.5	-	8.0	13.0	11.5	2
3	12.5	8.0	-	5.0	10 ⁷	3
4	12	13.0	5.0	-	5.0	4
5	7.0	11.5	107	5.0	-	5

	1	2	3	4	5
1	-	20	60	60	30
2	20	-	40	65	50
3	60	40	-	25	10 ⁷
4	60	65	25	-	25
5	30	50	107	25	1 <u></u> 1

т

L

	l	2	3	4	5	
1	1	1	2	1	1	
2	2	2	2	3	1	
3	2	2	3	3	2,	
4	4	3	4	4	4	
5	5	1	2	5	5	

,th	•				-74-
4	iteration:	Pivot	on	node	4

						т					
	1	2	3	4	5		1	2	3	4	5
1	-	4.5	12.5	12.0	7.0	1	-	20	60	60	30
2	4.5	-	8.0	13.0	11.5	2	20	-	40	65	50
3	12.5	8.0	-	5.0	10.0	3	60	40	-	25	50
4	12	13.0	5.0		5.0	4	60	65	25	-	25
5	7.0 · ·	11.5	10	5	·	5	20	50	50	25	·_ ·

			\mathbf{L}		
	1	. 2	3	4	5
1	1	1	2	1	l
2	2	2	2	3	1
3	2	2	3	3	4
4	4	3	4	4	4
5	⁻ 5	1	4	5	5

5th iteration: Pivot on node 5

		С							т		
	· ·1 · · · ·	· · · 2 · · ·		4	5		1	2	3	4	5
1	-	4.5	12.5	12.0	7.0	1	-	20	60	60	30
2	4.5	-	8.0	13.0	11.5	2	20	-	40	65	50
3	12.5	8.0	-	5.0	10.0	3	60	40	-	25	50
4	12	13.0	5.0	-	5.0	4	60	65	25	-	25
5	7.0	11.5	10.0	5.0		5	30	50	50	25	·

(cont. 5th iteration)

			L			
• •	. l	2	3	4	5	
1	1	1	2	1	1	1
2	2	2	2	3	1	
3	2	2	3	3	4	
4	4	3	4	4	4	
5	5	1	4	5	5	

Therefore the minimum cost route for each O-D pair has been found. e.g For the (2-5) pair, the vehicle operating costs are \$11.5, the travel time 50 minutes, and the route is (2-1), (1-5).

-76-APPENDIX 2: Example about Congestion

This is an example to **show** how the approach of computing congestion costs can be applied. The following data is assumed for the example:

CAP (road capacity): 2000 PCU/hr and DIS (Length): 100kms; Road Design speed: 95 km/hr; rise and fall: 3.0m/100m ; The number of vehicles per vehicle type and their speeds are:

l .		VEHI	CLE TYPES	
	1	2	3	4
Medium volume road traffice	800	400	500	400
Low volume road traffice	100	100	50	80
Speed (in km/hr)	70	60	55	50

a. <u>Road design index</u> (RDI) and road condition factor (ROC) RDI= 3.67 - 0.027 *95= 1.1

 $ROC = 3 \times 1.10 = 3.3$

b. Vehicles Equivalent factors is given by (3-2) So:

PCE (1)=1., PCE (2)=5.3, PCE (3)=6.95, PCE (4)=8.6

c.l Average daily traffic: (low volume road)

ADT = 1565 PCU/day

- d. Daily link capacity: DCAP= 16 *CAP=32000 PCU/day
- e.l Volume to capacity Vatio:

 $VOLCAP = \frac{1565}{32000} = 0.05$ less than 0.10. Therefore no congestion will occur.

c.2. Average daily traffic (Medium volume road)

ADT= 9250 PCU/day



Figure 3.9: The Traffic Distribution

e.2 <u>Volume to capacity vatio:</u> $VOLCAP = \frac{9280}{32000} = 0.29$ f. <u>Probability mass function</u> (represented infigure 3.9) RVOL = 1.25 * (VOLCAP - 0.10) = 0.2375f (1) = 1.*(1-RVOL)⁴ = 0.338 f (2) = 4* RVOL x(1-RVOL)³ = 0.421 f (3) = 6* RVOL²x(1-RVOL)² = 0.197 f (4) = 4* RVOL³x(1-RVOL) = 0.041

$$f(5) = 1 * RVOL^{3} = 0.003$$

Road design speed: V=95. VEL (1) = 95 * $(1-\frac{200}{2000})=84.6$ VEL (2) = 95 * 0.7 = 65.8 VEL (3) = 95 * 0.5 = 47. VEL (4) = 95 * 0.3 = 28.2 VEL (5) = 95 * 0.1 = 9.5

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j. Additional travel time for the vehicles of type I Additional travel times if it was at volume levels 1,...,5 AT (1)= 0. (VEL (L)) speed of vehicle type I) AT (2)= $\frac{100}{65.8} - \frac{100}{70} = 1.52 - 1.43 = 0.09$ hrs.

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AT (3) = 2.13 - 1.43 = 0.70 hrs.

-80-CHAPTER FOUR

THE NETWORK SIMULATION MODEL

4.1 Overview

The developed model generates, screens and evaluates network development strategies for a rural road networks. Given actual road network demand on an origin-destination basis, and potential demand, if road service were provided, and data on the cost and value of potential investments on network links, the model generates sequences of link investments, screens them for overall value and satisfaction of economic constraints, and allows cost-benefit analysis of the most interesting strategies. The model is integrated with the Highway Cost Model which carries out a simulation and evaluation of the investment strategies for a single link. It may deal with the individual link with the accuracy of the HCM or use more aggregate costs. Its final output may be a ranked list of network strategies, with their evaluation, and the timing of each of the link investments.

The model consists of four computer packages and their data files. The data files store network configuration and strategy data, link strategy data, and origin-destination demand data. The packages are an input data processor, the Highway Cost Model (HCM), a network strategy generator, and an evaluator which simulates the operation of the network over the analysis time span. The model simulates the construction and maintenance activities of each link by using government costs, segregated by local and foreign currency etc., developed by the



Figure 4.1.: Network simulation system flow

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HCM or elsewhere. Simulation of the network operation includes the routing of traffic, based on vehicle operating costs, using a minimum cost path criterion. The flow of information in the model is shown on figure 4.1.

The generation of network strategies, to be evaluated and ranked later, is based upon two types of constraints and a single criterion. The first constraints are limits on the timing of link strategies, the amount by which such a strategy can slip in time from its initial sequencing with the HCM. The second are constraints on the capacity for constructing and maintaining the network. Initially we included financial and skilled manpower constraints by regions of the road network. To limit and choose among the large number of remaining potential combinations of link strategies, the model, allows the analyst to assign a social criticality index for each link strategy. The criteria for choice of strategies is to maximize the cumulative criticality indices for included strategies. Only a small number of strategies are kept and evaluated at the analyst's request.

The evaluation of the network strategies follows the simulation of network performance over the time horizon during which: it finds the route of the vehicles from an origin to a distination, computes the total transport costs, compares them with those of the base strategyi.e., the network to be changed or remain the same according to a present plan-, performs the demand adjustments and computes the benefits, i.e. the savings in transport costs.

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4.2 Link simulation (HCM)

The link is simulated by the HCM over the time horizon of interest. All the activities of construction and maintenance are simulated and therefore the financial and economic costs are computed, giving the total expenditures for the road link in each year over the time horizon. Also, the HCM simulates the vehicle operation of a link according to the road conditions but not considering the presence of other vehicles on the link. The network simulation model takes the information about the vehicle operation costs and simulates the vehicle operation according to the traffic calculated to be on the link. Any delays due to possible congestion are computed and the total transport costs on the link for each vehicle type are calculated as the operation costs plus the time loss costs.

It is useful to point out that a link is composed of different segments. Each one may have different surface type, alignment etc. Each project is redated to one segment and consists of upgrating or changing the surface type, applying a certain maintenance policy. The HCM simulates the different projects on the link over time, simulates the vehicles operations on the link, then computes the resulting financial and economic costs. Note that a link strategy to be used as a term later is a series of projects over time on the link.

4.3 Network strategies generation

The purpose of each network strategy is to specify a feasible program to improve the existing network over the time horizon. The

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existing network, or base network, consists of the links, in the condition they are in the beginning of the time horizon plus any link improvements or additions, which are fully fixed and have been decided in advance by the decision makers, and not to be changed or delayed. To be feasible, it must satisfy regional budget, foreign exchange and skilled labor constraints in each year. The network strategies are generated from the link strategies introduced by the decision maker. Two types of link strategies are considered; mandatory strategies, with no restriction of when they will be implemented and optional strategies. In using these terms, we are naming the link upgrading strategies as link strategies. For a link multiple strategies may be proposed for implementation and it is up to the model to choose the one to be part of the network strategy.

The generation is coordinated with a branch and bound technique. Because of large calculation requirements, it is not looking for the best feasible solution but for a reasonable set of feasible solutions.

A network strategy is generated as follows: All obligatory links are to have one of their strategies included in the network strategy. The sum of the critical indices of the obligatory link strategies is compared with the network minimal index. If the sum is less, links from the optional set are included until either the minimum critical index is reached or there is no link left to be included. A link strategy critical index is an arbritary number set by the decision maker. It may reflect the priorities for the link strategies set by the

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decision makers. The higher it is, the more likely for the link strategy to be included in a feasible network strategy. It may merely reflect the importance of a link according to decision maker's intution, it may be set high to include a specific link and its importance of connecting remote areas, or it may reflect the importance of a link to the economic activities of an area. The network strategies minimal critical index is very important, since it prunes all network strategies with lower critical indices than it.

When the preliminary network strategy has been generated, it is tested to see that it verifies the constraints (regional budget, skilled labor and foreign exchange) for each year. If it does, then the generated preliminary network strategy is feasible, and one the strategies of the optional links will be included, but the link will be different than the ones, the network strategy consists of. If one of the constraints is not verified then the model tries to slip the last included link strategy by a number of years (not exceeding the specified maximum slippage for each link strategy) to have the constraints verified. If this can be accomplished the generated network strategy is feasible and it proceeds to generate another one. If the verification of constraints is impossible, it tries to include another link strategy, if available, of the same link, and it tests if the constraints are verified. If they are not, it slips it by a number of years (less than the allowable slippage). If the constraints are verified, it proceeds to generate another one, otherwise it tries to include

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another link strategy of the same link. If there is one, the same procedure will be repeated, otherwise it drops the link from the network strategy and tries to fit another one, repeating the same. If none of the remaining links can be fitted in the network strategy, it generates the network strategy as it is. If a link strategy is included, it searches for one from another link to be added. It repeats the same procedure until either no more links are available or no more link strategies can be included in the network strategy. Had the number of feasible network strategies equaled the number of strategies to be generated, as specified by the decision maker, the algorithm keeps the ones with the highest critical indices. However, it keeps only a specified percentage of the generated ones. These are the ones to be evaluated by the network strategies evaluator and be ranked according to their computed NPV's.

4.4. Network strategies evaluation

4.4.1 Base network strategy

The base network strategy establishes the basis for evaluation, since it is to if that strategy against which other network strategies are compared. The base network is the existing network in the beginning of the time horizon; plus link improvements or additions, which are fully fixed, decided in advance by the decision makers, not to be changed or delayed.

The base network is simulated to the same detail as other network strategies. The demand for each O-D pair may change over the years of

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the time horizon, as specified by input. This input is based on 1st year transport costs; thus, the input demand for other than the 1st year is computed from the first year applying the annual growth factors, not taking into account any change in transport costs.

4.4.2 Demand adjustments

For the base network transport demand may change over the years, if the transport costs have changed. This is the result of the demand function: (equation 3.20).

$$T=A \cdot \theta^{-ELA}$$
(4-1)

if θ changes, so will T; (since the demand is sensitive to transport price changes if the price elasticity is not zero). Therefore the new demand will be:

$$\mathbf{T}' = \mathbf{A} \cdot \left(\boldsymbol{\theta}'\right)^{-\mathrm{ELA}} \tag{4-2}$$

Since the initial demand is known, as well as the transport costs, dividing the two expressions:

$$\mathbf{T}^{\bullet} = \mathbf{T} \cdot \left(\frac{\theta^{\bullet}}{\theta}\right)^{\text{ELA}}$$
(4-3)

Where:

ELA: elasticity of demand with respect to price T,T': traffic demands before and after the improvement θ, θ' : unit transport costs before and after the improvement.

Demand adjustment will happen also when a network strategy is considered. However, this will be the outcome of change in transport costs those of base network as opposed to those of the network under

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consideration. In this case θ is the transport cost of the base network and θ ' the transport costs of the new network. The transport costs may increase if congestion occurs. Thus, the model checks if congestion exists at any link and if it does the transport cost are updated properly and the demands are adjusted.

4.4.3 Network simulation

For every network strategy the network is simulated through the time horizon having the specified characteristics and road conditions by the network strategy under evaluation. The simulation is done for these years of the time horizon, during which an improvement has been terminated or the demand at least for one O-D pair has changed. At the analyst's request the simulation may be done for any year specified by him. The benefits and the costs from one year to the other will remain the same, if no improvement has been undertaken or any change in demand structure has been noticed:

The simulation is done as follows:

a. For each link the passenger car equivalents, PCE, for every vehicle
type are computed according to the road conditions, applying equations
3-2 and 3-3.

b.1 For an Origin-Destination pair the minimum transport cost route is found for every vehicle type, and the corresponding economic and financial transport costs are computed. (The process is described in § 3.6.1).

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b.2 If the economic transport costs are greater than the price, the user is willing or could afford to pay for the transport, no traffic will be generated from the origin.

b.3 Otherwise, the traffic generated is assigned to the links that belong to the O-D pair minimum cost route. The traffic is computed in number of vehicles per vehicle type and in passenger car units, PCU, applying the computed PCE

c. The steps (b.1),(b.2) and (b.3) are repeated for all O-D pairs for which demand exists.

d.l For each link the possibility of congestion is checked. If it is not congested, no change in the already computed transport cost will be made. In case it is congested, the congestion costs, due to the additional travel time are computed, and added to the already calculated transport costs. (The process is described in § 3.6.2).

d.2 The step d.1 is done for all links of the network, thus the total transport costs for all vehicle types are calculated.

e. For each O-D pair the demands are adjusted for the new transport costs applying the equation: 4-3:

$$T' = T \cdot \left(\frac{\theta'}{\theta}\right)^{-ELA}$$

where:

- T': the new demand
- T : the demand as it would be, if the base network strategy was applied
- θ ': the new transport costs
- θ : the transport costs, if the base network strategy was applied.

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ELA: the elasticity of demand with respect to transport costs. The demand is measured in number of vehicles (in case that it is given in tons for the commodities, dividing the tons by the vehicle capacity times the load factor, we come out with the number of vehicles). If no route existed before the improvement connecting the two nodes, (O-D), θ is set to be the maximum transport costs the user is willing to pay for the transport. In the case of a commodity this maximum cost is the difference of the selling price at destination and the production costs at the origin. Having the simulation done, we may proceed to evaluate the network strategy comparing it with the base network strategy.

4.4.4 Network strategies evaluation

To do the evaluation the benefits and the cost of the network strategy must be calculated. The network strategy costs, are the economic costs associated with the activities of construction and maintenance proposed by the strategy, less those costs of the base network strategy. They are calculated for each year of simulation, remaining the same until the next simulation.

The benefits are computed for each year of the simulation, and for each O-D pair generally applying the equation 3-17:

$$BEN = \frac{1}{2} (T+T') \cdot \Delta \theta \qquad (4-4)$$

for every vehicle type. (The variables are as specified in page. The total benefits of the year are the sum of the benefits al all O-D pairs. They remain the same until the next simulation. There are some

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-91special cases to be considered in calculating the benefits:

i. If no traffic exists between an origin-destination pair, although there is potential demand, the benefits are zero.

ii. If no route existed before the improvement connecting an origin to destination, although there is potentional demand, the benefits are computed applying equation (4-3). However, instead of θ being the transport costs of the base network strategy- which in this case would be infinity since no route exists-, θ equals to the maximum price the user could affort to pay for the transport between origin to destination.

Having computed both costs and benefits the calculation of the net benefits is done:

$$NETBEN = BEN-COSTS$$
(4-5)

Finally, the net present value of benefits and costs is calculated discounting the net benefits to the present and adding them for all years:

$$NPV = \sum_{I=1}^{N} NETBEN*(1+r)^{-(I-1)}$$

where:

r: the discount rate and I: the year number.

Thus, the network strategy has been evaluated. It will be compared with the others and finally a ranking of the generated network strategies will be undertaken, the first being the one with the greater net present value. This will be the strategy recommended by our approach for implementation.

-92-The following application of the model in Ethiopia's regional network of Asela-Dodola will show its capabilities and possible limitations from the introduced assumptions.

CHAPTER FIVE

APPLICATION OF THE MODEL IN ETHIOPIA

5.1 Ethiopia

Ethiopia lies in the Horn of Africa, the north-east of the continent bordered by the Indian Ocean and the Gulf of Aden. The country is situated just north of the Equator, and is bounded to the east by Somalia and the French Territory of Afars and Issas, so that its own costline of about 1,000 kms lies on the Red Sea. Ethiopia's other neighbors are Kenya, to the south, and Sudan, to the west. (A map is provided in the next pages).

Its area is 1,220,000 square kilometres, mainly high plateaux and mountains. The official population is 26,000,000 people, and the annual growth rate ranges 2.0% to 2.6%. In terms of urban areas, there are only two cities of significant size: They are Addis Ababa, the capital with a population of 1,000,000 and Asmara with a population approaching 300,000. All other towns, including the provincial capitals, have a population of less than 50,000. With 90% of its population living in the countryside, Ethiopia is basically an agricultural country. Ethiopia's economy is to a large extent dependent on farming and cattle raising. At present, Ethiopia's main crops are teff (staple food of the Central Highlands), maize, sorghum, wheat, barley, soybeans, coffee, oil, seeds, pulses, cotton and sugar cane.

Ethiopia's major industry is construction followed by textile, food and beverage processing and marketing. Most of the industries are located in or near the three largest cities, Addis Ababa, Smora and

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🐇 Map l - Ethiopia

Diredawa. The handful of major industries not located in these cities are widely scattered and include a refinery, a cement factory, a textile mill and two sugar factories. The country's only sea ports are at Assab and Massawa.

Ethiopia's main imports are machinery, vehicles, spare parts, crude oil, rubber, electrical supplies and building materials.

5.2. Ethiopia's transport network

Ethiopia's development has been hindered by the slow improvement and growth of its transportation network. In a country that covers 1,300,00 square kilometers, the total length of its transport network of roads and railroads is limited to 30,000 kms. The country has two lines of railroad, one from Massawa to Asmara and from Djibouti to Addis Ababa. The Ethiopian Highway Authority (EHA) is responsible for the maintenance of 7,000-8,000 kms of existing all weather roads and some 16,000-20,000 kms of dry weather roads including trails made "servicable" by the provincial authorities. The EHA is responsible for the planning, supervision and maintenance of the most additions to the road system. Domestic air transportation is minimal although about 50 towns over the country are serviced. Freight movement by air is limited to coffee shipments from a few regions that lack adequate surface transportation. The bulk of air traffic is passenger.

In regard to road transportation, the majority of roads have been built to connect the provincial capitals to Addis Ababa. The country has a severe lack of penetration and farm to market roads. This is

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the result of inadequate budget and the difficult terrain as well the weather conditions prevailing in the central, west and Southwestern regions.

The Fourth Highway Program, with a planned level of investment in road construction during the second Five Year Plan of E\$140,100, 000, had actual expenditures of E\$130,100, 000, or 93% of the target. This tends, however, to mask the fact that the mileage of new roads actually constructed was under implemented by 40%. The Third Five Year Plan proposes an investment in road construction amounting to E\$250,000,000. According to the Plan provisions, the constructions of the Asela-Dodola road was to be undertaken. Our analysis and evaluation is concerned with this construction and its effect on the regions transport network.

5.3 Asela-Dodola road and the surrounding region

The Asela-Dodola project was envisioned primarily as a service road to be used by farmers in the area to deliver their products to large population center. The region the road is currently engaged in an agricultural development program which is expected to produce (or increase) surpluses in several crops. The region is now served by dirt tracks, which make it both difficult and expensive to deliver products to the markets. The EHA planned to make these markets accessible and thus spur development of the region.

For the purpose of describing the regions traffic characteristics, the area primarily affected by the road can be divided into two zones.

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Map 2 - Existing Network of Asela-Dodola Region

The first zone is about 20 kms. wide and 70 kms long stretching from Asela to Meraro. The second zone is 20 kms wide and 51 kms long, beginning at Meraro and ending at Dodola. (see Map 2).

The region which encompasses the two zones is served by a network of five roads. They are: Mojo-Shashemane, Shashemane-Dodola, Dodola-Asela, Asela-Nazreth, and Nazreth-Mojo. The Shashemane-Dodola road (76 kms) is a gravel road in good condition. The Mojo-Nazreth road (24.7 kms) and the first 16 kms.of the Nazreth-Asela road are highly designed, bituminous in good condition. The other 62 kms.of the Nazreth-Asela road is gravel and in good condition. The Mojo-Shashemane road (182 kms) is bituminous surfaced and in fair condition. The road we are primarily concerned with, Asela-Dodola, is an earth track, most of which is washed out during the rainy season. While the section from Asela to Meraro is in fair shape, the section from Meraro to Dodola is passable only with 4-wheel drive vehicles even during the dry season. It is almost impossible to travel the length of the road during the wet season; as such there is no through traffic during that part of the year. On the network, the majority of the vehicles using the link is through traffic having neither its origin nor destination within the region served. The purpose of the planned road is to provide a shorter, faster route for through traffic and provide an access to markets for the agricultural surpluses of zones one and two. The agricultural development program now in progress is expected to increase the freight traffic originating in the two zones. Also, an increase in personal income is likely to encourage more passenger traffic. The road improvement is also

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seen as part of Ethiopia's continuing effort to upgrade its transportation network.

5.4 Feasibility analysis of the road by Sauti consultants

The feasibility analysis of the Asela-Dodola road's potential for upgrading was conducted by **Sa**uti (42) in 1969 and 1970. The road had earlier been investigated by the Ethiopian Highway Authority (EHA) to determine the feasibility of upgrading the road to a gravel, secondary road (see EHA road standards, table #5.1). The information from this investigation was combined with information from the General Road Study (43) and their own investigation served as a data base for the study. The options that were to be investigated were: optimal size (feeder, secondary or primary standard), gravel vs. surface treated, optimal timing of the project and labor intensive vs. capital intensive construction. Several assumptions were made to facilitate the study. Among the assumptions were: complete information for traffic forecasts are certain, inelastic transport demand, and inclusion of only direct benefits (user savings and maintenance savings). The investigation was to cover a twenty year life of the project.

5.4.1 Construction and maintenance

As previously noted the EHA had evaluated the feasibility of upgrading the Asela-Dodola road to a gravel, secondary road. The Sauti team had this information available when their study began. After reviewing the EHA's calculation for accuracy, it was determined that these calculations could be used as a basis for estimation of earthwork. The EHA's calculations were based on a secondary road so it was necessary

		1			1			t		
Topography	· · · · · · · · ·		Flat	·····		Rolling	· · · · · · · · · · · · · · · · · · ·	1	Mountainous	
Secondary		Pri- mary	Secon- dary	Feeder	Pri- mary	Secon- dary	Feeder	Pri- mary	Secon- dary	Feeder
Design speed	(km/h)	100	90	80	80	70	60	50	40	30
Width of pavement	(m)	· · · · · · · 7 · · ·	· 6 · · · ·	. 5	7	6		. 7	6	5
Total width	(m)	8	7	6 6			6	8		
Radius: minimum	(m)	500	300	250	300	175	125	175	100	60
Radius: mirimum exceptional	(m)	300	175	125	175	100	60	100	60	40
Maximum gradient	(%)	4	4	5	4	5	6	5	6	7
Maximum excep - tional gradient	(%)	6.	8	8	7	. 9	9	8	9	10

Table 5.1 Road Design Standards

to determine the variance in earthwork quantities between primary, secondary and feeder standards roads. The variance in earthwork quantities could then be applied to determine quantities for feeder and primary roads. Investigations were made by the Sauti team to determine the unit cost of different construction operations (for gravel and for surface treatment), was also determined. These costs with that of the clearing effort gave the costs for the entire operation.

In terms of road maintenance, the Sauti team used a, estimation technique to determine the costs. The technique is an application of the conclusions of the Highway Research Board Bulletin 155, January 1956. The procedure takes into account the type of pavement, traffic intensity and the road width in determining the annual average maintenance costs on a per kilometer basis. The "basic maintenance costs" (minimum maintenance costs for a certain type surface encountered up to a certain traffic level) was determined through investigations with the EHA; this basic maintenance cost with adjustment factors for road width and traffic above a certain level produces an annual cost per kilometer for routine and periodic maintenance.

5.4.2 Traffic and vehicle operating costs

The Sauti team estimated traffic based on the traffic data of the General Road Study and the expected traffic due to an agricultural development program in the area. The increased level of production expected in the area was determined from yield/hectare estimates. The surplus was determined by subtracting from this figure, the local consumption and the loss due to spoilage and re-utilization. The surplus

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was then allocated to deficit zones in ten ton trucks to determine the increased traffic from agricultural activity. The investigating team also considered diversion of traffic from other roads in the network in their estimation of traffic. The traffic growth was presented in the form of projected average daily traffic (according to three vehicle types) for 1970, 1980, and 1990. The calculation of vehicle operating cost was through the use of "virtual lengths" of road. Information was already available for the costs of operating each vehicle type.

5.4.3 Conclusions

The Sauti team investigators concluded that the best alternative was a primary road with bituminous surface treatment for the first seventy kilometers, Asela to Meraro, and a secondary road with bituminous surface treatment for the last fifty kilometers, Meraro and Dodola. The optional opening year would be 1981 if the road was constructed with capital intensive technique and 1977 if constructed with labor intensive technique. The investigators concluded that staged construction does not improve the solution because of the slow growth of traffic and the major benefits accruing after the second stage of construction. In determining the net benefits, the benefit/cost ratio, the cost of construction and savings in user cost and maintenance were discounted to the opening year of the road. The results of the calculations using a 10% discount rate are shown below.

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Table 5.2 .a Base network Links characteristics

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Link						Cost	s (ine	\$)
	Length (kms)	Capa- city (PCU/hr)	Design speed (Kms/hr)	Rise and fall (m/100m)	Finan- cial	Econo- mic	Foreign Exchange	Skilled Labor
l: Moijo-Nazreth		2000	95	- 1 7	50,000	40,000	20,000	1,000
2: Nazreth-Asela	73	1550	75	4.8	58,000	48,000	20,000	3,000
3: Asela-Meraro	71	900	45	6.9	46,000	35,500	1,000	500
4: Meraro-Dodola	49	900	45	6.9	32,000	24,500	1,000	500
5: Dodola-Shashmene	73	1370	80	4.0	58,000	47,000	20,000	1,000
6: Shashmene-Moijo	182	1750	95	1.7	364,000	291,000	70,000	5,000

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Table 5.2.b Base Network Vehicle Operation on Links

			· · · · · · · · · · · · · ·					· · · · · · · · ·			
		CAR BUS						TRUCI	TRUCK		
No .	Link	Travel Time (in hrs.)	Finan- cial cost (inE\$)	Econ o- mic costs (in _E \$)	Travel Time (in hrs)	Finan- cial cost (inE\$)	Econo- mic cost (inE\$)	Travel Time (in hrs)	Finan- cial costs (in ^E \$)	Econo- mic costs (inE\$)	
1	Moij o- Nazreth	0.40	4.30	2,20	0.45	26,90	18,70	0.45	18.0	13.50	
2	Nazreth- Asela	1.20	15.0	7.60	1.40	61.50	42,60	1.40	42.0	30.10	
3	Asela - Meraro	1.80	23.30	14.40	2.0	104.40	79,50	2.0	68,30	56.70	
4	Meraro- Dodola	1.6	16.0	9.0	1.9	69.0	56.0	1.9	47.0	40.0	
5	Dodola- Shashmene	1.40	19.50	11.20	1.80	68.0	62.0	1.80	48.0	45.0	
6	Shashmene- Moijo	3.10	35	22	3.50	130	113	3,50	93	84	

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		Capital Intensive	Labor Intensive
Net Ben	efit (E\$)	4,817,000	5,784,000
Benefit	/Cost Ratio	2.2	2.2
Cost of	Construction		
	(financial)	6,020,000	7,139,000
	(economic)	4,174,000	5,015,000

5.5 Applications of the Model

5.5.1 Inputs

5.5.1.1 Network configuration

The network considered is the one consisting of the links Mojo-Shashemane, Shashemane-Dodola, Dodola-Meraro, Meraro-Asela, Asela-Nazreth and Nazreth-Mojo. Only links Dodola-Meraro and Meraro-Asela are to improved. The figure 5.1 represents the network with its links and nodes numbers. The network configuration inputs are handled by the Input Data Processor.

5.5.1.2 Links characteristics and strategies

Also, the link characteristics and the link strategies are handled by the Input Data Processor; however, some of the data will be provided by the HCM performing the link simulation, when its modification will be done.

Table 5.2 presents the link characteristics if the base network strategy will be applied. The characteristics, being the same for all years of the time horizon, are being presented only for year 1.



Figure 5.1: Representation of the Asela-Dodola Region's Network

Strategy Followed					T		Cost (inE \$)				
		Year(s)	Capa- city (PCU/hr)	Design speed (kms/hr)	Length (kms)	Rise and F all(m/ 100m)	Finan- cial	Econo- mic	Foreign Exchange	Skilled Labor	
1:	No change	1.20	900	45	72	6.9	46,000	35,500	1,000	500	
2:	Capital intensive techniques, Primary Road Standards	1	2000	85	72	4.5	9,640,000	6,560,000	6,508,000	1,000,000	
:		2-20	2000	85	72	4.5	142,000	113,6000	40,000	3,500	
3: (] t	Capital Intensive tech., sec. road stand.	1	1750	75	71	4.5	8,000,000	5 ,40 0,000	6,110,000	900,000	
		2.20	1750	75	71	4.5	122,000	103,000	35, <u>000</u>	3,000	
4: C t f r	Capital in- tensive	l	, 1550	60	71	4.5	6,600,000	4,40 0,000	4,60 0,000	800,000	
	tecn., feeder road standar	2-20	1550	60	71	4.5	100,000	195,000	28,000	2,500	
5:] 1 1 1 1	Labor in- tensive tech.,: primary road stand.	1 .	2000	85	71	4.5	7,630,000	5,300,000	3,800,000	500 , 000	
		2- 20	2000	85	71	4.5	130,000	105,000	30,000	1,000	

Table 5.3.a. Link #3 Characteristics, according to strategy followed

Continuation	of	Table	5.3.	à

	Cont	inuation	of Table	5.3.a					
Strategy	Years(s)	Capa-) city (PUC/hr)	Design Speed (kms/hr)	Length (kms)	Rise and Fall (m/ 100m)	Cost (inE\$)			
Followed						Finan- cial	Econo- mic	F o reign Exchange	Skilled Labor
6: Labor Intensive	1	1,750	75	71	4.5	6,400,000	4,400,000	3,170,000	400,000
Secondary Road Standards	2-20	1,750	75	71	4.5	113,000	93,000	25,000	800
7: Labor Intensive		1,550	60	71	4.5	5,3000,000	3,600,000	2,600,000	300,000
technique: Feeder Road Standards	2-20	1,550	60	71	4.5	100,000	85,000	20,000	600

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		CAR			BUS		TRUCK		
Link Stra- tegies	Travel Time (in hrs.)	Financial cost (inE\$)	Econo- mic costs (inE\$)	Travel Time (in hrs)	Finan- cial costs (inE\$)	Economic cost (inE\$)	Travel Time (in hrs)	Financial costs (inE\$)	Econo- mic costs (inE\$)
1	1.80	23.30	14.40	2.0	104.40	79.50	2.0	68.30	56.70
2,5	0.95	13.50	7.00	1.10	57.0	40.0	1.10	39.0	29.00
3,6	1.01	14.40	7.50	1.16	60.0	4 1. 50	1.16	41.0	30.0
4,7	1.30	19.0	10.15	1.50	80.0	55.7	1.50	54.0	40.0

Table 5.3.b Vehiclesoperation on link #3 according to strategy followed

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Strategy	Years(s)	Capa-					Cost (inE\$)	
Followed		city (PCU/hr)	Design Speed (kms/hr)	Length (kms)	Rise and Fall (m/100m)	Finan- cial	Econo- mic	Foreign Exchange	Skilled Labor
l: No change	1-20	900	45	49	6.9	32,000	24,500	1,000	500
2: Capital intensive technique:	1	2000	85	49	4.5	6,650,000	4,500,000	4,850,000	700,000
Primary Rd. Standards	2-20	2000	85	49	4.5	98,000	78,000	25,000	2,500
3: Capital Intensive Techniques:	1	1,750	75	49	4.5	5,500,000	3,730,000	4,200,000	500,000
Secondary Road Standards	2–20	1,750	75	49	4.5	90,000	72,000	20,000	2,000
4: Capital Intensive Technique	1	1,550	60	49	4.5	4,550,000	3,000,000	1,900,000	300,000
Feeder Rd. Standards	2-20	1,550	60	49	4.5	83,000	67,000	15,000	1,500
5: Labor in- tensive	1	2,000	85	49	4.5	5,260,000	3,640,000	2,650,000	200,000
tech., Pri- mary Rd. Standards	2-20	2,000	85	49	4.5	90,000	73,000	20,000	600

Table 5.4.a Link #4 Characteristics according to strategy followed

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Continuation	of	Table	5.4.a		
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Strategy	Years(s)	Capa-	Dogian	Longth	Dice and	andC		t (inE\$)	
Followed		city (PCU/hr)	Speed (kms/hr)	(kms)	Fall (m/ 100m)	Finan- cial	Econo- mic	Foreign Exchange	Skilled Labor
6: Labor Inten -	1	1,750	75	49	4.5	4,400,000	3,000,000	2,200,000	200,000
Tech., Secondary Road Standars	2-20	1,750	75	49	4.5	82,000	67,000	17,000	500
7: Labor Intensive Technique	l	1,550	60	49	4.5	3,600,000	2,500,000	1,800,000	100,000
Feed er Rd Standards	2-20	1,550	60	49	4.5	75,000	61,000	14,000	400

	(CAR			BUS		TRUC	CK		T
Link Stra- tegies	Travel Time (in hrs)	Finan- cial costs (inE\$)	Econo- mic costs (in E \$)	Travel Time (in hrs)	Finan- cial costs (in <u>E</u> \$)	Econo- mic costs (inE\$)	'Travel Time (in hrs)	Finan- cial costs (inE\$)	Economic costs (inE\$)	
1	1.6	16.0	9.0	1.9	69.0	56.0	1.9	47.0	40.0	
2,5	0.65	9.0	4.70	0.75	38.0	27.0	0.75	25.50	19.00	-112-
3,6	0.70	10.0	5.10	0.80	41.0	28.70	0.80	28.0	20.0	
4,7	0.90	13.0	7.0	1.02	55.0	38,50	1.02	38.0	27.30	

Table 5.4.b Vehicles operation on Link #4 according to strategy followed

Tables 5.3 and 5.4 present the characteristics of links 3 (Asela-Meraro) and 4 (Meraro-Dodola) respectively, according to the proposed link strategies. The data used in the application of the model is the same with what the Sauti consultants used, with some differences in vehicle operating costs.

5.5.1.3 Demand

The demand is given on a O-D pair basis in number of vehicles, Three types of vehicles have been considered: a 5-passengers car, a 45-50 passengers bus and a 7.0 ton-truck. The load factors, common for all O-D pairs demands, are 50% for passenger cars and 75% for bus and trucks. Also, common are: the elasticity of demand, being 1% for all vehicles types and the value of travel time being:E\$0.24/pass-hr for cars and bus and E\$.001/ton-hr for the trucks.

Table 5.5 presents the demand in vehicle numbers for each O-D pair and the maximum price the user is willing to pay for transport in $E^{/vehicle}$.

It should be noticed that the demand although shown as originating from Moijo, it is actually originating from Addis Ababa, the link Addis-Ababa-Moijo being omitted for simplicity. Furthermore, it is assumed that the traffic, having destinations at intermediate points on the links, it is not considered. The data about the data has been derived from the information provided by the Sauti report. It is given for the opening year 1977 and it is updated every 5 years. The assumptions that the demand will remain constant over the 5 year period,

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	Num	ber o	f cars		Numbe	r of	Busses		Numb	er of	Trucks	S	Maximur for tra	n price to ansport (in	be paid E\$/veh)	
O-D Pair		Yea	rs			Year	s			Yea	rs		Cars	Busses	Trucks	
	1-4	5-9	10-14	15-20	1-4	5-9	10-14	15 - 20	1-4	5-9	10-14	15-20				ļ
1-2	8	11	15	20	4	Ģ	9	.11	7	.9	13	15	8.	35.	25.	
1-3	42	60	. 75	90	20	30	45	60	30	45	60	80	30.	110.	70.	
1-4	9	12	17	22	4	6	8	10	.4	.6	8	10	50.	230.	135.	ŀ
1-5	. 7.	10	15	20	15	20	30	40	28	35	50	65	60.	250.	150.	
1-6	12	20	. 30	40	7	10	15	20	4	5	. 7	10	40.	160.	100.	
2-3	25	30	40	50	15	. 20	30	40	15	20	30	40	20.	80.	50 [°] .	
3-4	8	12	15	18	6	8	10	14	. 7	10	13	18	25.	125.	70.	
3-5	11	15	20	26	5	6	8	10	20	28	32	40	24.	166.	95.	
4-5	11	15	20	28	3	4	6	. 8	15	20	28	35	9.	70.	39.	
5-6	3	4	6	8	6	8	10	12	6	7	9	11	25.	90.	55,	

Table 5.5. Demand Between O-D Pairs

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made by the Sauti study will prevail in our study too. All inputs are handled by the Input Data Processor, i.e., they are provided exogeneously, since the interface of the system with the HCM has not yet been accomplished.

5.5.2. Network strategies generation

From the provided 7 strategies for the two links: Asela-Meraro and Meraro-Dodola and the 5 years allowable delay in implementing a strategy, the network strategies generator, comes out with 29 feasible network strategies. Each network strategy is composed of link strategies and the corresponding opening year. They are presented in Table 5.6.

5.5.3. The network strategies evaluation

Table 5.6 presents the results of the evaluation of the 29 network strategies. They are ranked according to their net present value of their costs and benefits. The NPV is given for discount rate 10% and considering as present the opening year 1977.

5.5.4. Conclusions

Our approach proposes as the best alternative, the network strategy applying labor intensive techniques for the construction of both links. When the discount rates are 10% and 12% the optimal is the one that proposes the two roads to be constructed to a secondary road design standards. However, when the discount rate is 8% the optimal alternative turns out to be the one that proposes the Asela-Meraro road to

Dault	N.S.# (as	NPV (inE\$)	Des	cription of N.S	5.	
Rank	Generated)	(Dis-	Link	3	Liı	nk 4
		10%)	L.S. #	Opening year	L.S. #	Opening year
1	29	14,438,980.	6	1977	6	1977
2	25	14,358,145.	6	1977	5	1977
3	24	14, 117,486	5	1977	6	1977
4	1	14,036,645	5	1977	5	1977
5	28	13,667,174	6	1977	3	1977
6	27	13,283,984	6	1977	2	1977
7	22	13,223,532	5	1977	3	1977
8	19	13,143,983	3	1977	5	1977
9	21	13,062,926	5	1977	2	1977
10	16	12,693,551	2	1977	6	1977
11	14	12,662,880	2	1977	5	1977
12	18	12,283,983	3	1977	2	1977
13	6	11,963,551	2	1977	3	1977
14	2	11,802,898	2	1977	2	1977
15	15	10,038,860	2	1977	5	1982
16	9	9,576,466	2	1982	3	1982
17	8	9,544,378	2	1982	3	1977
<u>1</u> 8	7	9,525,780	2	1977	3	1982
19	5	9,502,151	2	1982	2	1982
20	3	9,451,621	2	1977	2	1982
21	4	9,307,841	2	1982	2	1977
22	26	7,038,169	5	1977	7	1977
23	23	6,538,165	5	1977	4	1977
24	17	5,778,170	2	1977	7	1977
25	10	5,278,158	2	1977	4	1977
26	13	4,536,436	2	1982	4	1982
27	11	4,485,769	2	1977	4	1982
28	12	4,199,106	2	1982	4	1977
29	20	2,779,301	5	1977	1	_

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Table 5.6. Network Strategies

Explanation of symbols in page

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Continuation of Table 5.6:

Explanations of symbols:

L.S. = Link Strategy ; N.S. = Network Strategy

L.S. #1: No improvement

L.S. #2: Construction to primary road with capital intensive techniques

L.S. #3: Construction to secondary road with capital intensive techniques

L.S. #4: Construction to feeder road with capital intensive techniques

L.S. #5: Construction to primary road with labor intensive techniques

L.S. #6: Construction to secondary road with labor intensive techniques

L.S. #7: Construction to feeder road with labor intensive techniques.

be constructed according to secondary road design standards and the Meraro-Dodola road according to primary road design standards. In all cases the opening year turns out to be 1977, i.e., no delay in initial construction.

Since the first 4 best alternative network strategies have resulted close NPV's all four are included in Tables 5.7, 5.8, and 5.9, where the NPV'sare computed for 3 discount rates 8%, 10% and 12% and possible delays in initial construction are considered as new alternatives network strategies. Tables 5.7, 5.8 and 5.9 give the total discounted costs, total discounted benefits and the NPV for each network strategy.

We conclude that the optimal network strategy will propose opening year 1977 and the roads to be constructed according to secondary road design standards, since the 10% discount rate is the one more frequently applied in the evaluation of transport investment. Table 5.10 presents the traffic on the links of the network if the above network strategy is implemented.

The conclusions derived from the analysis are:

(1) The low demand for almost all O-D pairs, suggests that any change in the elasticity of demand will not increase the demand significantly. e.g. From Table 5.5., between Mojo and Asela the average daily traffic consists of 7 cars, 15 buses and 28 trucks. Considering the demand for trucks, the transport costs before the improvement were 129 E\$/vehicle. If the optimal network strategy is implemented the new transport costs will be 93.60 E\$/vehicle.

TABLE	5.	7	The	4	Best	Network	Strategies	=	1,24	,25,	,29
the second se			a second s		and the second sec					<i>.</i>	

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Discount rate: 8%

h				ана алы алы алы алы алы алы алы алы алы ал	
N.S. # Gas Generated	Ope- ning Year	Total Dis- counted costs (inE\$)	Total Dis- count Bene- fits (inE\$)	Net Pre- sent Value (inE\$)	Rank
1	1977	10,013,272	27,892,953	17,879,681	3
24	1977	9,142,776	27,008,457	17,865,681	4
25	1977	8,825,152	26,927,463	18,102,311	1
29	1977	8,127,528	26,215,814	18,088,286	2
l	1982	7,156,000	21,525,996	14,369,996	
24	1982	7,239,296	20,976,266	13,736,970	
25	1982	6,418,996	20,912,823	14,493,827	
29	1982	5,910,844	20,363,115	14,452,271	

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Table 5.8 The 4 Best Network Strategies: 1,24,25,29 Discount rate 10%

N.S. # (as Gene- rated)	Opening year	Total Dis- counted costs (inE\$)	Total Discounted costs (in E \$)	Net Pre- sent value (E\$)	Rank
1	1977	9,716,500	23,753,145	14,036,645	4
24	1977	9,026,310	23,143,796	14,117,486	3
25	1977	8,716,120	23,074,265	14,358,145	2
29	1977	8,025,930	22,464,910	14,438,980	1
1	1982	6,584,540	17,699,021	11,114,481	
24	1982.	6,116,250	17,247,462	11,131,212	
25	1000	5 007 500			
20	1982	5,907,500	17,195,010	11,287,510	
29	1982	5,439,210	16,743,396	11,304,186	

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Table 5.9 The 4 Best Network Strategies: 1,24,25,29

Discount rate: 12%

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N.S. # (as Gene- rated)	Opening year	Total dis- counted costs (inE\$)	Total dis- counted be- nefits (in <u>e</u> \$)	Net pre- sent value (in <u></u> f\$)	Rank
1	1977	9,616,600	20,619,080	11,002,480	4
24	1977	8,932,404	20,090,481	11,158,077	3
25	1977	8,628,208	20,029,991	11,401,783	2
29	1977	7,944,012	19,634,130	11,690,118	1
1	1982	6,080,580	14,696,591	8,616,011	
24	1982	5,647,566	14,321,924	8,674,358	
25	1982	5,456,232	14,278,199.	8,821,967	
29	1982	5,023,218	13,903,539	8,880,321	

Table 510 Average daily traffic on links

(Simulated by the model for the optimal network strategy 29)

Type 1977 1982 Moijo- Nazreth ars 66 93 Moijo- Nazreth ars 69 95 in PCU's 431 612 Nazreth- Asela ars 83 112 Nazreth- Asela ars 83 112 Nazreth- Asela ars ars 77 106 In PCU's 1183 1725 Asela- ars 35 49 Meraro ars 35 49 Meraro- ars ars ars ars Meraro- ars ars ars ars Dodola ars ars ars ars Dodola- ars ars ars ars ars ars ars ars ars	1987 122 92	1992
Moijo- Nazreth cars 66 93 Moijo- Nazreth function 69 95 In PCU's 431 612 Nazreth- Asela cars 83 112 Nazreth- Asela cars 83 112 Meraro- Dodola cars 35 49 Meraro- Dodola cars 35 49 Meraro- 	122 92	
Moljo- Nazreth bus 43 62 Nazreth frucks 69 95 in PCU's 431 612 Nazreth- Asela $\begin{bmatrix} cars & 83 & 112 \\ bus & 54 & 76 \\ trucks & 77 & 106 \\ in PCU's & 1183 & 1725 \\ \hline \\ rucks & 59 & 1183 & 1725 \\ \hline \\ bus & 30 & 40 \\ trucks & 59 & 79 \\ in P.C.U.'s & 658 & 1037 \\ \hline \\ Meraro-Dodola Meraro-Dodola \begin{bmatrix} cars & 29 & 40 \\ bus & 23 & 30 \\ trucks & 63 & 83 \\ in P.C.U.'s & 631 & 969 \\ \hline \\ bus & 66 & 8 \\ trucks & 6 & 7 \\ \hline \\ bus & 66 & 7 \\ \hline \\ bus & 7 \\ \hline $	92	152
Nazreth trucks 69 95 Nazreth- 33 112 Nazreth- 54 76 Asela 112 54 76 Asela 77 106 112 Asela- 633 112 Meraro $cars$ 35 49 Meraro- $cars$ 30 40 Meraro- $cars$ 29 40 Dodola $cars$ 29 40 Dodola $cars$ 33 4 Dodola- $cars$ 33 4 Dodola- 6 8 77 Dodola- 6 7 113 139		121
in PCU's431612Nazreth- Asela $\begin{array}{c} cars & 83 & 112 \\ bus & 54 & 76 \\ trucks & 77 & 106 \\ trucks & 77 & 106 \\ in PCU's & 1183 & 1725 \\ \end{array}$ Asela- $\begin{array}{c} cars & 35 & 49 \\ bus & 30 & 40 \\ trucks & 59 & 79 \\ in P.C.U.'s & 658 & 1037 \\ \end{array}$ Meraro- Dodola $\begin{array}{c} cars & 29 & 40 \\ bus & 23 & 30 \\ trucks & 63 & 83 \\ in P.C.U.' & 631 & 969 \\ \end{array}$ Dodola- Shashemane $\begin{array}{c} cars & 3 & 4 \\ cars & 3 & 4 \\ bus & 6 & 8 \\ trucks & 6 & 7 \\ in P.C.U.'s & 113 & 139 \\ \end{array}$	131	170
Nazreth- Asela cars 83 112 bus 54 76 trucks 77 106 in PCU's 1183 1725 Asela- bus 35 49 Meraro cars 35 49 Meraro- bus 30 40 Meraro- cars 59 79 Dodola cars 29 40 bus 23 30 139 Dodola- cars 3 4 bus 6 8 83 trucks 6 7 139	849	1100
Nazreth- Asela bus 54 76 heraro in PCU's 1183 1725 Asela- Meraro cars 35 49 bus 30 40 trucks 59 79 in P.C.U.'s 658 1037 Meraro- Dodola cars 29 40 bus 23 30 trucks 63 83 in P.C.U.' 631 969 Dodola- Shashemane cars 3 4 Dodola- Shashemane cars 6 8	147	182
Asela trucks 77 106 in PCU's 1183 1725 Asela- cars 35 49 Meraro cars 30 40 Meraro trucks 59 79 Meraro- cars 29 40 Dodola cars 29 40 bus 23 30 50 Dodola cars 63 83 in P.C.U.' 631 969 Dodola- cars 3 4 Dodola- cars 6 8 in P.C.U.'s 61 969	113	150
in PCU's 1183 1725 Asela- $cars$ 35 49 Meraro 30 40 Meraro- 59 79 In P.C.U.'s 658 1037 Meraro- $cars$ 29 40 Dodola $cars$ 29 40 Lucks 63 83 83 In P.C.U.' 631 969 Dodola- $cars$ 3 4 Dodola- $cars$ 3 4 Dus 6 8 139	148	195
Asela- 35 49 Meraro 30 40 trucks 59 79 in P.C.U.'s 658 1037 Meraro- $cars$ 29 40 bus 23 30 bus 23 30 trucks 63 83 in P.C.U.' 631 969 Dodola- 6 8 bus 6 8 trucks 6 8 in P.C.U.'s 113 139	2339	3079
Asela- Sus 30 40 Meraro trucks 59 79 in P.C.U.'s 658 1037 Meraro- cars 29 40 bus 23 30 trucks 63 83 in P.C.U.' 631 969 Dodola- cars 3 4 bus 6 8 8 trucks 6 7 139	67	86
Meraro trucks 59 79 in P.C.U.'s 658 1037 Meraro- Dodola cars 29 40 bus 23 30 trucks 63 83 in P.C.U.' 631 969 Dodola- Shashemane cars 3 4 in P.C.U.'s 6 8 trucks 6 7 in P.C.U.'s 113 139	56	74
in P.C.U.'s 658 1037 Meraro-Dodola cars 29 40 bus 23 30 trucks 63 83 in P.C.U.' 631 969 Dodola-Shashemane cars 3 4 Dodola-Shashemane 6 8 139	103	133
Meraro- 23 30 Dodola 23 30 trucks 63 83 in P.C.U.' 631 969 Dodola- 5hashemane 6 8 trucks 6 7 139	1180	1535
Meraro- Dodola Cars 29 40 bus 23 30 trucks 63 83 in P.C.U.' 631 969 Dodola- Shashemane cars 3 4 in P.C.U.' 631 969 in P.C.U.' 631 969 in P.C.U.' 6 8 trucks 6 7 in P.C.U.'s 113 139	FF	74
Dodola Dods 23 30 trucks 63 83 83 in P.C.U.' 631 969 Dodola-	55	
Dodola- Shashemane	44	38
Dodola- Shashemane cars 3 4 bus 6 8 trucks 6 7 in P.C.U.'s 113 139	1133	1460
Dodola- Shashemane $\begin{array}{cccccccccccccccccccccccccccccccccccc$		
Dodola- Shashemanebus68trucks67in P.C.U.'s113139	6	8
trucks 6 7	10	12
in P.C.II.'s 113 139	9	11
	181	219
		4.0
Shashemane-	30	40
Moijo bus / 10	15	20
$\frac{1}{100}$ D C H la $\frac{4}{5}$	/	

Applying the equation 3.19 about the new demand due to decrease in transport costs, we have:

$$T' = 28 \star \left(\frac{93.6}{129}\right)^{-ELA}$$

The new demand is changing as the elasticity changes:

ELA = 0. (inelastic demand): T=28 (no change)
ELA = 0.1 (elastic demand) T = 28.9 (3.2% increase)
ELA = 0.01 (approaching inelastic demand)

T = 28.09 (.32% increase)

(2) Any postponement of the initial construction is not worth it, since the traffic is at such high level that it pays to improve the road immediately.

(3) The case of constructing the road according to feeder road design standards does not have to be considered in any further analysis, since it comes up with low NPV.

(4) Congestion did not occur at any link. (It may be seen also in Table 5.10 how low the traffic is on the links).

5.6 Comparison with the Sauti study

The Sauti investigators concluded that the best alternative was a primary road for Asela to Meraro and a secondary road from Meraro to Dodola. They set opening year 1977 if the road is constructed using labor intensive techniques and 1981, if capital intensive techniques are used. Our approach concluded that the best alternative was a secondary road for both Asela-Meraro and Meraro-Dododla. This results

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from: (i) not considering any maintenance costs over the years in the Sauti study for the improved road; however ours takes them into account,

(ii) Our approach considers the demand on a O-D pair basis and computes the benefits attributed to each O-D pair; they consider demand on a link-basis and they compute the benefits resulting from the travel on the each link,

(iii) As an evaluation criterion the Sauti Consultants have used the Benefit/cost ratio; our approach uses the net present value criterion.

According to our model the alternative that the Sauti study proposes as the optimal has a NPV by E\$321,500 less than the one of the best alternative proposed by our approach. Therefore, we may conclude that both alternatives are acceptable for implementation, and it is up to the decision maker, to choose the one proposed by the approach he thinks best.

CHAPTER SIX

CONCLUSIONS, RECOMMENDATIONS

The development model has found to be a very useful tool for the network strategies evaluation. It is capable of generating the 29 most interesting network strategies, to simulate the network activities to evaluate them and to rank them. Work that may require in a consultant firm months of computation and analysis by engineers, it may be done in few minutes and with minimal expenses applying the developed model.

The presented case study showed the model's capabilities efficiency. The comparison with the Sauti study found it in a better position.

Although the model, as it has been developed, is appropriate for less developed countries, some additions would be useful. The issue of demand generation is an important one. A model may be developed to generate the demand not only according to transport costs flunctuations, but according to population growth, the per capital income changes, etc. The issue of other modes competing for the same O-D pair may be considered. As a result the demand for the O-D pair will be distributed to different modes according to the offered transport prices.

The issue of multi-regional distribution of the same commodity will complicate the model, but it would be very useful. The nature of this is that a truck may not follow the minimum cost route for each O-D pair having to distribute a payload of a commodity to more than one distribution points. It will follow the route that will maximize the revenues of the shipper (how much he is going to get selling the commodity minus the costs of transport).

Another issue to be addressed in the possible redistribution of traffic after the first assignment if congestion occurs to some links.

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However if all these are included in a model, it will become very complicated, sophisticated and hard to be applied in a less developed country, since it would require disaggregate data, sophisticated computer facilities and a lot of planning.

APPENDIX A

DRAFT USER'S MANUAL

The Network Evaluation Model consists of four computer packages: the Highway Cost Model, the Input Data Processor, the Network Strategies Generator and the Network Strategies Evaluator. A description of each and its subroutines appear in Chapter 4 and Appendix B of this document. A listing of the computer programs is presented in Appendix C.

The Network Evaluation Model (NEM) allows a user to investigate, in a searching, probing manner, the behavior of a rural highway network to the consequences of investment criteria and constraints. It is a data base system, thus allowing the user to reuse prior information and results, to change small amounts of information for sensitivity analysis, and to direct the evaluation process himself. Each processor may be applied numerous times. Constraints on this probing an minimal, and logical. Network strategies must be generated prior to evaluation, the base network against which alternative strategies are compared must be evaluated first. Demand and user cost data must be input prior to evaluation and link strategy data provided for generation. Whenever a process is executed the most recent and existing data and intermediate results are used.

1. Language Conventions for the Model's Input

The language used for the Input to NEM is a flexible problem oriented language. It allows great freedom in the ordering and presentation of input. Each communication to the computer program is given through a statement called a command. Each of these commands either supplies some data to the program or instructs it to perform some calculations on the

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data already specified, or both.

There are three basic elements that are used to make up the various commands. They are:

- (a) Integers: These are numbers that do not contain a decimal point. Examples: 1, 38, +999, -108. Possible errors (non-integers): 6.0 - This contains a decimal point 10,000 - This contains a comma. If a sign is omitted, it is assumed to be plus(+). The notation used for the integers is: i₁, i₂,..., or n₁, n₂,... in the language description.
- (b) Real numbers: These must contain a decimal point. Only normal decimals are accepted in the commands. They consist of digits only, a decimal point, and optionally a sign. Example: 6.0 3.14 -2. .003 If a sign is omitted, it is assumed to be plus(+). The notation used for the real numbers for the language description is x_1, x_2, \dots or y_1, y_2, \dots or z_1, z_2, \dots I_n some

commands integers may be used whe**re** real numbers are expected.

c) words: Various words and single letters have specific meaning as input to the models. These words may be used in commands and are not chosen by the user. They are symbols that are recognized by the processors. Words are shown in the language description in capital letters. If a word in the language description is in parenthesis, this means that the word may be omitted or included. Unless its inclusion is

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merely cosmetic, the consequences of including or omitting a word is explained in the description of the command. A word may be consisted of letters and numbers. Since the processors read only the three first character of each word, any additional characters may be omitted. Words are also used in special ways as data labels, identifying the meaning of the data value immediately following the label. For convenience, data labels may be ommitted if the standard order (given in the command description) is used. If only selected data values are given or the data is given in a different sequences, labels are needed. The one exception is that labels are not needed, if the standard order is used, but proceeds through only part of the potential input. Note: non-inputted data in a command remains unchanged from its prior value, unless otherwise stated in the command description. Labels are identified with brackets, [], in the command descriptions.

The input commands for the processors must be punched onto cards and submitted as program data. In doing so, all 80 columns of the card may be utilized, in free format. A blank and/or comma must separate each field in a command. If more than 80 columns are needed for any command, the user will use the continuation symbol \$ at the 80th column of the card and continue on the next. If the user desives to insert comments into the input data, he may punch in the column 1 of any card the \$. This card is taken as a comment card, echo printed on the output listing, and its contents.

2. Language Description for the Model's Input. Instructions for its Application

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2.1 Data Input Processor

The commands are divided into six categories:

(1) System commands, (2) Network configuration, (3) Link Characteristics, (4) Demand Input, (5) Budget input and (6) Additional minor data input commands.

2.1.1 System commands

At the beginning of a run, the user must indicate whether he wants to start accumulating data, or supplement or modifying prior data. He does so using one of the following two commands:

- INITIALIZE: performs initialization of the files and the zeroing of any previously stored data. The data input node is then assumed to be ADD.
- UPDATE: initializes without zeroing data, in preparation for new input which will add to, change or delete prior data. The ADD mode is also assumed initially. Data may be input not only to add new information to the data base, but also to change or delete prior input. An input mode is therefore identified with one of the following commands, and all subsequent input so treated until the mode is changed. CHANGE: part or all of some existing data is to be changed. If data to be changed does not exist, a warning message is given and the data added as new.

DELETE; used when the stored data is to delected.

PRINT: used to print all the data stored on the files.

FINISHED: used to terminate execution.

STORE: used to store the basic data on the files.

These commands are one-word commands; each must appear on a separate card.

2.1.2 Network Information

The network configuration is input with the NETWORK and LINK DATA commands:

NETWORK [LINKS] i, [NODES] i2 [REGIONS] i3

where:

i1: the number of links in the network
i2: the number of nodes in the network
i3: the number of regions.

Note that the words and their corresponding numbers may change order.

LINK DATA [LINK] i₁ [BEGINS] i₂ [CONCLUDES] i₃ [REGION] i₄ [FEASIBLE STRATEGIES] END

where:

 $i_1 = link number$ $i_2 = node$, where link begins $i_3 = node$, where link concludes $i_4 = region$, where link belongs $i_5 = total number of link strategies.$ The data for the link characteristics must begin with the word LINK or its number. If the user wants to change the order of the other numbers or ommit one of them, he must use, in front of all numbers, the corresponding word. Otherwise, he may ommit the words, but keep the numbers in the specified order.

END denotes the end of the command, i.e. the data about links connectivity.

2.1.3 Link Characteristics

Following is the way to input the data about: the travel time, the financial and economic costs of the vehicles travelling on the links, the costs resulting from any construction and maintenance activities on the links and the link characteristics, such as capacity, design speed and rise and fall.

LINK i_1 [STRATEGY] i_2 [INDEX] i_3 [SLIPPAGE] i_4 (n_i) ATT [V1] x_1 [V2] x_2 [V3] x_3 [V4] x_4 [V5] x_5 [V6] x_6 [V7] x_7 (n_i) EOC [V1] x_1 [V2] x_2 [V3] x_3 [V4] x_4 [V5] x_5 [V6] x_6 [V7] x_7 (n_i) FOC [V1] x_1 [V2] x_2 [V3] x_3 [V4] x_4 [V5] x_5 [V6] x_6 [V7] x_7 (n_i) FOC [V1] x_1 [V2] x_2 [V3] x_3 [V4] x_4 [V5] x_5 [V6] x_6 [V7] x_7 (n_i) [ETC] y_1 [FTC] y_2 [FOR] y_3 [SKL] y_4 (n_i) [LEN] z_1 [CAP] z_2 [RAF] z_3 [DSP] z_4

END

where: i₁ = link number i₂ = link strategy number i₃ = critical index of the link strategy

 i_4 = maximum allowable delay indicative of the strategy If not given, i_2 is assumed equal to 1, i_3 and i_4 equal to zero.

- n_i = the year number. Data need be given in the ADD mode only for years when values change. Intermediate years up to the time horizon are automatically inserted with prior year values.
- ATT = average travel time over the link in hours, for each
 vehicle type.

- FOC = financial costs of vehicle operation over the link,
 with x in \$/vehicle.
- y₁ = economic costs of construction and maintenance activities on the link in given year (in \$).
- $y_2 =$ financial costs for the same.
- $y_3 = foreign exchange costs for the same.$
- $y_A = skilled labor costs for the same.$
- $z_1 = link's length (in kms).$
- $z_2 = link's$ capacity (in PCU/hr)
- $z_3 = link's$ rise and fall (in m/100m)
- $z_4 = link's$ design speed (in kms/hr).

It should be pointed out that only the first data card for a year must contain the year. The order of the cards for a year may be altered, and not all cards given for a year. Labels must be used on the construction and maintenance cost and link characteristics cards. In the ADD mode, years must be given in accending order. Except for the header data and the years, both integer and real numbers are acceptable for the data.

2.1.4 Demand

The data about demand is given by O-D pair using the multi-statement DEMAND command.

DEMAND (0) i_1 (D) i_2

END

where:

 $i_1 = origin node$ $i_2 = destination node$ $\eta_i = the year number for the volume data.$ Volume data may be given for each vehicle type either in vehicles per day or, for truck types, in tons per day. This latter form is designated by the user by issuing a command to this effect prior to demand input. This is currently an OPTION 1 command. In the ADD node, demand volumes must be given for assending years, and after the first only for those years when values change from the previous year.

The remaining data is considered to be year independent. The elasticity is given in terms of the percentage change in demand due to a percentage change is user costs over the links. The commodity price is the maximum transportation cost that would result in any shipment between O-D pair, given in demand units. These values are used to determine whether or not a demand is likely to be fulfilled, and the consumers surplus for newly generated demands. Similarly, the time value of the transported goods, given in \$/passenger-hour and for Vl and V2, and \$/ton-hour for trucks is used for benefit calculation. Load factor are given as decimal fractions of load.

2.1.5 Budget constraints

The following command used input of budget constraints: BEDGET CONSTRAINTS REGION i_1 η_i [TB] x_1 [FE] x_2 [SL] x_3 END

where:

i₁ = region number. All budget constraints are input separately for every region, and therefore must proceed regional budget data.

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 η_{i} = year number

- $x_1 =$ Total budget available in \$, for year
- x_2 = Foreign exchange available in \$; for year
- $x_3 =$ Skilled labor available is \$, for year.

In the ADD mode, years, after the first, unchanged from the prior year for a region need not be repeated in input.

2.1.6 Additional minor data

The user must input the following data:

 The vehicle capacities, their input to be handled by the command:

VEHICLE CAPACITIES [V1] x_1 [V2] x_2 [V3] x_3 [V4] x_4 [V5] x_5 [V6] x_6 [V7] x_7

where x will be given in pass./vehicle for vehicle types 1 and 2 and in tons/vehicle for the rest vehicle types.

ii. The interest rate, to be given by the command: INTEREST RATE \mathbf{x}_{1}

where x is a percentage number (e.g. 10, for 10%)

and

iii. The time horizon, which is stated with the command: TIME HORIZON i

where i_1 the total number of years.

2.2 Network Strategies Generator

The network strategy generator takes link strategy and budget constraint data and generates interesting and feasible alternatives.

It considers three types of links, unchanged links in the base network, for which a single defined strategy is taken, obligatory links, for which one among alternate strategies must be taken (the difference might merely represent slippage), and optional links, for which one alternative strategy may be taken, or the link left unalterel. The later two links are specified with the commands

OBLIGATORY (LINKS) n₁, n₂,...

OPTIONAL (LINKS) n₁, n₂,...

where n are link numbers. For all links, the strategy 1 is assumed to be the base network.

Four data input commands are given to allow more efficient generation of alternatives. The command

SLIPPAGE (INCREMENT) i

provides an alternative to considering year by year slippage combinations. The command

MINIMUM CRITICALITY INDEX i

provides an additional pruning rule. Until the sum of the link CI's for all included links exceeds the value i, other constraints need not be checked. If, when it does exceed i, it also, exceed busget constraints, the branch in the search, may be terminated.

For efficiency, this processor generated a block of feasible network strategies at one time, rank orders these, and discards the worst. These are then replaced with more and the process repeated. The size of the block is specified with the command

NETWORK (STRATEGIES) n

taken usually to be about 100. The percentage retained after ranking is specified with

PERCENTAGE (OR) (NETWORK) (STRATEGIES) x

x being a decimal number.

Generation is performed with a command GENERATE at the n*x best strategies identified in the data use for evaluation.

2.3 Network Strategies Evaluator

With the network strategies generated, the user looks at the output, chooses those he wants to evaluate further. He does so with a series of simple, directive commands. These commands are of two types, those which cause an operation, such as the evaluation of a strategy to take place, and those which provide data for the operations.

2.3.1 Data Input Commands

The simulate command, in the form:

SIMULATE n, n₂,... (YEARS)

is used to define to the evaluation operations the year for which, at a minimum, the network must be analyzed. Results from one year will be used in subsequent years up to the next analysis year or the end of the time horizon. Intermediate analysis years will be inserted by the processor. In any year user or government costs change on any link.

The PRINT command, similarly, in the form

PRINT n₁, n₂, ... (YEARS)

is used to state years for which detailed output is to be provided. This output consists of:

1. The routing of the traffic

2. The traffic volumes or the links.

The economic and financial transport costs for
 O-D pair.

2.3.2 Operational commands

For a particular network configuration, the user compares alternatives against a base network strategy. He may do so by selectively requesting the evaluation of specific generated strategies, and even going back to the generator and, by changing some input, generating new strategies for evaluation. Prior to such evaluations, the base network must be analyzed and, if any of its conditions changed, reanalyzed. To analyze the base network the user uses the command:

ANALYZE (BASE) (NETWORK)

He may then evaluate alternatives using the command:

EVALUATE (N.S.) n;

or

```
EVALUATE ALL (n;) (N.S.)
```

where n, is a strategy number and

 n_j is the number of strategies, 1 to n_j , evaluated. Any number of EVALUATE commands may be given, and the results stred in the data base. If n_j is omitted, all saved generated strategies are evaluated. Evaluation go to the point of determining the net present value of the total costs and benefits of the alternative relative to the base network.

The RANK command, with no arguments, provides a ranked list of network strategies ordered on decreasing NPV. It considers all alter-

alternatives for which evaluation results have been stred in the data base.

3. Job Control Language Cards

The Network Evaluation Model needs the following Job Control Cards to be operational in the IPC Computer facility of MIT.

In the beginning of each one of the computer programs the JCL cards are:

//' name of the user', REGION=200K

- /* MITID (problem no, programmers no, passeword)
- /* MAIN LINES=15
- EXEC FORCGO
- // C. SYSIN DD.*, DCB=BLKSIZE=2000

At the end of the main program and before the data cards the JCL cards are:

// G.FT10F001 DD DSNAME=U.M11943. 12404. BASIC DATA
// DISP=(OLD, KEEP)

//UNIT=STORAGE, SPACE=(3600,(6))

//G.FT11F001 DD DSNAME=U.M11943. 12404. LINK. DATA, DISP=(OLD-KEEP),

// UNIT = STORAGE, SPACE=(2332,(300))

// G.FT12F001 DD DSNAME=U.M11943. 12404. DEMAND DATA, DISP=(OLD,KEEP),

// UNIT=STORAGE, SPACE=(1792,(30))

/*

// G.SYSIN DD*, DCB=BLKSIZE=2000

APPENDIX B

SYSTEMS DOCUMENTATIONS

1. System structure and file usage

The system consists of four computer packages: the HCM, the Input Data Processor, the Network Strategies Generator, and the Network Strategies Evaluator. It allows flow of input-output from one computer package to the other with the use of files, independent runs of each computer package, changes in the inputs. The system is presented in the figure B.1. All the computer packages are written in FORTRAN language and with the DEFINE FILE command, and the READ - WRITE statements for the access to the files.

There are three files with the identification numbers 10, 11 and 12, as they have been initialized in the IPC Computer facility of MIT.

1.1 File 10

File 10 stores data provided by the Input Data Processor and the Network Strategies Generator. It consists of 6 records each of 900 words length.

a, Record 1

The following variables are stored with the WRITE statement from the Input Data Processor (with the only exception of NRANK which is stored from the Network Strategies Evaluator):

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Figure B.1: Network simulation system flow

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VARIABLES	WORDS	COMMENTS
NLINK	1	Numb er of links in the network
NODE	1	Number of nodes in the network
NREG	l	Number of regions
IHORIZ	1	Time Horizon
JIM	1	Number of O-D pairs
RATE	1	Interest rate
VCAP	7	Vehicle capacities for the 7 types (in pass. for 1,2 and tons for the rest)
LBEG	30	Node where a link (x) begins
LEND	30	No de where a link (x) ends
LST	30	Number of strategies p er lin k
MDIS	30	Region where a link (\mathbf{x}) belongs
IOPT	1	Index number for option of demand data units (tons or vehicles)
COSTMA	200	A (10,20) array about annual re- regional budget constraints
FOCAMA	200	A (10,20) array about annual re- regional foreign exchange constraints
SKLAMA	200	A (10,20) array about annual re- gional skilled labor constraints
NRANK	30	Rank of the N.S. according to their NPV.

Total length of the record (actual): 794 words.

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b. Record 2

It stores only one array LLA(30,30) provided by the Input Data Processor. LLA is the link incidence matrix, giving for each node pair the corresponding link number, if it exists.

Total length of the record (actual): 900 words.

c. Record 3

It stores the array LOD(30,30) provided by the Input Data Processor. Since the Input Data Processor arbritrary assigns a number to each O-D pair, LOD facilitates to found the O-D pair given this number. Total length of the record (actual): 900 words.

d. Record 4

It stores NWSTR(30,30) provided by the Network Strategies Generator. NWSTR stores the link strategy to be implemented given the specified network strategy and the link number.

Total length of the record (actual): 900 words.

e. Record 5

It stores NWSL(30,30) provided by the Network Strategies Generator. NWSL stores the link strategy slippage to be implemented given the specified network strategy and the link number. Total length of the record (actual): 900 words.

f. Record 6

It stores TCOST(30,20), BCOST(20), IAA(30) provided by the Network Strategies Generator.
TCOST Stores the annual total costs for each network strategy.

BCOST Stores the annual total costs for the base network strategy.

IAA Stores the correspondance between the actual link number, as specified in Record 1 and the number given to each link by the Network Strategies Generator.

Total length of the record (actual): 650 words.

1.2 File 11

File 11 includes identical records of total length of 583 words. Each record stores information for each link strategy. Only ten strategies per link are permitted. The number is given to each record as follow: Assuming a link has the number: x. (Note that x should be at the most 30), and the specified link strategy is y $(1 \le y \le 10)$. The record number is then: $10 \cdot (x-1)+y$. Therefore no matter how the data of the links is provided, the record number is specified. The total number of records are 300 (30 links times 10 strategies). The data is provided partially by the HCM and by the Input Data Processor. The variables stored are:

VARIABLES	WORDS	COMMENTS
АТТ	140	A (20,7) array about average travel time on the link (assumed uncon- gested) per vehicle type, per year.
EOL	140	A (20,7) array about vehicle eco- nomic costs of operation on the link per vehicle type, per year.

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VARIABLES	WORDS	COMMENTS
FOC	140	A (20,7) array about vehicle finan- cial costs of operation on the link per vehicle type, per year.
ETC	20	Array about annual economic costs of link construction and mainte- nance according to the specific link strategy.
FTC	20	Array about annual financial costs of link construction and mainte- nance according to the specified link strategy.
SKL	20	Array about annual skilled labor costs of link construction and maintenance according to the speci- fied link strategy.
FOR	20	Array about annual foreign exchange of link construction and mainte- nance according to the specified link strategy for every year.
DIS	20	Array about link length according to the specified link strategy.
СР	20	Array about link capacity according to the specified link strategy for every year.

VARIABLES	WORDS	COMMENTS
RAF	20	Array about rise and fall of the road surface according to the specified link strategy for every year.
DSP	20	Array about the design speed of the road surface according to the speci- fied link strategy for every year.
ISTR	1	Link strategy number
NCRIT	1	Critical Index for the link strategy
NSLIM	1	Max slippage for the link strategy.

The variables CP, ISTR, NCRIT and NSLIM are provided only by the Input Data Processor. The others may be provided by the HCM.

1.3 File 12

It includes identical records of total length of 448. The data is provided by the Input Data Processor, except of the BVEC, BVFC variables provided by the Network Strategies Evaluator. The record number is assigned arbritrary to each O-D pair, however once it is set, it remains the same. The variables are:

VARIABLES	WORDS	COMMENTS
DEMAND	140	A (20,7) array about the daily de-
		mand per commodity type for the
		O-D pair. For types 1, and 2 it
		gives in vehicles, for the rest it
		depends on the options (either tons or vehicles).

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VARIABLES	WORDS	COMMENTS
ELA	7	Elasticity of demand with respect to transport costs for each commodity type.
PRICE	7	maximum transport cost per unit of com- modity, per commodity type, to be worthing the production. (\$/unit of comm.).
VALT	7	Value of loss of time for each commodity type (\$/hr.unit).
FLOAD	7	Load factor of each vehicle type.
BVEC	140	A (20,7) array about the transport eco- nomic costs of each commodity type.
BVFC	140	A (20,7) array about the transport fi- nancial costs of each commodity type, if the base network strategy was to be implemented.

2. HCM modification and interface with the system

The HCM is designed to simulate the costs of various investments strategies on a road link. It simulates: (i) the construction and maintenance activities over the time horizon of each alternative link strategy and (ii) the vehicles operation on the link.

The HCM simulates one link at a time. However, it may simulate alternative link strategies in each run. The role of the HCM in the system is the following: For each link, that either no data about costs (for construction or maintenance activities or vehicle operation)

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exists; or the link will be improved; or the link was not existed before and it will be constructed, the HCM will simulate the activities and provide (1) the financial and economic costs of the construction and maintenance activities over the time horizon, as well the skilled labor costs and the foreign exchange; (2) the vehicle operation costs (financial and economic) and the average travel time for the whole link over the time horizon according to the link strategy followed. Note that it always simulates the link for the base strategy', i.e., no activity different than the existing one up to date would take place. This data is stored on disk according to the number the link has in the network and the strategy followed. This data complemented by the data provided by the Data Processor will be input data to the Network Strategies Generator and Evaluator.

3. The Input Data Processor

The purpose of this computer package is to read the data required for the function of the system and to store it into disks for further use.

It has the capability to read from the same card words and numbers. This simplified the input of the data, minimize possible errors and allows the change of any part of the data stored. This is accomplished with the use of the SUBROUTINE MATCH, developed originally by R.D. Logcher et.al.

3.1 MATCH subroutine

MATCH is designed to be usable with FORTRAN for operations on logical input fields. The translation of a field identifies its form and meaning. MATCH reads a card into a alphanumeric array, converts each column to an integer code in a numeric array and decodes each logical field on the card. Each code number represents a character and is formed into list words by combining the code times some power of 100. Therefore each words need to be read has to be included in an integer array (to be called dictionnary) with its corresponding integer numbers. Although MATCH provides a general input capability, versatile translation requires extensive logical programming. Branching on translated words is accomplished with the "computed GO TO" statement, with the control variable determined from the position of the translated word in the dictionary. The subroutine MATCH is used by the Data Processor program, the card to be read and the dictionnary to be utilized have been specified. The MATCH gives back the word read, for the branching, or the number read.

Virtually any type of input can be performed. Even if a word is read from the card but not found in the dictionnary, and it is not neccesary to be translated, it is possible with the appropriate logic in programming for this case to makeMATCH to skip it.

3.2 Input data

Input to the Data Processor can be separated into the following types:

(i) Systems commands: The processor may handle the cases of updating

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Figure B.2: Input Data Processor - Flow Chart (Partial)











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Figure B.2: (Continued) Input Data Processor - Flow Chart

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already existed data; changing parts of it; delete portions or add others. The format is simple. One-word commands, i.e., INITIATE, UPDATE, DELETE, CHANGE, ADD.

(ii) Network Information: This data type describes the network, assigning numbers on the nodes and links; specifies the regions to be examined and the links they belong to each of them .

(iii) Budget Information: For each year the available budget, the skilled labor and the foreign exchange for each region is provided. (iv) Demand Information: Two options of demands are provided. Option 1 gives the demand in vehicle numbers. Seven types of vehicles are possible. Option 2 gives the demand in vehicle numbers for the passenger cars and buses but in tons for the rest 5 types, assuming a commodity will be transported by its corresponding vehicle (i.e. commodity, its demand given by type 3, will be transported by vehicle type 3). Demand for both options is given on an average daily basis, for each year, for each supply-demand nodes pair. (to be called origin destination pair). Also for each O-D pair the following data is provided: the elasticity of demand with respect to transport costs; the maximum transport price the operator is willing to pay (where costs equal to revenues for the vehicle's operator); the value of travel time (in \$/hr/passenger for the passenger cars and buses and in \$/hr./ton for the trucks); the load factor of the vehicles. Also the capacities of the vehicles used are specified: In passengers for cars and buses and in tons for trucks.

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(v) Link Information: Portion of this data may be provided from the HCM. This portion includes: the average travel time on the link, the link length, the design speed of the link, the rise and fall, the vehicle operating costs (financial and economic), costs of construction and/or maintenance (financial and economic). If a link have not been stimulated by the HCM this data should be provided here. The portion that has to be inputed here includes the link capacity in PCU/hour, the critical index for each link strategy (to be specified in the Network Strategies Generator) and the maximum allowable slippage in years of a link strategy.

This is the data required as input to the Network Strategies Generator and Network Strategies Evaluator. The presented flow chart of the part of the Data Processor handling the instructions about the System gives a feeling of how the computer package works: It is a branching mechanism. (Branch on each key-word). The Data Processor has the option of printing the data stored on files.

4. <u>Network Strategies Generator.</u> (Developed originally by Y. Lasage) The objective of this computer package is the generation of feasible network strategies for the improvement of a given network of roads over the time horizon. A network strategy will be feasible if it verifies the following regional constraints per year:

(i) budget (ii) skilled labor (iii) foreign exchange.

It is assumed that four kinds of links exist:

(i) link with maintenance activities (maybe no maintenance at all)

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(ii) link with activities of either initial construction or improvement; however according to a fixed strategy. (they belong to the socalled "base network").

(iii) link with mandatory activities of either initial construction or improvement; however the timing of the strategy may change (obligatory link).

(iv) link with optional activities of initial construction or improvement (optional link).

The Generator deals with (iii) and (iv) kinds of links. Base network is the original network as it is up to date to which the links of kinds (i) and (ii) are added.

The inputs to the Generator are (1) the data stored on files by the HCM and the Data Processor and (2) the desired feasible network strategies to be generated; the optional and obligatory links; a minimal network strategy critical index. The inputs (2) are read with the use of SUBROUTINE MATCH, the input formats being words and numbers.

The output is stored on files for further use by the Network Strategies Evaluator. The output consists of two matrices: matrix NWSTR will give the links and their corresponding link strategies included in each generated feasible network strategy. Matrix NWSL will give the links, and the corresponding slippage in years of their defined link strategy in matrix NWSTR, for each generated feasible network strategy.

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4.1 The approach

In order to clarify the approach we describe the treatment of link (iv). (Note that the treatment of link type (iii) is quite similar) Definitions:

i: number of the link I considered

i: maximum number of links

L: number of strategy L considered

l: maximum number of strategies

j: number of N.S.

The algorithm is the following:

STEP 1: Initialization: i=1, j=1, l=1, k'=1

STEP 2: Consider the N.S. j

STEP 3: Add the L.S. (link strategy) (i, ℓ) to NS.

-If NS, verifies the constraints set k=i Go To 4 -If NS, does not verify the constraints Go To 6

STEP 4: Set: i=i+2

If i is greater than \overline{i} Go To 5

If i is not greater than \overline{i} , make $\ell=1$ and Go To 2

STEP 5: Set j=j+i and i=k

Include in NS, all LS of NS(j-1) [LS(i, 2)] Go To 6

STEP 6: Substract LS (i, 2) from NS.

Slippage of LS (i, l) possible?

Yes: slip it and Go To 3

No: Go To 7

STEP 7: Is there another strategy available for link i?

Yes: L=L+1 Go To 3

No: Go To 8

STEP 8: Is k'=k?

No: Set k'=k Go To 4

Yes: Go To 9

STEP 9: Is k'=1?

No: k=k-1, k'=k and i=k Go To 4

Yes: END

4.2 Description of SUBROUTINES

- 4.2.1 SUBROUTINE ADDCOM (N, VBAR, V1, V2, V)
- Objectives: This subroutine computes the sum of two vectors V2 and V, taking in account a slippage of N components between the two vectors. Then it compares the sum to a vector VBAR.
 - If V1 > VBAR INDEX=1
 - Vl < VBAR INDEX=0
- N.B. V1 > VBAR if one of the components of V1 at least is greater than its corresponding component of VBAR.

4.2.2 SUBROUTINE ADDCOl (N, ABAR, Al, A2, V)

Objectives: This subroutine is similar to ADDCOM for the arrays.

4.2.3 SUBROUTINE CALCUL

Objectives: This subroutine uses ADDCOM and ADDCOl to verify that a N.S. verifies all the constraints.



Figure B.3: Network Strategies Generator Flow Chart of Subroutine CRITIC



Figure B.4. Network Strategies Generator. Flow chart of subroutine VERCAL





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4.2.4 SUBROUTINE REMEMB

Objective: This subroutine reinitializes matrices, when a N.S. does not verify the constraints.

4.2.5 SUBROUTINE REINIT

Objective: This subroutine reinitializes matrices, when a N.S. verifies the constraints.

4.2.6 SUBROUTINE RECAL

Objective: This subroutine, as REMEMB, reinitializes matrices but when the reinitalization does not concern the same number of L.S. in a N.S.

4.2.7 SUBROUTINE CRITIC

- Objective: This subroutine computes
 - a. the number of L.S. in each N.S.
 - b. the N.S. critical index from L.S. critical indices

Then it prunes the feasible N.S. with a low number of L.S. and with a low critical index.

4.2.8 SUBROUTINE VERCAL

Objective: This subroutine generates N.S. from the L.S. It operates on links.

A link may be either a link the inclusion of which is obligatory: Ll, or a link the inclusion of which is facultative: L2.

Ll have only one strategy which may be slipped by a variable number of years, L2 have as many strategies as the Decision Maker asks.

4.2.9 MAIN

Objective: The main program defines the set of obligatory and links for VERCAL. In order to do this selection, it uses a minimal critical index, and a minimal number of strategies. -164-

4.2.10 SUBROUTINE BUDGET

Objective: This subroutine computes the economic costs of base network strategy construction and maintenance activities. It substracts the financial costs from the available budget and if the resulting budget turns out to be less or equal to zero the task of generation is abadonned. It updates also the available foreign exchange and the skilled labor.

4.2.11 SUBROUTINE INITIA

Objective: Reads the data from the files and from the input cards.

4.2.12 SUBROUTINE ECRIRE

Objective: Writes the NWSTR and NWSL arrays to the records 5 and 6 of file 10 and prints out the results.

5. Network strategies evaluator

This computer package evaluate each network strategy applying the NPV criterion for the economic costs of the construction and maintenance activities proposed by the strategy and the resulting benefits.

It needs only as Input data the desired network strategies to be evaluated, chosen from the generated ones the years to be simullated and the years for which the detail results will be printed. The rest of the data is read from the files. In the event the base network has been analysed previously, it is not necessary to be analysed again, if no change has been occurred to it. The results of the analysis may be read from the file and used directly for the evaluation. Also, there is the option of keeping the ranking of previously evaluated N.S.

The provided output for each network strategy consists of:

(1) The net present value, (2) the annual benefits and costs, (3) the average daily traffic on links every year of the time horizon, (4) for each origin-destination pair the minimum cost route. Finally, a ranking of all network strategies according to their NPV is provided.

5.1 Description of SUBROUTINES

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. 5.1.1. SUBROUTINE BASENE

Objective: It simulates each year of the base network. If no change occurs the same data of the previous year is saved for this year.

> If changes occur, then it computes the new transport costs between the O-D pairs and updates the demand according to the elasticity of demand with respect to price, as follows:

DEMAND' = DEMAND*
$$\left(\frac{BVFV(I)}{BVFV(I-1)}\right)^{-ELA}$$
, where:

DEMAND: old demand DEMAND': new demand BVFV(I): transport costs of year I BVFV(I-1): transport costs of previous year (I-1).

Finally it saves the results into file 12 according to the O-D pair number.

5.1.2. SUBROUTINE ROUTE

Objective: It finds the minimum cost route of each vehicle type, computes the transport costs (both economic and financial) as a sum of the vehicle operation costs and the loss of time costs. Then it assigns the traffic on the links. The algorithm that computes the minimum cost route is described in Chapter 3.



Figure B.6: Network strategies evaluator - Flow Chart of Subroutine BASENE

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Figure B.6: (Continued) Network strategies evaluator Flow Chart of Subroutine BASENE



Figure B.7: Network strategies evaluator. Flow Chart of Subroutine ROUTE





Figure B.7: Network strategies evaluator. Flow Chart of Subroutine ROUTE



Figure B.8 Network Strategies Evaluator. Flow chart of subroutine COST.





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Figure B.8 (Continued) Network Strategies Evaluator. Flow chart of subroutine COST



Figure B.9: Network strategies evaluator. Flow chart of MAIN



Figure B.9. Network strategies evaluator. Flow chart of MAIN

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Figure B.9. Network strategies evaluator. Flow chart of MAIN

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5.1.3. SUBROUTINE COST

Objective: It checks if congestion occurs. If it does, it computes the congestion costs. (The method is described in Chapter 3). Finally, it computes the total transport costs for each O-D pair.

5.1.4 MAIN

Objective: It reads the data from the cards and the files. For each network strategy it does the evaluation. It computes for each O-D pair the minimum cost routes calling ROUTE, it computes the vehicle equivalent factors and it calls COST to do the congestion computations. It computes the benefits, applying the formula (in general form):

$$CS = \frac{1}{2} (T+T') (C-C')$$
, where:

T,C: the demand and the costs of the base network

 $T' = T \cdot \left(\frac{C'}{C}\right)^{-ELA}$ the new demand and, C' = the new costs.

Next it computes the net benefits of the year

NETBENEFITS = (TOTAL BENEFITS-TOTAL COSTS).

It discounds them to the present and it computes the NPV for all years of the time horizon.

If desired, it ranks the alternative network strategies according to their computed NPV.

APPENDIX C:

COMPUTER LISTINGS
INPUT DATA PROCESSOR

С	MAIN PROGRAM TO READ INPUT DATA FOR NETWORK EVALUATION	PGN 1000 1
	DEFINE FILE 10 (6,900,U,INF)	PGM10002
	DEFINE FILE 11 (300,583,U,LAU)	PGM 10003
	DEFINE FILE 12 (30,448,U,JINC)	PGM10004
	DIMENSION F10 (900), F11 (583), F12 (168), VCAP (7), LBEG (30), LEND (30),	PGM10005
	1LST (30), LREG (30), RAF (20), TB (10, 20), FF (10, 20), SL (10, 20), LLA (30, 30	PGN10006
	2),LOD(30,30),ATT(20,7),BOC(20,7),FOC(20,7),ETC(20),FTC(20),SKL(20)	PGM10007
	3, FOR (20), CAP (20), DEMAND (20, 7), FLA (7), PRICE (7), VALT (7), FLOAD (7),	PGM10008
	5IDICT1 (19), IDICT2 (5), IDICT3 (9), IDICT4 (7), IDICT5 (14), IDICT6 (8),	PGM10009
	6IDICT7(11), IW(10), L(10), RL(11), IDICT8(8), DSP(20)	PGM 10010
	INTEGER UED, RG	PG M10011
	REAL LEN(20)	PGN 100 12
С	WOBDS IN IDICT1: INITIALIZE, UPDATE, ADD, DELETE, CHANGE, STOP, NETWORK, TIME, LIN	K, PGN10013
С	BUDGET, DEMAND, INTEREST, VEHICLE, END, PRINT, FINISHED, OPTION	PGN 100 14
С	WORDS IN IDICT2: LINKS, NCDES, REGIONS	PGM10015
С	WORDS IN IDICT3: STRATEGY, DATA, 0, D, END, INDEX, SLIPPAGE	PGM 10016
С	WORDS IN IDICT4: TB,FE,SL,END,REGION	PGM10017
С	WORDS IN IDICT5: ATT, EOC, FOC, ETC, FTC, SKL, FOR, LEN, CAP, RAF, DSP, END	PGM 100 18
С	WORDS IN IDICT6: VOLUME, ELASTICITY, COMMODITY, TIME, LOAD, END	PGM10019
C	WORDS IN IDICT7: V1, V2, V3, V4, V5, V6, V7, VOLUME, CAPACITIES	PGM 10020
С	WORDS IN IDICT8: LINK, BEGINS, CONCLUDES, REGION, FEASIBLE, STRATEGIES	PGM10021
	DATA IDICT1/3,17,283328,403523,202323,232431,222720,	PGM 10022
	1383934,332439,392832,312833,214023,232432,283339,412427,243323,353	PGM10023
	2728,252833,343539/	PGM10024
	DATA IDICT2/3,3,312833,333423,372426/	PGN 10025
	DATA IDICT3/3,7,383937,232039,341414,231414,243323,283323,383128/	PG N10026
	DATA IDICT4/3,5,392114,252414,383114,243323,372426/	PGM 10027
	DATA IDICT5/3,12,203939,243422,253422,243922,253922,383031,253437,	PGM10028
	1312433,222035,372025,233835,243323/	PGM10029
	DATA IDICT6/3,6,413431,243120,223432,392832,313420,243323/	PGM10030
	DATA IDICT7/3,9,410114,410214,410314,410414,410514,410614,410714,	PGM10031
	14 13 4 3 1, 2 2 20 3 5/	PGM10032
	DATA IDICT8/3,6,312833,212426,223433,372426,252420,383937/	PGN10033
	JIM=?	PGM 10034
	IOPT=0	PGM10035
	DATA F1C/900*0./	PGM10036
		PAGE 1

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	DATEA ET1/593×0 /	55 x 4 () () 7
	BATA P17/169*0 /	PGMTU037
		PGM10038
		PGM10039
		PGM 10040
		PGM10041
	DATA LS1/3U*0/	PGM10042
	DATA = LREG/30*0/	PGM 10043
	DATA = LIA/900 = 0/	PGM10044
		PGM10045
	DATA TB/200*0./	PG M1 0 0 4 6
	DATA = FE/200*0./	PGM 10047
~	DATA SL/200*0./	PGM10048
Ç	EXECUTION BEGINS.	PGM 10049
0	FIND THE FIRST WORD OF THE CARD	PGM10050
	10 LAPG = 1	PGM10051
	CALL MATCH (ITYPE, IDICT1, K, RK, LARG)	PGM 10052
	GC TO (10,11,11,11,12,45), I TYPE	PGM10053
	11 GO TO 2001	PGM10054
	12 IK1=K	PGM10055
	GO TO (15,50,100,105,11C,3000,150,200,250,400,500,800,850,10,40,45	PGM 10056
	1,900),IK1	PG M1 0 05 7
С	INITIATE COMMAND. ZERO ALL RECORDS.	PGM 10058
	15 UPD=0	PGN10059
	DO 20 INF=1,3	PGM10060
	WRITE(10 'INF) F10	PGM 10061
	20 CONTINUE	PGM10062
	DO 30 $JIMC=1,30$	PGM10063
	WRITE (12* JIMC) F12	PGM1)064
	30 CONTINUE	PGM 10065
	GC TO 10	PGM10066
	40 CALL GRAPHE	PGM 10067
	GO TO 10	PGM10068
	900 LAEG=0	PGM10069
	CALL MATCH (ITYPE, IDICT2, K, RK, LARG)	PGM10070
	GC TC (10,911,910,900,900), ITYPE	PGM10071
	910 K=RK	PGM 10072
		PAGE 2
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911 ICFT=K	PGM 10073
GO TO 10	PGM10074
C IF UPDATE OCCURS: PUT IN CORE ALL BASE DATA	PGM10075
50 UPD=1	PGM10076
INF=1	PGM10077
READ (10 ' 1) NLINK, NODE, NREG, IHORIZ, JIM, RATE, VCAP, LBEG, LEND, LST, LREG,	PGM10078
1TB,FE,SI,IOPT	PGM10079
READ(10'2)LLA	PGM10080
READ (10 · 3) LOD	PGM10081
GO TO 10	PGM 10082
CCC CEECK FOR TYPE OF UPDATE	PGM10083
100 MOD=0	PGM 10084
GO TO 10	PGM10085
105 MOD=2	PGM10086
, GO TO 10	PGM10087
101 DO 25 IAU=1,300	PGM10088
WRITE(11'LAU)F11	PGM10089
25 CONTINUE	PG N1 0090
GO TO 10	PGM 10091
110 MOD=1	PGM10092
GO TO 10	PGM 10093
C EXECUTION TERMINATED	PGM10094
3000 WRITE (1011) NLINK, NODE, NREG, IHORIZ, JIM, RATE, VCAP, LBEG, LEND, LST, LREG	PGM10095
1, TB, FE, SL, IOPT	PGM10096
WRITE (10 ⁺ 2) LLA	PGM13097
WRITE (10'3) LOD	PGN10098
GO TO 10	PGM 10099
45 CONTINUE	PGM10100
CALL EXIT	PG M 10 10 1
C INFORMATION ABOUT THE NETWORK	PGM10102
150 KK=0	PGM10103
L(1)=0	PGM 10 10 4
L(2) = 0	PGM10105
L(3) = 0	PGM10106
$I \mathbb{R}(1) = 1$	PGM 10 10 7
IW (2) =2	PGM10108
	PAGE 3

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		IW(3) = 3	PGM10109
	160	CALL MATCH (ITYPE, IDICT2, K, RK, 0)	PGM10110
		GO TO (165, 185, 2005, 2005, 190), ITYPE	PGM10111
	165	IF (KK.EQ.0) GO TO 2005	PGM10112
		IF (UPD. EQ. 0) GO TO 180	PGM 10 113
		DO 175 I=1,3	PGN10114
		IF(L(1),EQ,0) GO TO 171	PGM 10 115
		N I I N K = I (1)	PGM10115
	171	IF (L(2).EQ.C) GO TO 172	PGM 10 117
		NODE = L(2)	PGM10118
	172	IF (L (3) . EO. 0) GO TO 175	PGM10119
		NREG=L(3)	PGM10120
	175	CONTINUE	PGN10121
		GO TO 10	PGM 10 122
	180	NLINK=L(1)	PGM10123
		NODE = L(2)	PGM 10 124
		NREG=L(3)	PGM10125 났
		GO TO 10	PG M10 126 9
	185	K K = K K + 1	PGM 10 127
		$\Gamma(IM(KK)) = K$	PGM10128
		GO TO 160	PGM10129
	190	$I \mathbb{M} (KK+1) = K$	PGM10130
		GC TO 160	PGM 10 13 1
С	INFO	ORMATION ABOUT THE TIME	PGM10132
	200	CALL MATCH (ITYPE, IDICT2, K, PK, O)	PGM 10 133
		GO TO (10,205,2010,200,200),ITYPE	PGM10134
	205	IHORIZ=K	PGM10135
		GO TO 10	PGM 10 136
C	INF	ORMATION ABOUT THE LINKS. CONSTRUCTION OF MATRICES INDICATING OF	PGM10137
С	WHI	CH NODES A LINK IS BOUNDED.	PGM10138
	250	CALL MATCH (ITY PE, IDICT3, K, RK, 0)	PGM10139
		GO TO (260, 1000, 2015, 2015, 255), ITYPE	PGM 10 140
	255	IF(K.NE.2) GO TO 2015	PGM10141
	260	LAFG=1	PGM 10 142
		K K = 0	PGM10143
		L(1) = 0	PGM10144
			PAGE 4

		L(2) = 0	PGM10145
		L(3) = 0	PGM 10 146
		L (4) -0 T (5) -1	PGM10147
2	65	L())-1 CALL MARCH/IMADE IDICED & DE IDICE	PG M 10 148
2	0.7	CALL BAICD (ITIPE, LDICT3, K, KK, LAKG)	PGM10149
2	70	$V_{R} = V_{L,1}$	PGM10150
2	10		PGM 10 15 1
2	75	L(NR) - R	PGM10152
2	13		PGM 10 15 3
n	<u>م</u> م		PGM10154
2	σu	LF(K.NE.5) GU TU 275	PGM10155
r	~ ^	GO TO	PGM 10 156
.5	0.0	$\frac{1F(KK,EQ,C)}{GC} = \frac{GC}{20} = \frac{2020}{C}$	PGM10157
2		1F(UPD.NE.U) GO TO 347	PGM10158
	01	$LF(L(1) \cdot EQ \cdot U \cdot OR \cdot L(2) \cdot EQ \cdot C \cdot OR \cdot L(3) \cdot EQ \cdot O)$ GO TO 2020	PGM10159
3	05	LINK=L(1)	PGM 10 16 0
		KO = L(2)	PGM10161
		KD=L(3)	PGM10162
		LLA(KO, KD) = LINK	PGM10163
		LLA(KD, KC) = LINK	PGM10164
		LBEG(LTNK) = KO	PGM10165
		LEND (LINK) = KD	PGM10166
		LBEG(LINK) = L(4)	PGM 10 167
		LST(LINK) = L(5)	PGM10168
		GO TO 260	PGM10169
.3	40	IF (MOD.EQ.0) GO TO 301	PGM10170
		IF (L (1) . EQ. 0 . OR. L (2) . EQ. 0 . OB. L (3) . EQ. 0) GO TO 2020	PGM10171
		LTNK=L(1)	PGM10172
		KO = L(2)	PGM10173
		KD=L(3)	PGM 10 174
		KLINK=LLA (KO, KD)	PGM10175
		MLINK=LLA (KD,KO)	PGM10176
		IF (KLINK. EQ. LINK. OR. MLINK. EQ. LINK) GO TO 350	PGM 10 177
C L	INK	TS A DIFFERENT THAN WHICH CUGHT TO BE. ERASE PECORDS OF KLINK	PGM10178
		$I = 10 \times (KLINK - 1) + 1$	PGM10179
		DO 342 1-1 583	
			PGM7(778()

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F11(J) = 0.	PGM10181
342 CONTINUE	PGM10182
II=I+9	PGM 10 18 3
DO 345 IAU=I,II	PGM10184
WBITE(11*LAU)F11	PGM 10 185
345 CONTINUE	PGM10186
350 IF(L(4).NE.0) GO TO 355	PGM 10 187
L(4) = LBEG(LINK)	PGM10188
355 IF (L (5).NE.0) GO TO 305	PGM10189
L(5) = LST(LINK)	PGN10190
GC TO 305	PGM10191
C INFORMATION ABOUT BUDGET CONSTRAINTS (TOTAL BUDGET, FOREIGN	PGM10192
C EXCHANGE, SKILLED LABOR)	PGN10193
400 KK = 0	PGM 10 194
BL(1) = ○ .	PGM10195
RL(2) = 0.	PGM10196
RL(3) = 0.	PGM10197 上
IW (1) =1	PGM10198 S
IW(2) = 2	PGM 10 199
$I \mathbb{K}(3) = 3$	PGM10200
CALL MATCH (ITYPE, IDICT4, K, RK, 1)	PG M 10 20 1
GO TO (2025,410,2025,2025,405),ITYPE	PGN 10 20 2
405 IF (K.EQ.4) GO TO 10	PGM10203
IF(K.NE.5) GO TO 2027	PGM10204
CALL MATCH (ITYPE, IDICT4, K, RK, 0)	PG M1 02 05
GO TO (2027,406,2027,2027,2027),ITYPE	PGM 10 20 6
$4 \bigcirc 6$ RG=K	PGM10207
GO TO 400	PGM 10208
410 IYR = K	PGM10209
415 CALL MATCH (ITYPE, IDICT4, K, RK, 0)	PGM10210
GO TO (420,450,452,2025,460),ITYPE	PGM 10 2 1 1
420 IF (KK.EQ.0) GO TO 2025	PGM10212
DO 440 KKK=1, KK	PGM10213
I = I H (K K K)	PGM10214
GC TO (425,430,435),J	PGM 10215
425 TB(RG, IYR) = RL(1)	PGM10216
	PAGE 6

	GO TO 440	DCN10217
430	FE(RG, IYR) = RL(2)	DCM10217
	GO TO 440	
435	SL(RG, TYR) = RL(3)	PGB10219
440	CONTINUE	PCM 10220
	TF(UPD, EO, O) GO TO 470	PGM 10221
	TF(MOD, NF, 0) GO TO 400	PCM10222
470	CONTINUE	PGH10225
		PGH 10224
	DO 480 T = TT 20	PGR10225
	TB(RG,T) = TB(RG,TYR)	PGR10220
	FE(RG, T) = FE(RG, TYR)	PGB1022 /
	SI(RG, T) = SI(RG, TYR)	PGH 10228
480	CONTINUE	PGM10229
		PGd 10230
450	5K = K	PG410231
450	KK = KK + 1	PGa10232
494	DI (TU (VK)) - DV	PGM 10233
	$\frac{dL}{dN} \left(\frac{dN}{dN} \right) = \frac{dN}{dN}$	PG M 10 2 3 4
060	TU (VV11) - V	PGM 10235
₩ ₹3)(j)		PGE10236
C TNP	ער טער האאתיה קינית היניסער איר איר	PGM 10237
U 105 E00	VERTION ADOUT THE UNHAND	PGM10238
976 47 7 7	ANTU ARRANG TH CORR	PGM 10 239
C LLR	DO 700 I-1 20	PGM10240
	DO 700 I=1,20	PG M 10 2 4 1
	DO = 690 = 1, 7	PGM 10 24 2
c 0 0	$DEMAND\left(1,\mathbf{J}\right)=0.$	PGM10243
690 690	CONTINUE	PGN10244
/uo	CONTINUE	PGM10245
	DO /10 I=1,7	PGM 10246
	ELA(I)=0.	PGM10247
	PRICE(I) = C.	PGM 10 248
	VALT(I) = 0.	PGM10249
	FLOAD(I) = 0.	PG N 10 2 5 0
7 1 2	CONTINUE	PGM 10 25 1
505	CALL MATCH(ITYPE,IDICT3,K,RK,0)	PGM10252
		PAGE 7

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8 HOAG	
PGM10288	CO LO (050°020°025°5000°000) LIXEE
L820LW9d	610 CALL MATCH (ITYPE, IDICT7, K, RK, 0)
BGM 10286	COD IXE=K
bCW10582	C BEVD DVLV ZEL OF VOLUME BETWEEN C-D PAIR.
6871058t	GO LO (5032°602°5032°5032°610)°11X55
60 J 05 83	CALL MATCH (ITYPE, IDICT6, K, RK, 1)
DEW10282	eos ccalinte
EGM10281	C = (I) MI
DGM10280	BL (I) =0.
6LZ0LW3d	L'L=I 809 00
5 CW 10518	600 KK= Ú
ELL TO LIGHT LOS LL	C START READING THE CAEDS WITH THE DATA
PC201MDd	CL OL OD
5LZOLN94	MELTE(12.1IMC) F12
bLZOLWBA	E CONIINOD SHS
ECM10273	E12(I)=0.
PGM10272	891'L=I StrS OD
PGM10271	ETO CONLINDE
DCL201NBG	SOS OT OD
DEM10269	232 K0=K
6GN 10 268	60 IO 505
EGM1 03 6 7	$\mathbf{K}\mathbf{D} = \mathbf{K}$
66W10266	IF(KK.FQ.1) GO TO 535
bew105e2	230 KK = KK + J
D GW 1026 th	GO TO 600
EGW10263	READ(12'JIMC) DEMA ND. ELA. FRICE, VALT. FLOAD
6410363	JIMCJ=JIMC
PGM10261	212 IL (WOD'EO'S) CO LO 200
DSCN10260	rod(ko·kd)=11wC
6220LM3d	IIWC=1IW
85C0LWDd	L+WIC=WIC
	IE (JIWC NE 0) GO TO SIS
99COLWDd	JIWC=FOD(KO*KD)
SSCULNUD	IE(DD ·EO·O) CO TO 600
	210 IF(KK.RO.C) GO TO 2030
PGM10253	GO LO (210°230°5030°5030°202) ILX BE

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62) IF (KK.EQ.0) GO TO 2040	PG M1 02 3 9
	DO = 625 KKK = 1, KK	PGM10290
	IK=IW(KKB)	PGM10291
	DEMAND(IYF, IK) = RL(IK)	PGN 10292
625	5 CONTINUE	PGM10293
62	8 IF (UPD. EQ. 0) GO TO 630	PGM10294
	IF (MOD.EQ.1) GO TO 600	PGN10295
63) II=IYR+1	PGM10296
	DO 640 I=II,20	PGM10297
	DO 635 KK=1,7	PGM10298
	IF(RL(KK).E0.0.) GO TC 635	PGM 10 29 9
	DEMAND (I, KK) = DEMAND (IYE, KK)	PGM10300
631	5 CONTINUE	PGM 10 30 1
64 (CONTINUE	PGM10302
	GC TO 600	PGM10303
659	$\mathbf{B} \mathbf{K} = \mathbf{K}$	PGM 10 30 4
£51	? KK=KK+1	PGM10305 I
	IF(IW(KK).NE.)) GO TO 655	PGM 10306 6
	IM(KK) = KK	PGM10307 T
655	5 RL(IW(KK)) = RK	PGM 10308
	GO TO 610	PGM10309
56) IF(K.EQ.8) GO TO 610	PGM10310
	I W (KK+1) = K	PGM 10 31 1
	GO TO 610	PGM10312
C BRI	ANCH ON WORD TYPE IN DATA SFT.	PGM10313
C ENI	D OF DATA FOR 0-D PAIR.	PGM10314
67() TK 1 =K	PGM 10 3 1 5
	GO TO (2040,720,750,780,760,675),IK1	PGM10315
C UPI	DATE THE RECORD NUMBER. STORE IN THE RECORD THE DATA	PGM 10 317
6 7 "	5 IF (UPD.NE.)) GO TO 680	PGM10318
	JIM=JIM+1	PGM 10319
	JIMC=JIM	PGM10320
	LCD (KO, KD) = JIMC	PGM10321
	GO TO 685	PGM10322
680) JIMC=JIMC1	PG M 1 0 3 2 3
681	5 WPITE(12'JIMC) DEMAND, ELA, PRICE, VALT, FLOAD	P GM 10 324
		PAGE 9

GO TO 10	DC#10335
C DATA ABOUT ELASTICITY OF DEMAND	EUBIUJZD DCM10325
720 CALL MATCH (ITYPE, IDICT7, K, PK, 0)	E GE 10320 DOM 10327
GO TO (725,740,742,2045,748), ITYPF	EGH10327
725 TF (KK.EO.0) GO TO 2045	
DO 730 KKK=1,KK	PGH 1032 9
IK = IW(KKK)	PG810330
ELA(IK) = RL(IK)	PU110311
730 CONTINUE	PGM 10332
GO TO 600	PGM10333
740 RK=K	PGM 10 334
742 KK=KK+1	PGM10335
IF(TW(KK), NE, 0) GO TO 745	PG 10 33 5
IW(KK) = KK	PGM10337
745 $RL(TW(KK)) = RK$	PGM10338
GO TO 720	PGM 10 3 3 9
748 IW(KK+1) = K	PGMT0340
GO TO 720	PGM 10341
C DATA ABOUT CONMODITY PRICE	PGM10342
750 CALL MATCH (ITTYPE TDICTT K RK O)	PGM10343 ឝ
GO TO (755, 770, 772, 750, 778) T T T T T T T T T T T T T T T T T T T	PGM10344
755 TF(KK, EO, O) GO TO 2050	PGM10345
DO 758 KKK=1.KK	PGM10346
	PGM10347
PRTCP(TK) = RL(TK)	PGM 10 348
758 CONTINUE	PGM10349
GO TO 600	PGM 10350
770 BK=K	PGM10351
772 KK=KK+1	PGM10352
$T \mathbf{F} \left(T \mathbf{W} \left(\mathbf{K} \mathbf{X} \right) \right) \mathbf{N} \mathbf{F} \left(\mathbf{O} \right) \mathbf{T} \mathbf{O} \mathbf{T} \mathbf{T} \mathbf{F} \left(T \mathbf{W} \left(\mathbf{K} \mathbf{X} \right) \right) \mathbf{N} \mathbf{F} \left(\mathbf{O} \right) \mathbf{T} \mathbf{O} \mathbf{T} \mathbf{T} \mathbf{F} \mathbf{F} \left(\mathbf{T} \mathbf{W} \left(\mathbf{K} \mathbf{X} \right) \right) \mathbf{N} \mathbf{F} \mathbf{O} \mathbf{T} \mathbf{T} \mathbf{F} \mathbf{F} \mathbf{T} \mathbf{F} \mathbf{T} \mathbf{F} \mathbf{T} \mathbf{T} \mathbf{F} \mathbf{T} \mathbf{T} \mathbf{T} \mathbf{F} \mathbf{T} \mathbf{T} \mathbf{T} \mathbf{T} \mathbf{T} \mathbf{T} \mathbf{T} T$	PGM10353
$\mathbf{T} = \{\mathbf{T} \in \{\mathbf{T} \in \mathbf{V}\} \land \mathbf{V} \in \mathbf{V}\} (\mathbf{T} \in \{\mathbf{T} \in \mathbf{V}\} \land \mathbf{V} \in \mathbf{V}\} (\mathbf{T} \in \{\mathbf{T} \in \mathbf{V}\} \land \mathbf{V} \in \mathbf{V}\}$	PGM10354
$\frac{2\pi(\pi A) - \alpha E}{775} = 1 (\pi R) (\pi R) - \rho R$	PGM10355
$\frac{1}{7} \frac{1}{7} \frac{1}{5} \frac{1}$	PGM10356
778 TU(KK+1) = V	PGM 10357
$\frac{1}{10} \frac{1}{10} \frac$	PGM10358
	PGM10359
C NULT ADCAT AVTAN CG 工工規程	~ PGM10360
	PAGE 10

LL EVGE 11	
DEWD4	GC TO (10,810,815,800,800,800,000 OT 05
BGRJ0332	800 CVTF WVICH (ILKES'R'BK'U)
t6E0LW9a	C INTREST PATE
E6E01W9d	60 IO 160
5CW10365	763 IM(KK+1)=K
LGEOLNDJ	CO IO 160
D6E0LW Dd	191 BT (IM (KK))=BK
58E0LN9d	IE(KK) = KK
BBEOLN Dd	IE (IM (KK) * NE*C) 30 IO 192
L8E0L0381	166 KK=KK+1
Der 10386	765 BK=K
DEWIG	GO TO 600
PGM10384	EINIINOD #9L
E8E0LN9a	EIOVD(IK) = ET(IK)
D CW 10 38 5	IK=IM(KKK)
PGM10381	DO 164 KKK=1*KK
5 GWJ 03 8 O	JEI IE(KK·EO·O) CO EO SOZJ
64010319	EGTT. (761,765,766,760,768), ITTPE
BEBLASS	760 CALL MATCH(ITYPE,IDICT7,K,RK,0)
LLEOL BE	C DVLV VBOAL FOVD EVCLOSE
9LEOLW 9d	C L 0 L 05
SLEOLNDA	798 IM(KK+1)=K
tleolw ba	00 L0 180
ECENT0373	195 BT (IA(KK))=EK
EGM10372	IM (KK) = KK
LLEOLWDa	IE (IM (KR) • NE•0) CO LC 192
DCW10310	792 KK=KK+1
69E0LW5d	790 RK=K
89ECLW5a	009 UL 05
	IDNILNOD S8L
99EULNDd	AVTL(IK) = BT(IK)
SAFOL MAG	IK=IM(KKK)
7960 LNDd	DO 182 KKEJ KK
E YE UL NDd	781 IF(KK.FQ.0) GO TO 2055
C9E0LNDd	GO TO (781,790,792,780,798), ITYPE
LAFOLMOG	780 CALL MATCH(ITYPE, IDICT7.K.RK.O)

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810 RK=K	PGM 10397
815 RATE=RK	PGM10398
GC TO 10	PGM10399
C VEHICLE CAPACITIES	PGM10400
850 KK=0	PGM10401
DC 860 I=1,7	PGM 10402
RL(I) = 0.	PGM10403
IW(I) = 0	PGM 10404
860 CONTINUE	PGN10405
865 CALL MATCH (ITYPE, IDICT7, K, RK, O)	PGM10406
GO TO (870,880,885,2060,890),ITYPE	PGM 10 40 7
870 IF (KK.EQ.C) GO TO 2060	PGM10408
DO = 875 KKK = 1, KK	PGM10409
IK=IW (KKK)	PGN1041 0
VCAP(IK) = PL(IK)	PGM 10 4 1 1
875 CONTINUE	PGM10412
GO TO 10	PGM 10413
880 RK=K	PGM10414
835 KK=KK+1	PGM10415 မိ
IF(IW(KK).NE.O) GO TO 888	PGM10416
IW(RK) = RK	PGM10417
888 RL(IW(KK)) = RK	PGM 104 18
GO TO 865	PGM10419
890 IF(K.EO.9) GO TO 865	P GM 10 4 20
$I \in (KK+1) = K$	PGM10421
GO TO 865	PGM10422
C DATA ABOUT LINK CHARACTERISTICS.	PGM10423
C FIND LINK NUMBER AND STRATEGY NUMBER.	PG M 10 4 2 4
1000 LINK=K	PGM10425
DC 1088 I=1,20	PGM10426
DO 1085 J=1,7	PGM 104 27
ATT(I, J) = 0.	PGM10428
EOC(I, J) = 0.	PGM 10 4 2 9
POC(I,J)=0.	PGN10430
1985 CONTINUE	PG M 10 4 3 1
1088 CONTINUE	PGM 10432
	PAGE 12

EV EE 13 8910LN9a DO 1030 I=1'283 L9toLW9a IE (WOD 'NE'S) CO LO JOHO 99h0LW9d IF(UPD.EQ.0) GO TO TO41 S9h0LW9d LAU2=LAU h9h0LW9a 1052 TVN=10* (TINK-1)+IZLB E9h0LW9d C FIND THE RECORD NUMBER. FEAD DATA FROM FILE IF UPDATE 5900LW98 L=(L)] L9n0LW9d 1051 IZE=1 0970LW9d CO LO 1652 6910LN9d (L) J=HISI 1020 IE(r(1) .EQ.0) BGHOLW98 1051 ΟĽ 09 LSHOLWDA 2001 01 09 95tolW9a JOJZ IM(KK+J)=K SSHOLNOd CO TO 1005 $\Gamma(IM(KK)) = K$ hShOLWDa ESHOLW9a JOJO KK=KK+J GO TO (1020, 1010, 2065, 2065, 1015), ITYPE 5GHJOH25 1005 CALL MATCH (ITYPE, IDICT3, K, RK, 0) LSHOLWDa 1001 CONTINUE 0 = (I) MI8 th to LN 9d 0=(I)I LAHOLWOJ $L^{\prime}L = I LOOL DU$ 9th0LW9d $\mathcal{C} = \mathcal{X} \mathcal{X}$ Sthulwod 0=HTRI thttolw9d U=WI'ISN ENHOLNDA ACE IL=0 2 th to L W9 d 1000 CONTINUE Ltho LW 9d 0 = (I) = 0Othol Wod .0=(I) 3AE 6EHOLN94 · 0= (I) =0 · BEHGLW94 •0=(I) NET LEHOLWDA •0=(I) HOA BEHOLW98 •0=(I) =0• SETOLNOG •0=(I) DLE t Et û Linda -0 = (1) DIEDO 1000 I=1*50 EEHOLW93

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	F11(I) = 0.	PGN10469	
1030	CONTINUE	PGM10470	
	WRITE(11ºIAU)F11	PGM10471	
	GO TO 10	PGM10472	
1040	READ (11 LAU) ATT, EOC, FOC, ETC, FTC, SKL, FOR, LEN, CAP, RAF, DSP, ISTR, NCRIT	PGM10473	
	1, NSLIM	PGN 10474	
	IF(L(6).NE.0) GO TC 1042	PGM10475	
	L(6) = NCRIT	PGN 10476	
1042	IF(L(7).NF.0) GO TO 1043	PGM10477	
	L(7) = NSLIM	PGM 10478	
1041	CONTINUE	PGM10479	
1043	NCRIT=L(6)	PG M 10 4 8 0	
	NSLIM=L(7)	PGM 10481	
	ISTR = L(1)	PGM10482	
C READ	D CATA ABCUT THE LINK	PGM 10483	
1045	LARG=1	PGM1 0484	
1050	CALL MATCH (ITYPE, IDICT5, K, RK, LARG)	PGM 10485	
	GO TO (1045,1060,2070,2070,1080),ITYPE	PGM10486	Ļ.
1060	IAB=K	PGM10487	ů.
	KK=0	PGN10488	•
	DC 1065 I=1,7	PGM10489	
	RL(I) = 0.	PGM10490	
	IW (I) =0	PGM 104 9 1	
1065	CCNTINUE	PGM 10492	
1070	CALL MATCH (ITYPE, IDICT5, K, RK, 9)	PGM10493	
	GO TO (2070,2070,2070,2070,1100),ITYPE	PGM 10494	
1080	IF(K.NE.12) GO TO 1095	PGM10495	
	LAU=LAU2	PGM10496	
	WRITE (11*LAU) ATT, EOC, FOC, ETC, ETC, SKL, FOR, LEN, CAP, RAF, DSP, ISTR, NCRI	PGM10497	
	1T, NSLIM	PGM10498	
	GC TO 10	PGM10499	
1(95	$\mathbf{K}\mathbf{K} = 0$	PGN 10500	
	DO 1098 I=1,7	PGM10501	
	RI(I) = 0.	PGM10502	
	IW(I) = 0	PGM 10503	
1098	CCNTINUE	PG M1 05 04	
		PAGE 14	

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		DACE 15
	IW(KK) = KK	20110037 DCM10540
	TE(TW(KK), NE.0) GO TO 1215	EG810008
1212	KK = KK + 1	PGE 10037
1210	RK=K	EGA10030 DCM10507
رد ل ي معه ۱	$GO = TO = (1250 \cdot 1210 \cdot 1212 \cdot 2080 \cdot 1220) \cdot T = V = R$	EGU10000
1200	CALL MATCH (TTYPE_TDTCT7_K_RK_0)	260 10004 DCN10505
C DATA	A ABOUT ECONOMIC COSTS OF VEHICLE OPERATION	EGH 10533
· · · · ·	GO TO 1045	PUR 10032
1170	CONTINUE	rua IUDJI DCM 10530
1168		PGE 10030 DCM10E01
	ATT (T, KK) = ATT (TYR, KK)	rg m 10 529
	$TF(RL(KK), EO, O_{*})$ GO TO 1168	PGR19528
	DO 1168 KK = 1.7	PGE 10527
	DC = 1170 = T = T = 20	2001V020 DCN10507
1165	TT = TYR + 1	EGR 10323
* <u>:</u> U U	TF(MOD.EO.1) GO TO 1045	PGH10024 Drw10505
1160	$TF(IIPD_EO_0) = GO_TO_1165$	PGH 19020
1155	CONTINUE	CURIU322 Dra10500
	$\Lambda TT (TYR_TK) = RT(TK)$	PGB10321
		PGM 10520
 4 all sub 	$DO = \frac{1155}{KKK=1.KK}$	PG110519
1150	TF(KK, FO, D) CO TO 2075	PG8 105 18
112.0	2 T (NOT) - N CC TO 1105	PGM10517
1120	「「「「」」 「「」」 「」」 「」」 「」」 「」」 「」」 「」」 「」	PGM 10516
1 1 1 2	a = (1 + (a b)) + a b	PGM10515
1115	L A [D A] - D A DI (III (A A) - D A	PGM 10 514
	TH(KK)-KK TH(KK)-KK	PG M 10 51 3
1112	ת אד (אד ה) הה שה 1115 דע (דע (גג) אד ה) הה שה 1115	PGN10512
1110		PGM10511
1110	$\frac{1}{2} \frac{1}{2} \frac{1}$	PGM10510
1100	CALL = MAICH(111PB, 101C17, K, KK, J) $CO = 0.0000000000000000000000000000000000$	PGM 10509
1165	A ADUUL AVERAGE FRAVEL LIME. CALL MARCHITENDE TETORE # EM ON	PGM10508
~		PGM10507
	GU 20 (*105,1200,1300,1400,1400,1400,1400,1500,1500,1500,15	PGM10506
	1K 1=K - CC - MO - /1105 1900 1900 1000 1000 1000 1000 1000	PGM10505
1110	T V 1 - V	

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1215	RL(IW(KK)) = RK	PGM 10541
	GC TO 1200	PGM10542
1220	IW(KK+1) = K	PGM 1054 3
	GC TO 1200	PG M 1 05 4 4
1250	IF(KK.EC.0) GO TO 2080	PGN 10545
	DO 1255 KKK=1,KK	PGM1 0546
	IK=IW(KKK)	PGM 10547
	EOC(IYR, IK) = RL(IK)	PGM 10 548
1255	CONTINUE	PGM10549
1260	IF (UPD. E0.0) GO TO 1265	PGM10550
	IF (MOD. E0.1) GO TO 1045	PGN10551
1265	II=IYR+1	PGN 10 552
	DO 1270 I=II.20	PGM10553
	DC 1268 KK=1.7	PGM 10 554
	IF (RL (KK) . EO.O.) GO TC 1268	PGM10555
	EOC (I.KK) = BOC (IYP.KK)	PGH10556
1268	CONTINUE	PGN 10557
1270	CONTINUE	PGN10558
	GC TO 1045	PGM 10559 4
C DAT)	A ABOUT FINANCIAL COSTS CF VEHICLE OPERATION	PGM1 056 0
1300	CALL MATCH (ITYPE.IDIC17.K.FK.0)	PGN 10561
	GO TO (1350,1310,1312,2085,1320), ITYPE	PGN10562
1310	R K = K	PGM10563
1312	KK = KK + 1	PGM10564
	IF (IW (KK) . NE.0) GO TO 1315	PGM10565
	$\mathbf{T}\mathbf{W}(\mathbf{K}\mathbf{K}) = \mathbf{K}\mathbf{K}$	PGM 10 566
1315	RI(IW(KK)) = RK	PGM10567
	GO TO 1300	P GN 10 56 8
1320	IW(KK+1) = K	PGM10569
	GC TO 1300	PGM 10570
135.)	TF (KK. FO. 0) GO TO 2085	PGN10571
	DC 1355 KKK=1.KK	PGM10572
	IK = TW(KKK)	PGM 10 57 3
	FOC $(IYR, IK) = RL(IK)$	PGM 10574
1355	CONTINUE	PGN 10575
1360	IF (UPD. RC.0) GO TO 1365	PG M 10576
		PAGE 16

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	IF(MOD.EQ.1) GO TO 1045	PGM10577
1365	IJ=IYR+1	PGM10578
	DO 1370 I=II,20	PGM10579
	DO 1368 KK=1,7	PGM10580
	IF(RL(KK).EQ.0.) GO TO 1368	PGN 10581
	FOC(I, KK) = FOC(IYR, KK)	PGM10582
1368	CCNTINUE	PGM 10583
1370	CONTINUE	PGM10584
	GO TO 1045	PGM10585
C DAT.	A ABOUT COSTS ASSOCIATED WITH LINK IMPROVEMENT, IF ANY.	PGM 10586
1400	IW(KK+1) = IK1	PGM10587
1405	CALL MATCH (ITYPE, IDICT5, K, RK, 0)	PGM 10588
	GO TO (1430,1410,1412,2090,1420),ITYPE	PGM10589
1410	RK=K	PGM 10590
1412	KK = KK + 1	PGM1 05 91
	BL(IW(KK)) = RK	PGM 10592
	GO TO 1495	PGM10593 L
1420	IW (KK+1) = K	₽G M 10 594 ㎏
	GO TO 1405	PGM10595 T
1430	CONTINUE	PGM10596
	DC 1445 KKK=1,KK	PGM 10597
	IK = IW (KKK)	PGM10598
	IKK=IK-3	PGM 10599
	GO TO (1431,1435,1440,1444),IKK	PGM10600
1431	ETC (IYB) = RL (4)	PGM 10601
	GO TO 1445	PGM10602
1435	FTC (IYR) = BL (5)	PG M 10 60 3
	GO TO 1445	PGM10604
1440	SKL(IYR) = BL(6)	PGM10605
	GC TO 1445	PGM 10606
1444	FOB(IYR) = RL(7)	PGM10607
1445	CONTINUE	P GM 10608
145C	IF (UPD. EQ. 3) GO TO 1455	PGM10609
	IF (MOD.FC.1) GO TO 1045	PGM10610
1455	CONTINUE	PGM10611
	II=IYR+1	PGM10612
		PAGE 17

	DC 1000 T-TT 20	`					DC N1 0612
		, 	1460				
	$\frac{1}{2} \left(\frac{1}{2} \left(\frac{1}{2} \left(\frac{1}{2} \right) + \frac{1}{2} \frac{1}{2} \left(\frac{1}{2} \right) + \frac{1}{2} \frac{1}{2} \left(\frac{1}{2} \left(\frac{1}{2} \right) + \frac{1}{2} \frac{1}{2} \left(\frac{1}{2} \right) \right) \right)$	GO 10	1400				PG410014
1463	$E_{1}(1) = E_{1}(1) E_{1}$		****				PGMTUBTS
1400	$1F(EL(5), FQ, U_{*})$	GO 10	1465				PG110616
40.05	FTC(1) = FTC(1YR)		41.74				PGM10617
1465	1F (FL (6) • FQ • 0 •)	GO TO	1470				PGM10618
	SKL(I) = SKL(IYR)						PGN10619
1470	IF (RL(7).EQ.0.)	GO TO	1490				PGM10620
	FOR(I) = FOR(TYR)						PGM10621
1490	CONTINUE						PGM10622
	LARG=C						PGM 10623
	GO TO 1050						PGM10624
C DA'	IA ABOUT LINK LEN	NGTH, C	APACITY, B	ISE AND FAL	LL, DESIGN	SPEED	PGN 10625
1500	IK(KK+1) = IK1						PGM10626
1505	CALL MATCH (ITYPE,	,IDICT5	,K,BK,))				PGM 10 62 7
	GO TO (1530,1510,	,1512,2	(95,1520),	ITYPE			PGM10628
1510	RK=K						PGM10629
1512	KK = KK + 1						PGM10630
	RL(IW(KK)) = RK						PGM10631
:	GC TO 1505						PGN 10632
1520	IW(KK+1) = K						PGM10633
	GC TO 1505						PGM 10634
1530	CONTINUE						PGM10635
	DO 1545 KKK=1,8	(K					PGN 10636
	IK=IW(KKK)						PGM10637
	IKK=IK-7					<u>,</u>	PGM10638
	GO TO (1535, 1540.	1570,1	580), TKK				PGM 10639
1535	LEN(IYP) = RI(8)	•					PGN10640
	GC TO 1545						PGM 10641
154.3	CAP(IYR) = RL(9)						PGM10642
	GO TO 1545						PGN10643
1570	BAF(TYR) = BL(12)						PGM10644
	GO TO 1545						PG M 10645
1580	DSP(TYR) = PL(11)						DGM10646
1545	CONTINUE						DG M 1 06/17
1550	TE (UPD. FO. C) GO T	n 1555					DCM 10 6/18
1 - 12 2							EGRIU040 DACE 19
							EAVU 10

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	IF (MOD.EO.1) GO TO 1045	DC M106/10
1555	CONTINUE	DCM10650
	II=IYR+1	
	DO 1590 I=II.20	PG210001
	IF (RL (8), EO, 0,) GO TO 1560	PG410002
	LEN(I) = LEN(IYP)	PG110003
1560	IF(RL(9), EO, 0, 0) GO TO 1575	
	CAP(I) = CAP(TYP)	PG 1 0655
1575	IF(RL(10), EO.0.) GO TC 1585	PG110656
	BAF(I) = BAF(IYP)	PGM10657
1585	TF(FL(11), FO, 0.) CO TO 1590	PGM 10658
1.000 10.00	DSP(T) = DSP(TVP)	PGM10659
1590		PGM10660
1.2.2		PGM 1066 1
	CO TO 1350	PGM10662
C 500	ОРС 10 10 10 10 10 10 10 10 10 10 10 10 10	PGM10663
2001 2001	UND FURMATE UND FURMATE	PGM10664 1
2001	RELIG(C, 2002) RCRMAR((LROPAN R REPORT IN REPORT CONVENTION FROM ST	PGM 10665 Q
2902	CO TO 10	PGM10666 Ĭ
2445		PGM 10667
2005		PGM10668
2000	CO TO 10	PG M 10669
2010	GU IU D) HETMER(C. 2014)	PGM10670
2010		PGM 10671
2011	FORMAT [/, 'FORMAT ERROR IN TIME HORIZON COMMAND CARD')	PGM10672
0010		PGM 10673
2915	WEITE(6,2016)	PGM10674
2015	FORMAT (/, 'FORMAT ERROR IN LINK DATA OR STRATEGY COMMAND CARD')	PGM10675
	GO TO 10	PGM10676
2020	WRITE(6,2021)	PGM 10677
20.21	FORMAT (/, 'FORMAT ERROR IN LINK DATA CARDS')	PGM10678
	GO TO 10	PGM 10679
2025	WEITE(6,2026)	PGM12680
2026	FOPMAT(/, 'FORMAT ERBOR IN BUDGET DATA CARDS')	PGM10681
	GO TO 400	PGM10682
2027	WEITE(6,2028)	PGM 10683
2028	FORMAT (/, ' FORMAT ERROR IN BUDGET CARDS')	PGM 10684
		PAGE 19

	GO TO 10		PGM 10685
2030	WRITE (6,2031)		PGM10586
2031	FORMAT (/, FORMAT ERROR IN DEMAN	ND O-D CARD")	PGM10687
	GO TO 10		PGM10688
2035	WRITE(6,2036)		PGM 10689
2036	FORMAT (/, FORMAT EBROR IN DATA	CARDS OF O-D DEMAND')	PGM10690
	GC TO 12		PGM 10691
2040	WRITE $(6, 2041)$		PGM10692
2041	FORMAT (/, FORMAT ERROR IN DATA	CAED OF VOLUME [*])	PGM10693
	GO TO 600		PGM10694
2045	WEITE(6,2046)		PGM 10695
2046	FORMAT (/, 'FORMAT ERFOR IN DATA	CARD OF ELASTICITY")	PGM10696
	GC TO 600		PGM 10697 /
2050	WR TTE (6,2051)		PGM10698
2051	FORMAT (/, 'FORMAT ERFOR IN DATA	CARD OF COMMODITY PRICE')	PGM10699
	GO TO 600		PGM10700 j
2055	WFITE(6,2056)		PGM 10 70 1 8
2056	FORMAT (/, 'FORMAT ERROR IN DATA	CARD OF VALUE OF TIME!)	PGM 10 70 2 🕇
	GO TO 600		PGM 10703
2057	WRITE(6,2058)		PGM10704
2058	FORMAT (/ FORMAT ERROP IN I	DATA CARD OF LOAD FACTOR [®])	PGM10705
	GO TO 600		PGM10706
2060	WRITE(6,2061)		PGM 10707
2061	FORMAT (/, FORMAT ERROR IN DATA	OF VEHICLE CAPACITIES!)	PGM 10708
	GO TO 10		PGM 10709
2065	WRITE(6,2066)		PGM10710
2066	FORMAT (/, FORMAT EFROR IN LINK-	-STRATEGY CARD*)	PGM10711
	GC TO 10		PGM10712
2770	WRITE(6,2071)		PGM 10713
2071	FOFMAT (/, 'FORMAT ERROP IN LINK	CHARACTERISTICS DATA CARD")	PGM10714
	GO TO 1045		PGM 10715
2075	WRITE(6,2076)		PGM10716
2075	PORMAT (/, 'FORMAT ERROP IN AVER!	AGE TRAVEL TIME DATA CAPD')	PGM10717
	GO TO 1045		PGM10718
2080	WRITE(6,2081)		PGM 10719
2081	FORMAT (/, 'FORMAT ERROR IN ECON	OMIC COSTS OF VEHICLE OPERATION DATA	PGM10729
			PAGE 20

1 CABD")	PGM 10721
GC TO 1045	PGM10722
2085 WRITE(6,2086)	PGM10723
2086 FORMAT (/, 'FORMAT ERROR IN FINANCIAL COSTS OF VEHICLE OPERATION DAT	PGM10724
1A CARD")	PGM10725
GC TO 1045	PG M10726
2090 WRITE(6,2091)	PGM 10727
2091 FORMAT (/, 'FORMAT ERROR IN COST DATA ABOUT THE LINK')	PGM10728
GC TO 1045	PGM 10729
2095 WRITE(6,2096)	PGM10730
2096 FCPMAT (/, 'FORMAT ERROR IN LINK LENGTH AND CAPACITY DATA')	PGM10731
GC TO 1045	PGM10732
9999 STOP	PGM 10733
END	PGM10734

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SUBBOUTINE GRAPHE		PGM 2000 1
C PROGRAM TO TEST IF DATA IS WRITTEN ACCURATELY IN THE DISK		PG M2 0002
DIMENSION $VCAP(7)$, LBFG (30), LEND (30), LST (30), LREG (30),	TB (10,20), FE (PGM 20003
110,20), SL(10,20), LLA (30,30), LOD(30,30), ATT(20,7), EOC	(20,7),	PGM20604
2FOC (20, 7), ETC (20), FTC (20), SKL (20), FOR (20), CAP (20),		PGM 20005
3DEMAND (20,7), ELA (7), PRICE (7), VALT (7), FLOAD (7), RAF (20)	, DSP (20)	PGM20006
RFAL LEN(20)		PG M20007
C READ THE BASIC DATA		PGM20008
READ(101) NLINK, NODE, N REG, IHORIZ, JIM, FAFE, VCAP, LBEG, I	END, LST, LREG,	PGM20009
1TE, FE, SL, IOPT		PGM2)010
READ (10 2) LLA		PGM20011
PEAD(1C'3)LOD		PGM 20012
C PRINT THE BASIC DATA		PGM20013
WFITE(6,10) NLINK,NODE,IHORIZ,RATE,NREG		PGM 20014
10 FORMAT (/, ' THE NUMBER OF LINKS IN THE NETWORK ARE:	,	PGM20015
115./.' THE NUMBER OF NODES IN THE NETWORK ARE: 15.	1.	PGM 20016
2' THE TIME HORIZON FOR THE EVALUATION IS: ', I5./,		PGM20017
3' THE DISCOUNT RATE IS: ', F10.5,/,' THE NUMBER	OF REGIONS	PGM 200 18 1
4 ABE: 1, I3)		PGM20019 8
DC = SC = I = 1, NREG		PGM 200 20 T
WRITE (6,85) I		PGM20021
85 FOPMAT (/,25X, 'FOR REGION', I3)		PGM20022
WRITE (6,70)		PGM20023
70 FORMAT (/,3X,"YEAR",5X,"TOTAL	BUDGET ', 10X,	PGM20024
1' FOREIGN EXCHANGE', 7X, ' SKILLED LABOR')		PGM20025
DO 75 $J=1$, IHORIZ		PGM20026
WRITE (6,60) J. TB (I, J), FE (I, J), SL (I, J)		PGM20027
60 FCRMAT (3X, I3, 7X, F15.5, 9X, F15.5, 9X, F15.5)		PG M 20028
75 CONTINUE		PGM20029
80 CONTINUE		PGM20030
WRITE(6,12)(I,I=1,7)		PGM20031
12 FORMAT (/,25X, 'VEHICLE CAPACITIES', /, 5X, 'TYPES', 13X, 7	(12, 12X))	PGM20032
WRITE(6, 14) (VCAP(I), $I=1,7$)		PGM 20033
14 FORMAT (20X, F5.0, 'PASS.', 5X, F5.0, 'PASS.', 4X, 5 (2X, F8.2,	, ' TONS '))	PG M2 0 03 4
15 CONTINUE		PGM 20035
$L A U = \mathcal{I}$		PGM20036
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	DC 300 I=1,NLINK	PGM20037
	LAUC = 10 * (I - 1)	PGM20038
	KK = LST(I)	PG M 20039
	DO 290 $J=1, KK$	PGM20040
	LAU = LAUC + J	PG M2)041
	READ (11'LAU) ATT, EOC, FOC, ETC, FTC, SKL, FOF, LEN, CAP, RAF, DSP, ISTR, NCRIT	PGM20042
	1,NSLIM	PG M20043
	WRITE(6, 195) I	PGM 20044
195	FORMAT (///' LINK', 15, /, 13X, 'STARTS', 2X, 'ENDS', 2X, 'BEGION', 2X, 'STR	PG M20045
	1ATEGY #1,2X, 'CRITICAL INDEX',2X, 'MAX SLIPPAGE')	PGM20046
	WRITE(6,20) LBEG(I), LEND(I), LREG(I), ISTR, NCRIT, NSLIM	PGM20047
50	FORMAT (15X, 12, 5X, 12, 5X, 12, 11X, 12, 11X, 12, 12X, 12)	PGM 20048
	WRITE (6,215)	PGM20049
215	FORMAT (//40X, VEHICLE INFORMATION*)	PG M200 50
	WRITE (6, 217)	PGM20051
217	FORMAT (/15X, 'TRAVEL TIME ON THE LINK IN HOURS')	PGM20052 .
	WRITE(6,218)	PGM 200 53 🛱
218	FORMAT (/20X, 'VEHICLE TYPE:',8X, 'V1', 10X, 'V2', 10X, 'V3', 10X, 'V4', 10X	PGN20054 4
	1, 'V5', 10X, 'V6', 10X, 'V7', /, 10X, 'YEAR')	PGM 20055
	DO 220 IK=1,IHORIZ	PGM20056
	WRITE(6,225) IK, (ATT(IK,IV),IV=1,7)	PGM 20057
225	FORMAT (11X, 12, 22X, 7 (2X, F8. 3, 2X))	PGM20058
220	CONTINUE	PGM20059
	WRITE(6,227)	PGM 20060
227	FORMAT (/15x, 'VEHICLE ECONOMIC COSTS IN \$ FOR THE WHOLE LINK')	PGM20061
	WRITE (6,228)	PGM20062
228	FOBMAT (/2CX, 'VEHICLE TYFE:',8X, 'V1', 10X, 'V2', 10X, 'V3', 10X, 'V4', 10X	PGM20063
	1, * V5', 10 X, * V6', 10 X, * V7', /, 10X, *YEAR*)	PGM20064
	DC 230 IK=1, IHOPIZ	PGM20065
	WRITE (6,235) IK, (EOC (IK, IV), IV=1,7)	PGM20066
235	FOPMAT (11X, I2, 22X, 7 (2X, F8.3, 2X))	PGM20067
230	CONTINUE	PGM 20068
	WRITE(6,237)	PG M20069
237	FORMAT (/15X, 'VEHICLE FINANCIAL COSTS IN \$ FOR THE WHOLE LINK')	PGM20070
	WRITE (6,238)	PG M20071
238	FORMAT (/20X, 'VEHICLE TYPE:', 8X, 'V1', 10X, 'V2', 10X, 'V3', 10X, 'V4', 10X	PGM20072
		PAGE 23

1, 'V5', 10 X, 'V6', 10 X, 'V7', /, 10X, 'Y EAR')	PGM 2
DC 240 IK=1,IHOFIZ	PGM2
WRITE (6,245) IK, (FOC (IK, IV), $IV = 1,7$)	PGM2
245 FORMAT (11X, I2, 22X, 7 (2X, F8, 3, 2X))	PGM2
240 CONTINUE	PGM2
WRITE (6,250)	PG M2
250 FORMAT(//40X, 'LINK INFORMATION')	PGM 2
REITE(6,301)	PGM2
301 FORMAT (/1X, 'YEAR', 2X, 'FINANCIAL COST', 2X, 'ECONOMIC COST', 2X, 'FOREI	PGM 2
IGN EXCHANGE', 2X, 'SKILLED LABOR', 2X, 'LINK LENGTH', 2X, 'LINK CAPACITY	PGM2
2', 2X, 'FISE-FALL', 2X, 'DESIGN SPEED', /, 12X, '(\$)', 13X, '(\$)', 15X, '(\$)'	PGM 2
3,14X, '(\$)',10X, '(KMS)', SX, '(PCU/HR)', 4X, '(M/100M)', 5X, '(KMS/HR)')	PGM2
DO 310 IK=1, IHORIZ	PGM2
WRITE (6,315) IK, FTC (IK), ETC (IK), FOR (IK), SKL (IK), LEN (IK), CAP (IK), RA	PGM2
1F(IK), LSF(IK)	PGM 2
315 FORMAT (/,I3,1X,F15.3,1X,F14.3,3X,F15.3,1X,F14.3,1X,F13.3,1X,F15.3	PGM2
1,1X,F9.4,2X,F12.4)	PGM 2
310 CONTINUE	PGM 2
DO 260 IK=1,IHORIZ	PGM2
ETC(IK) = 0.	PGM 2
FTC(IK) = 0.	PG M2
SKL(IK) = 0.	PGM 2
FOR $(IK) = 0$.	PGM2
LEN(IK) = 0.	PGM 2
CAP(IK) = 0.	PGM2
RAF(IK) = 0.	PGM2
DSP(TK) = 0.	PGM 2
DO 255 IV=1,7	PGM2
ATT(IK, IV) = 0.	PGM2
ECC(IK, IV) = 0.	PGM2
FOC(IK, IV) = 0.	PGM2
255 CONTINUE	PGM2
260 CONTINUE	PGM 2
290 CONTINUE	PGM2
300 CONTINUE	PGM2
DO 201 KO=1, NODE	PGM2
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GM 2007 3 2GM20074 GM20075 PGM20076 PGM20077 PG M2 0 07 8 PGM 20079 PGM20080 GM 20081 GM20082 GM 20083 GM20084 GM20085 PGM20086 PGM 20087 1 PGM 20088 9 PGM 20089 9 GM20090 PGM20091 GM 20092 PG M2 0 0 9 3 PGM20094 PG M2 0095 PGM 20096 GM20097 PG M 20098 GM20099 PGM20100 GM20101 PGM20102 PGM 20 10 3 PG M2 01 04 GM 20 10 5 GM20106 PGM20107 GM20108

DO 190 KD=1,NODE	PGM 20 10 9
IF (LOD (K0, KD) . EQ.0) GO TO 190	PGM20110
WFITE(6,100)KO,KD,LOD(KO,KD)	PG M 20 1 1 1
100 FORMAT (///, ' DATA FOR O-D PAIR: ', 12, '-', 12, ' (S'	TORED IN PGM20112
1 BECOBD', I2, ') ')	PGM 20 1 1 3
JIMC=LOD(K0, KD)	PGM20114
READ (12 'JINC) DEMAND, ELA, PRICE, VALT, FLOAD	PGM20115
WRITE (6, 102)	PGM20116
102 FOBMAT (/30X, 'DEMAND')	PGM20117
WRITE(6,105)	PGM20118
105 FORMAT (/5X, 'YEAR', 5X, 'TYPE: ', 5X, 'V1', 10X, 'V2', 10X, 'V3', 10)X, V4, 10 PGM20119
1X, ' V5', 10 X, ' V6', 10 X, ' V7')	PGM20120
IF (IOPT.EQ.1) GO IO 500	PGM 20121
WBITE(6,106)	PGM20122
106 FORMAT (21X, 'VEHICLES', 4X, 'VEHICLES', 2X, 5 (4X, 'TONS', 4X))	PG M 20 1 2 3
GC TO 550	PGM20124 1
500 WRITE(6,510)	PGM 20 125 Q
510 FORMAT (19X, 7 (2X, 'VEHICLES', 2X))	PGM20126 i
550 DO 140 I=1, IHORIZ	PGM 20 127
WRITF $(6, 115)$ I, (DEMAND $(I, J), J=1, 7$)	PGM20128
115 FCBMAT (5X,I2,10X,7(2X,F8.2,2X))	PGM20129
140 CONTINUE	PGM20130
DC 143 I=1,IHORIZ	PGM20131
JO = 142 J=1,7	PGM20132
DEMAND (I, J) = 0.	PG M2 0 1 3 3
142 CONTINUE	PGM 20134
143 CONTINUE	PGM20135
WBITE(6,145)	PGM 20 136
145 FORMAT (/10X, 'TYPE:', 33X, 'V1', 10X, 'V2', 10X, 'V3', 10X, 'V4', '	10X, V5', 1 PGM20137
10x, *V6*, 10x, *V7*)	PGM 20 138
WRITE $(6, 150)$ (ELA (I), I=1,7)	PGM20139
150 FORMAT (/ ELASTICITY WITH RESPECT TO TRANSPORT COSTS',	7(2X,F8.4, PGM20140
12X))	PGM20141
WRITE(6,152) (PRICE(I),I=1,7)	PG M20142
152 FORMAT (' COST OF TRANSPORT (\$/VFH.)', 14X, 7 (2X, F8.3, 2)	K)) PGM20143
WRITE(6,153) (VALT(I),I=1,7)	PGM20144
	PAGE 25

153	FORMAT (* VALUE OF TIME-PASSENGERS (\$/PASS-HR)*,5X,2(2X,F8.3,2X)	PGM20145
	1,/, 16X, 'COMMODITIES (\$/ION-HR)', 31X, 5(2X, F8.5, 2X))	PGM 20 146
	WRITE (6,154) (FLOAD (I), I=1,7)	PGM20147
154	FORMAT(' LOAD FACTOR', 31X,7 (2X, F8.4, 2X))	PGM 20 148
	DO 151 IV=1,7	PGM20149
	ELA(IV) = 0.	PGM 20150
	FLCAD(IV) = 0.	PGM20151
	PRICE(IV) =0.	PGM20152
	VALT(IV) = 0.	PGM20153
151	CONTINUE	PGM20154
19.0	CONTINUE	PGM20155
200	CONTINUE	PGM20156
	RETURN	PGM20157
	END	PGM20158

SUBROUTINE MATCH (NATCH,LIST,K,RK,LARG)	00000010 PGM30001
	00000060 PGM30002
MATCH READS A CARD IN 80A1 FORMAT INTO JBUF, CONVERTS FACH	00000070 PGM30003
COLUMN TO AN INTEGER CODE IN IBUF, AND DECODES EACH LOGICAL	00000080 PGM30004
FIELD ON THE CARD. THE LAST USFABLE COLUMN IS INDICATED BY THE	00000090 PGM30005
DATA SPECIFICATION FOR "LASTCC".	00000100 PGM30006
EACH CODE NUMBER REPRESENTS A CHABACTER AND IS FORMED	00000110 PGM 30007
INTO LIST WORDS BY COMBINING THE CODE TIMES SOME	00000120 PGM30008
POWER OF 100. THUS IF A WORD MAY CONTAIN 4 CHARACTERS,	00000130 PGM30009
(IIST (1)=4), AND THE WORD 'THE' IS TO BE REPRESENTED, THE CODED	00000140 PGM30010
WORD IS 39272414, BLANK PADDED (14) ON THE RIGHT	00000150 pgm 30011
LIST=DICTIONARY ADDRESS (INTEGER ARRAY)	00000160 PGM30012
LIST (1) =NUMBER OF CHARACTERS/WORD	00000170 PGM30013
LIST (2) = NUMBER OF LIST WOFDS IN DICTICNARY	00000180 PGM30014
LIST (3) TO LIST (N) ARE CODED WORDS	00000190 PGM30015
TOTAL LENGTH=LIST (2) + 2 INTEGER WORDS	00000200 PGM30016
	00000210 PGM30017
NATCH=	00000220 PGM33018
1, END OF STATEMENT	00000230 PGM30019
2, INTEGER NUMBER	00000240 PGN 30020
3.REAL NUMBER	00000250 PGM 30021
4, WORD NOT IN DICTIONARY	00000260 PGM30022
5. WORD IN DICTIONARY	00000270 PGM 30023
CODE IS INTEGER DECIMAL. CO TO 45. AS INDICATED BELOW.	00000280 PG M30024
THE CODES ARE AS FOLLOWS	00000290 PGM30025
CODE CHARACTER REPR3SENTED	00000300 PGM30026
	00000310 PGM30027
1 1	00000320 PGM30028
2 2	00000330 PGM30029
3 3	00000340 PG#30030
ů ů	00000350 PGM30031
с. с. С. С.	00000360 PG#30032
6 6	0000C370 PGM30033
7 7	00000380 PGN30034
8 8	00000390 PCM30034
9 9 9	00000000000000000000000000000000000000
	DACP 27
	ravo Z/

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10	•	00000410	PGM30037
11	, . I –	00006420	PGM30038
12		00000430	PGM30039
1 -		00000440	PGM 30040
14	RT	A NK 00000450	PGM 30041
1 =	, <u>,</u>	00000460	PGM30042
16	5 /	00000470	PGM30043
17	7 \$	00000480	PGM30044
18	3 =	00000490	PGM 30045
10	, п	00000500	PGM30046
20	А	00000510	PGM30047
21	1 B	00000520	PGM30048
22	2 C	00000530	PGM30049
23	3 0	00000540	PGM30050
24	4 E	00000550	PGM 30051
25	5 F	00000560	PGM30052
26	5 G	00000570	PGM30053
27	7 н	0000580	PGM30054
28	3 I	00000590	PGM30055
29	э ј	00000600	PGM30056
30) К	00000610	PGM30057
31	1 L	00000620	PGM 30058
32	2 M	0 0 0 0 0 6 3 0	PGM3 005 9
33	3 N	00000640	PGM 30060
34	4 O	00000650	PGM30061
35	5 P	00000660	PGM30062
36	5 Q	00000670	PGM30063
37	7 R	00000680	PGM30064
38	3 S	0000690	PGM30065
39	Э Т	00000700	PGM30066
40) U	00000710	PGM 30067
41	1 V	00000720	PGM30068
42	2 W	00000730	PGM30069
4	3 X	00000740	PGM30070
40	ı Y	00000750	PGM30071
4 5	5 72	00000760	PGM30072
		PAGI	E 28

-20**9-**

С		00000770	PGM 30073
С	K=POSITION OF WORD IN DICTIONARY (EXCLUSIVE OF FIRST 2 CONTROL	00000780	PGM30074
С	WORDS) IF MATCH=5	00000790	PGM30075
С	=NUMBER IF MATCH=2	00000800	PGM30076
С	=SUBSCRIPT IN JBUF OF FIFST CHARACTEP OF UNRECOGNIZED WORD	00000810	PGM30077
С	IF MATCH=4	00000820	PGM 30078
С	RK=REAL NUMBER IF NATCH=3	00000830	PGM30079
С		00000840	PGM30080
C	LARG=0, READ NEXT FIELD ON CARD	00000850	PGM30081
с	=1. BEAD NEW CARD-FIRST FIELD	00000860	PGM30082
С	• • • • • • • • • • • • • • • • • • • •	00000870	PGM30083
Ċ	* \$* TS CONTINUATION CARD MARK	00000880	FGM30084
Ċ	\$ IN CC1 IS A COMMENT CARD	00000890	PGM30085
č		00000900	PGM 30086
č	THE MAXIMUM NUMBER OF CHARACTERS PER WORD DEPENDS ON THE	00000910	PGM30087
č	ALLOWARLE NUMBER OF DECIMAL DIGITS PEP INTEGER WORD.	00000920	PG M 30 0 8 8
C	TN SUBROUTINE CODES	00000930	PGM30089 I
C	THE ABOVE CODES ARE SET BY A DATA SPECIFICATION FOR LET (1-46)	00000940	PGM30090
č	LET(I) HAS THE CHARACTER REPRESENTATION (1H) OF THE CHARACTER	00000950	PGM30091
č	with CODE $T-1$. Thus if $T(21) = 1$ has	00000960	PG M30092
ĉ	" I' II CODE I I • INCO INI (LI) INK•	00000970	PGM30093
<u> </u>	TNTEGER BIANK.COMMA PIUS.MTNUS.DP	00000980	PG M3 0 0 94
	INTEGRE ITST(2)	00000990	PGM 30095
	$\frac{1}{1} \frac{1}{1} \frac{1}$	000000000	PGM30096
	$\frac{1}{1} = \frac{1}{1} = \frac{1}$		PGM30097
			PGN30098
	$\frac{1}{2} + \frac{1}{2} + \frac{1}$		PGM30099
C		00001010	DGM 30 10 0
5	DATE TASTC TOTAL TOTAL BIANK COMMA DIES MINES DO 280 5 6 14 13 10	.00001020	PGM30101
	- DAIR PROICEFOURDEILENUIS DER MACOUCHEREIDOEUTHOOFDELOEDOEDEUS - DAIR PROICEFOURDEILENUIS DER MACOUCHEREIDOEUTHOOFDELOEDEUS	00001020	DCN30102
~	D11912/	00001030	DCM 30 10 3
~	THERE OF CORE	00001040	
ί.	ANTRI PUINI-CHECK OP COUL	00001050	DCM30105
		00001000	
	L = LAKG	00001070	2033VIV0
	IF(L.SU.V) GU TU 110 I 1 DEDD VER GARD CONVERS TO DEGIMAL CODE CHE DUEERE DOINTED IC		
C	L=1,33AU NEW CARD,CONVERT TO DECLMAL CODE, SET BUFFEE POINTER IC	00001090	
		PAG	ビー イソ

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C	TO FIRST NON-BLANK CHAR.	00001100	PGM 30109
	DO 800 ISS=1,80	00001110	PG M 30 110
	IBUF(ISS) = LET(15)	00001120	PGN30111
800	CONTINUE	00001130	PGM30112
	READ(TEEAD, 1000, ERE=801, END=802) TBUF		PGM 30 113
1000	FORMAT (30A1)	00001150	PGM30114
	GO TO 801		PGM 30 115
872	NATCH=6		PGM30116
	GO TO 280		PGM30117
801	DO 101 I=1,30	00001160	PGM30118
	DO 102 J=1,46	00001170	PGM30119
	IF (IBUF (I) - LET (J)) 102,103,102	00001180	PGM 30 120
102	CONTINUE	00001190	PGM30121
С	NC MATCH-ILLEGAL CHARACIEF, SET=50 IN IBUF	00001200	PGM 30 122
	IBUF(I) = 50	00001210	PGM30123
	GC TO 101	00001220	PGM 30 12 4
С	MATCHED	00001230	PGM 30 125
103	IBUF(I) = J - 1	00001240	PGM30126 ₽
101	CONTINUE	00001250	PGM30127 🕇
С	SET IC AS FIRST NON-BLANK COLUMN	00001260	PG M3 0128
	DO 104 $I=1, LASTC$	00001270	PGM 30 129
	TF (IBUF (I) - BLANK) 105, 104, 105	00001280	PGM30130
104	CCNTINUE	00001290	PGM 30 13 1
105	IC=I	00001300	PGM30132
C		00001310	PGM30133
C	POINTER IS ALWAYS SET TO FIRST CHARACTER OF NEW FIELD ON LEAVING	00001320	PGM30134
С	MATCH OR BY BEADING A NEW CARD-IT MAY BE LEFT PAST THE LAST	00001330	PGM30135
С	RECOGNIZAELE COLUMN, LASTCC	00001340	PGM 30136
110	ICAR=IBUF (JC)	00001350	PGN30137
	IF(IC-LASTC)115,115,120	00001360	PGM 30 138
С	END OF STATEMENT	00001370	PGM30139
120	NA TCH= 1	00001380	PGM 30 140
280	RETURN	00001390	PGM30141
С		00001400	PGM30142
C	OK-CHECK IP NEW FIELD IS A NUMMER, 0-9, +, -, OR.	00001410	PGM 30143
115	IF (ICAR-12) 125,125,300	00001420	PGM30144
		PAGE	: 30

С NUMBER FOUND-SET INITIAL PARAMETERS C DECIMAL POINT=NO С 125 IDP=0 С NEGATIVE=NO ISGN=0 NO GIGNIFICANT DIGIT YET С ISIG=) NUMERICAL VALUE OF NUMBER (REAL OR INTEGEF) C NUMB=0 SAVE START OF NUMBER C ICSTR = ICIS FIRST CHAR A PLUS SIGN-IGNORE IF YES C TF (TCAE-PLUS) 126, 130, 126 CHECK IF MINUS SIGN-SET ISIGN=1 IF YES С 126 IF (ICAR-MINUS) 135, 127, 135 127 TSGN=1LFADING PLUS OF MINUS SIGN-BUMP CARD COLUMN POINTER-CHECK С IF END OF FIELD С THIS IS GENERAL CC BUMPER SECTION OF CODE C 130 TC = IC + 1ICAR=IBUF(IC) IF(IC-LASTC) 135,135,140 CHECK IF CC IS BLANK OR COMMA C 135 IF (ICAR-BLANK) 145, 140, 145 145 IF (ICAR-COMMA) 150, 140, 150 NOT END OF FIELD-IS IT A DIGIT ... C 150 IF (ICAR-9) 155, 155, 160 DIGIT C-9, DECIANL POINT YET... С 155 IF (IDP-1) 165,170,165 ALREADY HAVE DP,N IS THUS NEGATIVE, NUMBER IN ANUMB C ANUMB=ANUMB+FLOAT (ICAR) * (10. **N) 170 N = N - 1GC TO 130 NO DP YET, IS DIGIT A ZEEO... С 165 IF (ICAP) 175, 180, 175

00001430 PGM 30145 00001440 PGM30146 00001450 PGM30147 00001460 PGM30148 00001470 PGM30149 00001480 PGM30150 00001490 PGM 30151 00001500 PGM30152 00001510 PGM30153 00001520 PGM30154 00001530 PGM30155 00001540 PGM30156 00001550 PGM30157 00001560 PGM 30158 00001570 PGM30159 00001580 PGM 30160 00001590 PGM30161 00001600 PGM30162 00001610 PGM30163 00001620 PGN30164 00001630 PGM30165 00001640 PGM30166 00001650 PGM30167 00001660 PGM30168 00001670 PGM 30169 00001680 PGM30170 00001690 PGM 30 17 1 00001700 PGM30172 00001710 PGM 30173 00001720 PGM30174 00001730 PGM30175 00001740 PGM30176 00001750 PGM30177 00001760 PGM30178 00001770 PGM30179 0000178 PGM 30180

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C
   NOT ZERC. THUS IT IS SIGNIFICANT
  175 ISIG=1
      GO TO 185
С
      ZEBO-CHECK IF SIGNIFICANT, IF NOT SKIP
  180 IF (ISIG-1) 130, 185, 130
185
      NUMB = 10 * NUMB + ICAF
      GO TO 130
C
C
      CHARACTER NOT DIGIT IS IT DP...
  160 IF (ICAR-DP) 195, 190, 195
С
  YES, WAS ONE GIVEN PREVIOUSLY...
  190 IF(TDP-1)200,99,200
200
      N = -1
      IDP=1
      A NUMB = NUMB
      GO TO 130
C
      NOT DIGIT OF DP, IS IT E..., IF NOT, ERROR (99)
С
      IF (ICAB-24) 99,205,99
195
      E FORM-E (PLUS OR MINUS) N1, (N2)
С
  205 IF (IDP-1) 210, 214, 210
      NO DP YET, FLOAT NUMBER
C
  210 ANUMB=NUMB
      IEP=1
  214 I=1
      SIGN OF EXPONENT=PLUS
C
      IEP=+1
С
      VALUE OF EXPONENT=0
      T \equiv X = 0
      NEXT COLUMN
C
  215 IC=IC+1
      ICAP=IBUF (IC)
      IF (IC-LASTC ) 216, 216, 99
  216 IF (ICAR-BLANK) 217,99,217
  217 IF (ICAR-COMMA) 218,99,218
  218 GO TO (220,225),I
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00001790 PGM30181 00001800 PGM30182 00001810 PGM30183 00001820 PGM30184 00001830 PGM30185 00001840 PGM30186 00001850 PGM30187 00001860 PGM30188 00001870 PGM30189 00001880 PGM30190 00001890 PGN 30191 00001900 PGM30192 00001910 PGM 30193 00001920 PGM30194 00001930 PGM30195 00001940 PGM30196 납 00001950 PGM30197 00001960 PGM30198 00001970 PGM30199 00001980 PGM30200 00001990 PGM30201 00002000 PGM 30202 00002010 PGM30203 00002020 PGM30204 00002030 PGM30205 00002040 PGM30206 00002050 PGM30207 00002060 PGM30208 00002070 PGM30209 00002080 PGM30210 00002090 PGM30211 00002100 PGM30212 00002110 PGM30213 20002120 PGM32214 00002130 PGM30215 00002140 PGM30216 PAGE 32

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С
      CHARACTER AFTER E, IS IT PLUS, MIMUS, OR DIGIT...
220
      IF (ICAR-PLUS) 226,230,235
235 IF (ICAP-MINUS) 99.240.99
      MINUS SIGN
C
  240 IEP=-1
      HERE FOR PLUS SIGN ALSO
C
C
      RESET SWITCH AND GET NEXT COLUMN
  230 I=2
      GO TO 215
      FIRST OF ONE OR TWO EXPONENT DIGITS
С
225 IF (ICAR-9) 226, 226, 99
  226 TEX=TCAR
      T = 1
  223 IC=IC+1
      ICAR=IBUF (IC)
      IF(IC-LASTC)231,231,250
231 IF (ICAR-BLANK) 227, 250, 227
227 IF (TCAR-COMMA) 228,250,228
  228 GO TO (224,99), I
224 IF (ICAE - 9) 229, 229, 99
  229 T = 2
      IEX = 10 * IEX + ICAR
      GC TO 223
      END OF E FORM-MULTIPLY NUMBER BY EXPONENT
С
  250 ANUMB=ANUMB* (10.** (IEP*IEX))
С
C
      END OF NUMBER, POINTER AT BLANK, COMMA, OR EOC
      IDP=0, INTEGEP IN NUMB-IDP=1, READ IN ANUMB
С
140
      IF (ISGN-1) 144.141.144
      NEGATE-CHECK IF INTEGER OF REAL
С
  141 IF(IDP) 142, 143, 142
С
      RFAL
142
      ANUMB = -ANUMB
      GO TO 144
C
      INTEGEE
  143 NUMB=-NUMB
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00012150 PGM 30217 00002160 PGM30218 00002170 PGM30219 00002180 PGM30220 00002190 PGM30221 00002200 PGM 30222 00002210 PGM30223 00002220 PGM30224 00002230 PGM30225 00002240 PGM30226 00002250 PGM30227 00002260 PGM30228 00002270 PGM30229 00002280 PGM30230 00002290 PGM 30231 00002300 PGM30232 00002310 PGM 30233 00002320 PGM30234 00002330 PGM 30235 N 00002340 PGM30236 00002350 PGM30237 00002360 PGM30238 00002370 PGM30239 00002380 PGM 30240 00002390 PGM30241 00002400 PGM30242 00002410 PGM30243 00002420 PGM30244 00002430 PGM30245 00002440 PGM30246 00002450 PGM30247 00002460 PGM30248 00002470 PGM 30249 00002480 PGM30250 00002490 PGM 30251 00002500 PGM30252 PAGE 33

576E 34 00005860 PGM30288 I MD=J 00002820 BCW30281 ICHJ=NCM+1 000058#0 bd W30580 NCM = IEND + J - ICZLB 00007830 bGW30782 С GET CHARACTEES IN WORD 00002820 PGM30284 (L) ISIT=ON 00002810 FGM30283 Э USE LIST FIRST 00002800 bew30282 t-DI=UNEI 077 00005790 PGM30281 END DE EIEFD Э 00005780 PGM30290 dlh*UZh*Olh(JNK)dl0*dJ0*dJ0 00005110 BCW30510 TIE (ICVE-COWWY) TO2 TO2 00005760 PGM30278 IE(IC-FVZLC) #J2 #J2 #J2 TCC 00005120 BC#30511 ICVS=IBUF(IC) 000051#0 bdW30510 L+DI=DI ULT 00005130 EGW30512 330 IC2LS =IC 00005120 BEW3051# ELANK PAD ON RIGHT. Э 00005710 PGM30273 FIEST MOED IN FIST AS NUMBER OF CHARS IN WORD. С 00005100 BGW30515 SOBW BYCKED MOSD IN DECIMPT CODE LO COMBYBE VEVINEL FIEL-NEED 00005690 PGM30271 T BY ELEMENTION, THE FIELD IS A WORD-SAVE IC AND GET END OF WORD. С 00005680 PGM30270 С С 00005010 bdw30500 T 00005660 PGM30268 IE (ICVE-11) 330'120'330 008 00005650 PGM30267 FIEST CHAP IS NOT FOC, NUMBER-IS IT \$... С 000050#0 BCW30500 С 00005030 EGW30502 Э 00005620 PGM30264 5.13 IE (IEAL (IC) -COWWY) 580 511 580 00005010 60W30503 512 IE (IBUE (IC) - BIV NK) 513 511 513 IF(IC-LASTC)272,272,286 00005600 PGM30262 00005200 BEW30501 511 IC=IC+1 510 IE(IC-TV2IC)511*511*580 00005280 BEW30560 00005210 BCW30520 **EEEOBE BELIBNING** С 00005200 bew30528 CHYEVELES ON LEVAE VI ECC-LHIZ RECLICH ON COLOR IS ARED С 00005220 BCW30521 BOTALEE AT BLAK, COMMA, OF BOC-BUND TO A NON-BLAK, NON-COMMA Э 00005200 BCW30520 С 00005230 BCW30522 BK=V NOWB 00005250 BEW3052# $K = N \cap WB$ 00005210 bGW30523 1dt NVLCH=IDE+5

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С	CHECK IF FIELDS IS SHORTER THAN DICT. WORDS	00002870
	IF (NCW-NC) 440, 455, 455	00002880
С	SHORTER-ELANK PAD	00002890
440	DO 445 I=1, NCW	00002900
	IJK=ICSTB +I-1	00002910
445	IWD=100*IWD+IBUF(IJK)	00002920
	DC 450 $I = NCW1, NC$	00002930
450	IND=100*IND+BLANK	00002940
	GC TO 465	00002950
С	NCW, GE, NC	00002960
455	DC 460 I=1, NC	00002970
	IJK=ICSTR +I-1	00002980
460	IWD=100 * IWD + IBUF (IJK)	00002990
С		00003000
С	NOW TWD CONTAINS NO CHARACTERS TO COMPARE	00003010
С	TC DICTICNARY WORDS	00003020
465	NWDS=LIST (2)	00003030
	DO 475 I=1, NWDS	00003040
	IF (IWD-LIST (T+2)) 475,480,475	00003050
475	CONTINUE	00003060
С	WORD NOT FOUND IN DICTIONARY	00003070
	NATCH=4	00003080
	K=ICSIR	00003090
	GO TO 270	00003100
С	WCRD FOUND IN DICTIONARY	00003110
480	K=T	00003120
	NATCH=5	00003130
	GC TO 270	00003140
С		00003150
С		00003160
С	ERFOR IN NUMBER FIELD	00003170
99	WFITE(IFRNT, 999)	00003180
	K= ICSTR	00003190
	NATCH = 4	00003200
	GO TO 270	00003210
999	FORMAT (25H REBOR IN NUMERIC FIELD.)	00003220

00002870 PGM30289 00002880 PGM30290 00002890 PGM30291 00002910 PGM30292 00002920 PGM30293 00002920 PGM30294 00002930 PGM30295 00002940 PGM30296 00002950 PGM30297 00002960 PGM30299 00002970 PGM30299 00002980 PGM30300 00002990 PGM30300 00002990 PGM30301 00003010 PGM30303 00003010 PGM30305 00003020 PGM30305 00003050 PGM30305 00003050 PGM30307 00003060 PGM30308 00003050 PGM30307 00003060 PGM30308 00003070 PGM30308 00003070 PGM30311 00003100 PGM30311 00003100 PGM30312 00003110 PGM30313 00003120 PGM30314 00003120 PGM30315 00003140 PGM30315 00003150 PGM30315 00003160 PGM30317 00003160 PGM30317 00003160 PGM30318 00003170 PGM30318 00003170 PGM30319 00003180 PGM30321 00003190 PGM30321 00003190 PGM30321 00003190 PGM30321 00003190 PGM30321 00003190 PGM30321 00003190 PGM30323 00003200 PGM30323 00003200 PGM30324 PAGE 35	216
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C C

RETURN END

00003230 PGM30325 00003240 PGM30326 PGM30327 00003250 PGM30328

NETWORK STRATEGIES GENERATOR

	DEFINE FILE 10(6,900,U,INF)	PGM 1000 1
	DEFINE FILE 11(300,583,U,LAU)	PGM10002
C		PGM 1000 3
C TE	IS PROGRAM GENERATES NETWOEK SRTATEGIES FROM LINK-STRATEGIES	PG M10004
С		PGM 10005
	COMMON /AME/ IDICA (32), NGENE (32), IDILIM	PGM10006
	CCMMON /CRI/ PERCE, NCRITI(100)	PGN10007
	COMMON /MIN/ MINCRI, MINSTR	PGM10008
	COMMON /NUM/ NUMCUM (32), NUMMM	PGM10009
	COMMON /PER/ IMP,LEC	PGM10010
	COMMON /SII/ NSLIP, MC, NUMSTE, IDIC, NSTR	PG M 10011
	COMMON/LYS/NSLIMA(100), NUMBER(30), MDIS(30)	PGM 100 1 2
	COMMON/FILE/ NLINK, NREG, LST (30), IAA (30)	PGM10013
	CCMMON /SIR/ ILIM, JMAX, NUMLIM, NADD	PGN 100 14
С		PGM10015
	INTEGER*2 IAA	PGM10016
	DIMENSION NGECRI(32)	PGM10017 🐰
C		PGM10018 6
	CALL INITIA	PGM10019
	IDICA (JMAX+1) = JMAX+1	PGM10020
	NUMSTR= 1	PGM 10021
	ILIMFO=ILIM	PGM10022
	MINSTREILIMPO	PGM10023
		PGM10024
	DC 1 1=1, JMAX	PGM10025
	1D1CA(1) = 1	PGM 10026
	NGENE(1) = 0	PGM10027
	1 CONTINUE	PGM 10028
		PG M1 0 02 9
		P GM 100 30
	NGENE(1) = 1	PGM10031
	NCRIGE=NCRITI(1)	PGM10032
	NGECRI(1) = 0	PGM10033
	NGECKI(Z) = NCHIGE	PGM10034
	4 1016=1016+1 TE (TRIT OF THIR) CO FO C	PGM 10035
	IT (IDIL. GT. JEAX) GO TO 2	PGM10036
		PAGE 1

11	IF (NGENE (IDIL).LT.NUMEER (IDIL)) GC TC 3	PGM10037
	NGENE(ILII) = 0	PGM10038
	IF (IDIL.LE.ILIMFO) GO TC 8	PGM10039
	GO TO 4	PGM10040
8	IF(IDIL.FQ.1) GO TO 9	PGM 10041
	IDIL=IDIL-2	PGM10042
	IDIR=IDIR-1	PGM 10043
	GO TO 7	PGM10044
9	IF(NUMSIE.NE.1) GO TO 16	PGM10045
	WRITE (IMP, 502)	PGM10046
502	FORMAT ("1"," IT IS IMPOSSIBLE TO FIND A NETWORK-STRATEGY WHICH IN	IC PGM10047
	1LUDES ALL OBLIGATORY LINK-STRATEGIES'/'1')	PGM10048
	STOP	PGN10049
16	NUMMM= O	PGM 10050
	CALL CRITIC	PGM10051
	CALL ECRIBE	PGM10052
	STOP	PGM10053
3	ILIR=IDIR+1	PG N 10054 N
	IDICA(IDIR) = IDIL	PGM10055 0
	NGENE(IDII) = NGENE(IDIL) +1	PGM10056
	MC= NUMCUM (IDIL) +NGENE (IIIL) -1	PGM 10057
	NCRIGE=NCRIGE+NCRITI(MC)	PG N1 0058
	NGECRI(IDIL+1) = NCRIGE	PGM 10059
	IF (NCRIGE.LT.MINCRI) GC TO 4	PGM10060
	IF (IDIR.LI.MINSTR) GO IC 4	PGM10061
	IDILIM=IDIR	PGM10062
	ILIM=IDII	PGH10063
	CALL VERCAL	PGM10064
	IDIR=IDILIM-1	PGM10065
	IDIL=ILIM	PGM 10066
	I1=IDIL+1	PGM1 006 7
	IF(I1.GT.JMAX) GO TO 19	PGM 10068
	DO 12 I=I1, JMAX	PGM10069
	NGENE(I) = 0	PGM 10070
12	CONTINUE	PGM 10071
19	CONTINUE	PGM10072
		PAGE 2

	MC=NUMCUM (IDIL) + NGENE (IDIL) - 1
	NCRIGE=NGECRI(IDIL+1) -NCRITI(MC)
	GC TO 11
7	ILIM=IDIL+1
	MC=NUMCUM (ILIM) + NGENE (IIIM) - 1
	NCRIGE=NGECRI (ILIM+1) -NCRITI (MC)
	I 1=ILIM+1
	DO 10 I=I1.JMAX
	NGENE(I) = 0
10	CONTINUE
	GC TO 4
2	DO 5 I=1.JMAX
	I = J MA X - I + 1
	IF (NGENE (11).EO.0) GC TC 5
	ICIL=I1-1
	IDIR=0
	DC 6 J=1,IDIL
	IF (NGENE (J) . NE. 0) IDIR=ICIR+1
6	CCNTINUE
	GO TO 7
5	CONTINUE
	NUMM=0
	CALL CRITIC
	CALL ECHIER
	STOP
	END

PGM10073 PGM 10074 PGM10075 PGM 10076 PGM10077 PGM10078 PGM10079 PGM10080 PGM 1008 1 PGM10082 PGM 10083 PGM10084 PGM 10085 PGM10086 PGM10087 PGM10088 PGM100891 PGM100902 PGM100911 PGM 10092 PGM10093 PGM 10094 PGM10095 PGM10096 PGM10097 PGM10098

SUEROUTINE VERCAL	PGM20001
C	PGM20002
COMMON /AME/ IDICA (32), NGENE (32), IDIIIM	P GM 2000 3
CCMMON /CCM/ KONPTE, KCMIIM	PG M20004
CCMMGN /IND/ INDEX	PGN 2000 5
CCMMON /IDR/ IDIR	PG N2 0006
CCMMON/LYS/NSLIMA(100),NOMBER(30),MDIS(30)	PGM 2000 7
CCMMON /NUM/ NUMCUM (32), NUMMM	PGM20008
COMMON /FES/ NWSTRA (102,20), NWSLIP (102,20)	PGM 2000 9
COMMON /PER/ IMP,LEC	PGN20010
CCMMON /SLI/ NSLIP, MC, NUMSTR, IDIC, NSTR	PG M20011
COMMON /STR/ ILIM, JMAX, NUMLIM, NADD	PGN 20012
CCMMON /YFA/ NY, NUMDIS	PG M20013
COMMON/FILE/ NLINK, NREG, LST (30), TAA (30)	PGM 20014
CCMMON/VB/LL	PG N20015
C	PGM 20016
INTEGER*2 IAA	PGN20017
DIMENSION IONVER (31)	PGN 20018 1
C	PGM20019 N
C FIBST PART OF THE PROGRAM SEARCH OF A NETWORK STRATEGY WHICH INC	LUDE PGN20020
C OBLIGATORY LINK-STRATEGIES	PGN20021
C	PG M20022
LI=1	PGN20023
CALL ZERC	PG M2 0024
DC 27 I=1, JMAX	PGM 200 25
IONVER(I) = 0	PGM20026
27 CCNTINUE	PGM 200 27
NUMST2=NUMSTR	PGM20028
IDIR=1	PGM20029
NSTR=0	PGM 200 30
INDEX=0	PGN20031
IDIC=IDICA(1)	PGM 20032
IF(ILIN.EQ.0) GO TC 1	PG M2 0 0 3 3
2 NSLIP = -NADD	P GM 20034
NUMDIS=MDIS (IDIC)	PGM20035
3 NSIR=NGENE (IDIC)	PGM20036
·	PAGE 4

	MC=NUMCUM (IDIC) +NSTR-1	PG M2 0 0 3 7
	4 NSLIP=NSLIP+NADD	PGM 20038
	CALL CALCUL	PGM20039
	IF(INDEX.EQ.1) GO TO 5	PGM 20040
	IONVER (IDIR) = 1	PGM20041
	CALL REINIT	PGM20042
	IF (IDIC.LE.ILIM) GO TC 2	PGM20043
	IF (JMAX.GT.ILIM) GO TO 1	PG M20044
	GO TO 19	PGM20045
1	5 CALL RENEMB	PG M20046
6	IF(LL.EQ.C) GO TO 26	PGM20047
	IF (NSLIP.LT.NSLIMA (MC)) GC TC 4	PGM20048
	IF(IDIR.EQ.1) GO TO 7	PGM20049
	NWSTRA (NUMSTR, IDIC) =0	PGM20050
	ILIR=IDIR-1	PGM20051
	IDIC=IDICA(IDIR)	 PGM20052
	CALL RECAL	PGM20053
	GO TO 6	PGM20054 N
С		PGM20055 ଫୁ
C SEC	CCND PART OF THE PROGRAM SEARCH OF LINK-STRATEGIES WHICH MIGHT FIT	PGM20056 '
C TH	E NETWORK-STRATEGY ALREADY FOUND	PG M20057
C		PGM 20058
	1 CONTINUE	PGM20059
:	8 NSLIP=-NADD	PGN20060
	NUMDIS=MDIS (IDIC)	PGM20061
1	9 NSTR=NSTR+1	PGM20062
	MC=NUMCUM (IDIC) +NSTR-1	PGM 2006 3
1	0 NSLIP=NSIIP+NADD	PGM20064
	CALL CALCUL	PGM 20065
	IF (INDEX.EQ.1) GO TO 11	PGM20066
	CALL REINIT	PGM 20067
1	5 IF (IDIC.LE.JMAX) GO TO 8	PGM20068
1	9 NUMSTR=NUMSTR+1	PGM20069
	DO 13 $I=1, JMAX$	PGM20070
	NWSTRA (NUMSTR,I) = NWSTBA (NUMSTR-1,I)	PGM20071
	N#SLIP(NUMSTR, I) = NWSLIP(NUMSTR-1, I)	PGM20072
		PAGE 5

13	CCNTINUE	PGM 2007 3
	CALL CRITIC	PGM20074
	IF (NUMSTE.LT.NUMLIM) GO IO 12	PGM20075
	NDMST2=0	PGM20076
12	CONTINUE	PGM20077
	DO 20 I=1, JMAX	PGM20078
	I1 = JMAX + 1 - I	PGM20079
	IF (NWSTRA (NUMSTR, I1) . EQ.C) GO TO 20	PGM 20080
	MC=NUMCUM (I1) + NW STRA (NUMSTR, I1) -1	PGM20081
	IF (NWSLIF (NUMSTR, I1).LT.NSLIMA (MC)) GO TO 21	PGM 2008 2
	IF (I1.IE.ILIM) GO TO 28	PGM20083
	IF (NWSTRA (NUMSTR, I1) .LT. NUMBER (I1)) GO TO 21	PGM20084
28	N WSTRA(NUMSTR, I1) = 0	PGM20085
20	CCNTINUE	PG N 2 0 0 8 6
	GO TO 26	PGM20087
21	IDIC=11	PGM20088
	CALL RECAL	PGN20089
	IF (IDIC.GT.ILIM) GO TC 14	PGM20090
	IDIR=0	PGM 20091 2
	DO 25 I=1,IDIC	PGM20092
	IF (NWSTRA (NUMSTR, I) . N E. C) IDIR=IDIR+1	PG M 20 0 9 3
25	CONTINUE	PGM20094
	IEIR=IDIR+1	PGM20095
	GO TO 6	PGM20096
11	CALL REMEMB	PG M2 0097
14	IF (NSLIF.LT.NSLIMA (MC)) GO TO 10	PGM 20098
	NSLIP=-NADD	PG M2 0 0 9 9
	IF(NSIR.LT.NUMBER(IDIC)) GO TO 9	P GM 20 100
	IDIC=IDIC+1	PGM20101
	NSTB=0	PGM20102
	GO TO 15	PGM20103
7	IF (NUMSTR.LE.NUMST2) GO TO 16	PG M 20 10 4
	GO TO 26	PGM 20 10 5
16	DO 23 J=1,IDILIM	PGM20106
	I=IDILIM+1-J	P GM 20 10 7
	IF (IONVER (I).EQ.0) GC IC 23	PG M2 01 08
		PAGE 6

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ILIM=IDICA(I)	PGM20109
ICIIIM=I	PG M20110
GO TO 26	PGM20111
CONTINUE	PG M2 0112
RETURN	P GM 20 113
CONTINUE	PGN20114
DO 24 I=1,JMAX	PGM20115
N WSTRA (NUMSTR, I) = 0	PGM20116
CONTINUE	PGM20117
RETURN	PGM 20118
END	PGM20119
	ILIM=IDICA(I) ITILIM=I GO TO 26 CONTINUE RETURN CONTINUE DO 24 I=1,JMAX NWSTRA(NUMSTR,I)=0 CONTINUE RETURN END

SUBROUTINE ADDCOM (CBAR, C1, C2, C)	PGM30001
C THIS SUBROUTINE MAKES C1=C2+C TAKING INTO ACCOUNT A SLIPPAGE	OF N YEARS PGM 30002
C, AND COMPARES THE C1 IC CBAR. INDEX=1 IF ONE OF THE ELH	EMENTS PGM30003
C OF C1 IS GFEATER THAN THE CORRESPONDING ELEMENT IN CHAF. J	INDEX=2 PGM30004
COTHERWISE	PGM30005
DIMENSION CBAR(10,20),C1(10,20),C2(10,20),C(20)	PGM 30006
CCMMON /IND/ INDEX	PGM30007
COMMON /SLI/ NSLIP, MC, NUMSTR, IDIC, NSTR	PGM 30008
CCMMON /YEA/ NY.NUMDIS	PGN30009
CCMMON/FILE/ NLINK, NEEG, LST (30), IAA (30)	PGM30010
INTEGER*2 IAA	PGM30011
С	PGM30012
N 1= N SL I E + 1	PGM30013
IF (N1.LE.NY) GO TO 3	PGM30014
WRITE(6,501)	PGM 300 15
501 FORMAT (11 , SOMETHING SIRANGE ONE SLIPPAGE EQUALS NY OR MORE	PGM30016
11*)	PGM 300 17
SIOP	PGM30018 4
3 IC 4 I=N1, NY	PGN 30019 N
C1(NUMDIS, I) = C2(NUMDIS, I) + C(I - NSLIP)	PGM30020 ግ
IF (C1 (NUMDIS, I) .LE.CBAR (NUMDIS, I)) GO TO 4	PGM30021
INDEX=1	PGM30022
RETURN	PG M 3 0 0 2 3
4 CONTINUE	PGM 300 24
RETURN	PGM30025
END	PGM30026

	SUBROUTINE CALCUL	PGM40001
С		PGM 40002
	COMMON/AVE/ GEC 01 (10,20),GEC 02 (10,20),GEF 01 (10,20),GEF 02 (10,20),	PGM40003
	1GESK1(10,20),GESK2(10,2C)	PGM40004
	COMMON /COM/ KOMPTE, KCMIIM	PGM40005
	CCMMON /IND/ INDEX	PGM40006
	COMMON/LIM/ COSTMA (10,20), FOCA MA (10,20), SKLA MA (10,20)	PGM40007
	CCMMON/PAR/ COST (20, 100), FOREIG (20, 100), SKILLE (20, 100)	PGM40008
	COMMON /SLI/ NSLIP, MC, NUMSTR, IDIC, NSTR	PGM40009
C		PGM40010
С	FOR REGIONAL BUDGET CONSTRAINTS	PGM 40011
	CALL ADDCCM (COSTMA, GECC2, GECO1, COST(1, MC))	PGM40012
	IF (INDEX.EQ.1) RETURN	PGM40013
С	FOR REGIONAL FOREIGN EXCHANGE	PGM40014
	CALL ADDCOM (FOCAMA, GEFC2, GEFO1, FOREIG (1, MC))	PGM40015
	IF (INDEX.EQ.1) RETURN	PGM40016
С	FOR REGICNAL SKILLED LABOR	PGM40017 N
	CALL AEDCOM (SKLAMA, GES 1/2, GES 1/5 KILLE (1, MC))	PGM40018 🏹
	RETURN	PGM40019
	END	PGN40020

	SUBROUTINE REMEMB	PGM50001
С		PGM50002
С	THIS SUBROUTINE GIVES BACK THE CLD VALUES TO THE VECTORS USED IN PRUNI	PGM50003
С		PGM50004
	CCMMON/AVE/ GECO1(10,20),GECO2(10,20),GEFO1(10,20),GEFO2(10,20),	PGM 50005
	1GESK1 (10,20),GESK2 (10,20)	PG M50006
	CCMMON /IND/ INDEX	PGM 50007
	COMMON /SLI/ NSLIP, MC, NUMSTR, IDIC, NSTR	PGM50008
	CCMMON /YEA/ NY, NUMDIS	PG M 50 0 0 9
С		PGN50010
	N1=NSIIP+1	PGM50011
	IF(N1.GT.NY) RETURN	PGM50012
	DO 1 I=N1, NY	PGM50013
	GECO2(NUMEIS,I)=GECO1(NUMEIS,I)	PGM50014
	GEF02(NUMDIS,I)=GEFC1(NUMDIS,I)	PGM50015
	GESK2(NUMDIS,I)=GESK1(NUMDIS,I)	PGM 50016
	1 CCNTINUE	PGM50017
	INDEX=0	PGM50018 J
	RETURN	PGM50019 👷
	END	PGM50020 Ÿ

SUBROUTINE RECAL	PGM70001
C	PGM70002
C THIS SUBROUTINE INITIALIZES SCME MATRICES AFTER GO	ING BACK TO A LINK PGM70003
C STRATEGY WITH A LOWER NUMBER OF REFERENCE	PGM70004
C	PGN70005
COMMON /AME/ IDICA (32), NGENE(32), IDILIM	PGM70006
CCMMON/AVE/ GECO1(10,20),GECO2(10,20),GEFO1(10	,20),GEF02(10,20), PGM70007
1GESK1 (10,20),GESK2 (10,20)	PGM70008
CCMMON /IDR/ IDIR	PGN 70009
COMMON/LYS/NSLIMA (100), NUMBER (30), MDIS (30)	PGN70010
CCMMON /NUM/ NUMCUM (32) , NUMMM	PGM 70011
COMMON/RAP/ RECOST (30, 10, 20), REFCRE (30, 10, 20)	, RESKIL (30, 10, 20) PGM70012
CCMMON /FES/ NWSTRA (102,20), NWSLIP (102,20)	PGM70013
COMMON /SLI/ NSLIP,MC,NUMSTR,IDIC,NSTR	PGM70014
COMMON /STR/ ILIM, JMAX, NUMLIM, NADD	PGM70015
COMMON /YEA/ NY, NUMDIS	PGM70016
CCMMON/FILE/ NLINK, NBEG, LST (30), IAA (30)	PGM70017
INTEGER*2 IAA	PGM 700 18
C	PGM70019
NSTB=NWSIFA (NUMSTR, ILIC)	PGM 700 20
NSLIP=NWSLIP (NUMSTR, IDIC)	PGM70021
NUMDIS=MDIS(IDIC)	PGM 70022
MC=NUMCUM (IDIC) +NSTR-1	PGM70023
IF (IDIC.FC.1) GO TO 8	PGM70024
I 1=IDIC-1	PGM70025
LO 3 I=7, NREG	PGM70026
DO 4 $J=1, I1$	PGN70027
J1 = 1D IC - J	PGM70028
IF (NWSTFA (NUMSTR, J1) . EQ. C) GO TO 4	PGM70029
IF(I.NE.MDIS(J1)) GC TC 4	PGM70030
DC = 5 K = 1, NY	PGM70031
GECO2(I,K) = RECOST(J1,I,K)	PGM70032
GFCOT(I,K) = GECOZ(I,K)	PGM70033
GFFO2(I,K) = REFORE(J1, I, K)	PGM70034
GFFOT (I, K) = GEFO2 (I, K)	PGM70035
GESK2(I,K) = RESKIL(J1,I,K)	PGM70036
	FAGE 12

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	SUBROUTINE REINIT	P GM 60 00 1
С		PGM60002
С	THIS SUBROUTINE INITIALIZES SOME MATRICES AFTER A LINK STRATEGY IS FOU	PGM60003
С	TO FIT INTO A NETWORK STRATEGY	PGM60004
С		PGM60005
	COMMON /AME/ IDICA(32),NGENE(32),IDILIM	PGM60006
	COMMON/AVE/ GECO1(10,20),GECO2(10,20),GEFO1(10,20),GEFO2(10,20),	PGM60C07
	1GESK1(10,20),GESK2(10,2C)	PGM 60008
	COMMON /IDR/ IDIR	PG M60009
	CCMMON/FAF/ RECOST (30, 10, 20), REFORE (30, 10, 20), RESKIL (30, 10, 20)	PGM60010
	CCMMON /FES/ NW STRA (102,20), NW SLIP(102,20)	PG M6 0 01 1
	CCMMON /SLI/ NSLIP, MC, NUMSTR, IDIC, NSTR	PGM 600 12
	COMMON /YEA/ NY, NUMDIS	PGM60013
С		PGM60014
	NWSTRA (NUMSTR, IDIC) = NSTE	PGM60015
	NWSLIP (NUMSTR, IDIC) = NSLIP	PGM60016
	DO 1 I = 1, NY	PGM60017
	RECOST (IDIC, NUMDIS, I) =GECO2 (NUMDIS, I)	PGM60018 🖧
	REFORE (IDIC, NUMDIS, I) = GEFO2 (NUMDIS, I)	PGM60019 P
	RESKIL (IDIC, NUMDIS, I) =GESK2 (NUMDIS, I)	PG N6 002 0
	GECO1(NUMLIS, I) = GECO2(NUMDIS, I)	PGM6 0021
	GEFO1 (NUNDIS, I) = GEFO2 (NUNDIS, I)	PGM60022
	GESK1(NOMDIS,I) = GESK2 (NOMDIS,I)	PGM60023
	1 CONTINUE	PG M6 0 02 4
	NSTR=0	PGM60025
	IF (IDIR.GE.IDILIM) GC TC 2	PGM60026
	ICIR=IDIR+1	PGM60027
	IDIC=IDICA(IDIR)	PGM60028
	GO TO 3	PGM60029
	2 IDIC=IDIC+1	PGM60030
	3 CCNTINUE	PGM60031
	RETURN	PGM60032
	E N D	PGM60033

	GESK1(I,K) = GESK2(I,K)	PGM70037
5	CONTINUE	PGM70038
	GC TO 3	PGM70039
4	CONTINUE	PGM70040
3	CCNTINUE	PGM 70041
	GO TO 11	PGM70042
8	CCNTINUE	PGM70043
	CALL ZEFC	PGM70044
11	CONTINUE	PGM70045
	DC 2 I=IDIC, JMAX	PGM 70046
	NWSTRA (NUMSTR, I) =0	PGM70047
2	CCNTINUE	PGM70048
	RETURN	PGM70049
	END	PGM70050

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SUBROUTINE CRITIC	PG M 8 0 0 0 1
	PGM 80002
C THIS SUBROUTINE COMPUTES CHITICAL INDICES FOR NETWORK-STRATEGIES A	ND PGM80003
C FRUNE STRATEGIES WITH LOW INDEX	PGM 80004
	PGM80005
CCMMON /CRI/ PERCE, NCRIII (100)	PGM80006
COMMON /RES/ NWSTRA (102,20), NWSLIP (102,20)	PGM80007
CCMMON /MIN/ MINCRI, MINSIR	PG M 8000 8
COMMON /NUM/ NUMCUM (32) , NUMMM	PGM80009
COMMON /SII/ NSLIP, MC, NUMSTE, IDIC, NSTR	PG M 8 0 0 1 0
COMMON /STR/ ILIM, JMAX, NUMLIM, NA DD	PGM80011
COMMEN /TRA/ NUMAX	PGM80012
CCMMON/FILE/ NLINK, NEEG, LST (30), IAA (30)	PGM 80013
CCMMON /YEA/ NY, NUMDIS	PG M80014
CCMMON/LYS/NSLIMA(10C), NUMBER(30), MDIS(30)	PGM80015
COMMON/PAR/ COST (20,100),FOREIG (20,100), SKILLE (20,100)	PGM80016
CCMMON/VB/LL	PGM 80017
INTEGER*2 IAA	PGN80018 &
LIMENSION NWCRIT(102)	PGM80019
DIMENSION NBSTRA (102)	PGN80020
NUMST1 = NUMSTR-1	PGN 80021
IF(NUMST1.GE.NUMAX) GO 10 28	PGM 80022
IF (NUMMM.NE.O) RETURN	PG M 8 0 0 2 3
NUMST 1= NUMST R	PGM 80024
NUMAX=NUMST1	PGM80025
28 CCNTINUE	PGM 80 0 2 6
DO 21 I = 1, NUMST1	PGM80027
J=0	PGN 80028
DC 22 K = 1, JMAX	PGM80029
IF (NWSTRA (I,K).EQ.0) GC TC 22	PG M 80 03 0
J=J+1	PGM80031
22 CONTINUE	PGM80032
NBSTRA (I) =J	PG M 80 0 3 3
21 CONTINUE	PGM80034
DO 23 I=1, NUMAX	PGM80035
$\Omega = 0$	PGM80036
	PAGE 14

DC 24 K=1, NUMST1 PGM80037 JJ=NBSTRA (K) PGM80038 IF (JJ.LE.J) GO TO 24 PGM80039 J=JJPGM80040 K1 = KPGM80041 24 CONTINUE PGM 80042 NBSTRA (R1) = -JPGM80043 23 CONTINUE PGM80044 JJ=-NBSTRA (K1) PGM80045 J=0PGM80046 DO 25 I=1,NUMST1 PGM80047 IF (NBSTRA (I) .LT.O) GC TC 26 PG M80048 IF (NBSTRA(I).LT.JJ) GO IC 25 PGM80049 26 J=J+1 PGM80050 IF(I.EQ.J) GO TO 25 PGM80051 DO 27 K=1, JMAXPGM80052 NWSTRA (J, K) = NWSTRA (I, K)PGM80053 27 CONTINUE PGM80054 1 25 CONTINUE PGN80055 👸 NUMST1=J PGM80056 1 IF (NUMST1.LT.NUMAX) NUMST1=NUMAX PGM80057 MINSTR=JJ PGM80058 DO 1 I=1, NUMST1 PGM80059 J=0 PGM80060 DO 2 K=1, JMAXPGM80061 IF (NWSTRA (I,K).EO.0) GO TO 2 PGM80062 MC = NUMCUM(K) + NWSTRA(I,K) - 1PGM80063 J=J+NCRITI(MC) PGM80064 2 CONTINUE PGM80065 NWCRIT(I) = JPGM80066 1 CCNTINUE PGM80067 LI=0PG M80068 DC 5 I=1, NUMAXPGM80069 J=0PGM80070 DC 6 K=1, NUMST1 PGM80071 JJ=NWCRIT(K) PGM80072 PAGE 15

IF(JJ.LE.J) GO TO 6 J=JJK1 = K6 CONTINUE NWCRIT (K1) = -J5 CONTINUE K=1 JJ = -100000DO 7 I=1, NUMST1IF (NWCRIT (I).GE.0) GO TC 7 IF (NWCRIT (I).GT.JJ) JJ=NWCRIT (I) DC 8 J=1, JMAX IF(K.NE.I) II=1NWSTRA (K, J) = NWSTRA (I, J)NWSLIP(K, J) = NWSLIP(I, J)8 CONTINUE K = K + 1IF (K.GT.NUMAX) GO TC 9 7 CCNTINUE 9 NUMSTR=NUMAX+1 MINCRI = -JJIF (NUMMM.NE.1) GO TO 11 DO 10 I=1, JMAX NWSTRA(NUMSTR, I) = NWSTRA(NUMLIN, I) NWSLIP(NUMSTR,I)=NWSLIP(NUMLIM,I) 10 CCNTINUE RETURN 11 K=NUMAX-1DO 12 I=1, KI1=IJJ=I+1K1=NWCRIT(I) DC 13 J=JJ, NUMAXIF (K1.LT.NWCRIT (J)) GO IO 13 K1 = NWCRIT(J)I 1=J

PGM80073 PGM80074 PGM 80075 PGM80076 PGM80077 PGM80078 PGM80079 PGN80080 PGM80081 PGM80082 PGM80083 PGM80084 PGM80085 PGM80086 PGM80087 PGN80088 PGM80089 PGM80090 PGM80091 PGN80092 1 PGM80093 PGM80094 PGM80095 PGN80096 PGM80097 PGM 80098 PGM80099 PGM80100 PGM80101 PGM80102 PGN80103 PGM80104 PGM80105 PGM80106 PG M80107 PGM80108 PAGE 16

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13	CCNTINUE	PGM 80 10 9
	IF(I1.EQ.I) GO TO 12	PGM80110
	DC 14 $J=1, JMAX$	PGN 80111
	N 1=NWSTRA (I 1, J)	PGN80112
	N2=NWSLIP(I1,J)	PG M80113
	NWSTRA(I1,J) = NWSTRA(I,J)	PGN80114
	NWSLIP(I1, J) = NWSLIP(I, J)	PGM80115
	NWSTBA(I,J) = N1	PGN80116
	NWSLIP(I,J) = N2	PGN80117
14	CCNTINUE	PGM 80118
12	CONTINUE	PGN80119
	RETURN	PG M 80 1 2 0
	END	PGM80121

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SUBROUTINE ECRIRE	PGM 90001
	PGM90002
COMMON/PAR/ COST (20,100), FOREIG (20,100), SKILLE (20,100)	PGM90003
COMMON /PER/ IMP, LEC	PGM90004
CCMMON /RES/ NW STRA (102,20), NW SLIP (102,20)	PG M 90005
COMMON /STR/ ILIN.JMAX, NUMLIM, NADD	PGM90006
CCMMON /TRA/ NUMAX	PGM90007
CCMMON/LYS/NSLIMA(100), NUMBER (30), MDIS (30)	PGM90008
COMMON /NUM/ NUMCUM(32), NUMMM	PGM90C09
CCMMON /CRI/ PERCE, NCRIII (100)	PGM 90010
COMMON/EXF/TCOST (30,20), BCOST (20)	PGM90011
CCMMON /YFA/ NY, NUMEIS	PGM90012
COMMON/FILE/ NLINK, NREG, LST (30), IAA (30)	PGN90013
	PGM90014
INTEGER*2 IAA	PGM90015
INTEGER*2 LET(52), MWSTRA(30,30), MWSLIP(30,30), IN(30,30)	PGM90016
DIMENSION NWSTR (30, 30), NWSL (30, 30), DUM (420), ETC (20), ETCB (20)	PGM90017 N
	PGM90018 0
DATA LF1/2H 0,2H 1,2H 2,2H 3,2H 4,2H 5,2H 6,2H 7,2H 8,2H 9,2H 10,2	PGM 90019
1H11, 2H12, 2H13, 2H14, 2H15, 2H16, 2H17, 2H18, 2H19, 2H20, 2H21, 2H22, 2H23, 2H	PGM90020
224, 2H25, 2H26, 2H27, 2H28, 2H29, 2H30, 2H31, 2H32, 2H33, 2H34, 2H35, 2H36, 2H3	PGM90021
37,2H38,2H39,2H40,2H41,2H42,2H43,2H44,2H45,2H46,2H47,2H48,2H49,2H50	PGM90022
4,2H /	PGM 90023
DATA NWSTR/900*0/	PGM90024
DATA NWSL/900*0/	PGM90025
DO 1 I=1,NUMAX	PGM9002 6
DC 50 JJ=1,16	PGM90027
MWSTRA(I,JJ) = LET (52)	PGM90028
MWSLIP(I, JJ) = LET(52)	PG M90029
IN(I, JJ) = LET(52)	PGM90030
50 CONTINUE	PGM90031
KKK=JMAX+1	PGM90032
IF(KXK.GT.16) GO TC 53	PGM90033
DC 52 KJ=KKK,16	PGM 90 03 4
IAA(KJ) = LET(52)	PGM90035
52 CONTINUE	PG M 90 0 3 6
	PAGE 18

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53 DO 2 K=1, JMAX PGM90037 IF (NWSTEA (I,K).EQ.0) GO TO 2 PGM90038 DO 4 L=1.16PGM90039 IF (NWSTFA (I,K). EO.L) GO TO 5 PGM90040 4 CONTINUE PGM90041 5 MWSTRA (I, K) = LET (L+1)PG M90042 DO 6 L = 1, 17PGM90043 L1=L-1 PGM90044 IF (NWSLIF (I, K) . EQ.L1) GC TO 7 PGM90045 6 CONTINUE PGM90046 7 MWSLIP(I,K) = LET(L)PGM90047 2 CONTINUE PGM90048 1 CONTINUE PGM90049 DO 30 I=1,NUMAX PGM90050 DO 25 R=1.NLINK PGM 90051 DO 26 IF=1,20 PGM90052 ETC(IE) = 0. PGM90053 26 CCNTINUE PGM90054 1 DO 41 KK=1, JMAXPGM90055 W IF(K.NE.IAA(KK)) GO TO 41 PGM90056 1 IK=NWSTRA (I, KK) PGM90057 IF (IK.EC.C) GO TO 51 PGM90058 GO TO 62 PGM90059 41 CCNTINUE PGM90060 IY=0PGM90061 51 LAU=10* (K-1) +1 PGM90062 GC TO 71 PGM90063 62 LAU=10* (R-1)+IK PGM90064 IY=NWSLIP(I,KK) PGM90065 71 READ (11'IAU) DUM, ETC PGM90066 DC 81 N=1, NY PGM90067 IF (N.EQ.1) GO TO 325 PGM90068 IF (N.GT.IY) GO TO 330 PGM90069 325 IF (IY.EQ.0) GD TO 326 PGM90070 IF (ETC (1) .GT .ETC (2)) GC TO 310 PGM 90071 326 TCOST(I,N) = TCOST(I,N) + ETC(1)PGM90072 PAGE 19

	GC TO 81	PGM90073
310	LAU = 10 * (K - 1) + 1	PGM90074
	DC 315 IE=1,20	PGM90075
	ETCB(IE)=0.	PGM90076
315	CCNTINUE	PG M 90077
	READ (11*LAU) DUM, ETCB	PGM90078
	TCOST(I,N) = TCOST(I,N) + ETCB(1)	PGM90079
	GC TO 81	PGM90080
330	N N = N - I Y	PG M 9 J 08 1
	TCOST(I,N) = TCOST(I,N) + ETC(NN)	PGM90082
81	CONTINUE	PGM90083
25	CCNTINUE	PGM 90084
30	CONTINUE	PGM90085
	WRITE (IMP,500)	PG M 90 0 8 6
500	FORMAT (* 1*)	PGM90087
	WBITE $(6, 501)$ (IAA $(K), K=1, 16$)	PG M 90 C 8 8
50 1	FORMAT(1X, 127('*')/' *', 13X, '*', 16(6X, '*')/' * LINK NUMBER *', 16(2	PGM90089
	1X, I2, 2X, ***) /* **, 13X, ***, 16(6X, ***) /1X, 127(***))	PG M90090
	DC 8 I=1, NUMAX	PGM 90091
	DO 10 K=1,JMAX	PGM90092
	IF (NWSTRA (I,K).EQ.0) GO TO 10	PGM90093
	II=NUMCUM (K) - 1+NWSTRA (I, K)	PGM90094
	DC 20 L=1,52	PGM90095
	L 1=L-1	PGM90096
	IF (NCRITI (II).EQ.L1) GC TC 27	PG M 9 0 0 9 7
20	CCNTINUE	PGM90098
27	IN(I,K) = IET(I)	PG M 90 0 9 9
10	CCNTINUE	PGM 90 100
	KK=JMAX+1	PGN90101
	IF (KK.GE.15) GO TO 40	PGM90102
40	WRITE (6,502) I, (MWSTRA (I,K), K=1,16), (MWSLIP(I,K), K=1,16), (IN(I,K), K	PGM90103
4	1=1,16)	PGM 90 104
502	FORMAT(' *', 13X, '*', 16(6X, '*')/' * N.S. ', I3, ' *', 16(2X, A2, 2X, '	PGM90105
	1*')/' *',13X, '*',16(6X, '*')/' * SLACK',7X, '*',16(2X, A2, 2X, '*')/' *	PG M 901 06
	2 CB.I.',7X, ***, 16 (2X, A2, 2X, ***)/* **, 13X, ***, 16 (6X, ***)/1X, 127 (***	PGM90107
-	3))	PGM90108
		FAGE 20

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8	CONTINUE	PGM 90109
	DO 150 I=1, NU MA X	PGM90110
	DC 140 $K=1$, JMAX	PGM90111
	I J = I A A (K)	PGM90112
	NWSTR $(I, LJ) = NWSTRA (I, K)$	PGM90113
	N # SL (I, LJ) = N # SLIP (I, K)	PGM90114
140	CCNTINUE	PGM90115
150	CONTINUE	PGM90116
	WRITE(10"4) NWSTR	PGM90117
	WRITE(10'5) NWSL	PGM90118
	WRITE (1046) TCOST. BCCST. IAA	PG M90119
	DO = 190 = 1.00 MAX = 5	PGM90120
	K K = J	PGM90121
	II = I + 4	PGM90122
	WRITE (6,85) (K.K=KK,II)	PGM90123
85	FORMAT ('1', 20X, 'TOTAL EXPENDITURES (\$)', /, 20X, 23 ('*'), /, 2X, 'YEAR'	PGM90124
	1.5X.5 (6X. 'N.S.', I3, 9X))	PGM90125
	DC = 200 J = 1.NY	PGM90126
	WRITE (6.87) J. (TCOST $(K.J)$. K=KK.II)	PGM90127
87	FORMAT(3X, 12, 6X, 5(F20, 0, 2X))	PG 128
200	CONTINUE	PGM90129
190	CONTINUE	PGM 90 1 3 0
	WRTTE(6,100)	PGM90131
100	FCEMAT (//.20X. 'BASE NETWORK'. /. 20X. 12 ('*') . /. 5X. 'YEAR'. 5X. 'TOTAL	PGM90132
	1RXPENDTTHEES (\$))	PGM90133
	DO 210 J=1.NY	PGM90134
	WRITE($6, 102$) J-BCOST(J)	PGM 90 135
10.2	FORMAT(6x, 12, 8x, F20, 3)	PGM90136
210	CONTINUE	PGM90137
2.10	RETIEN	PGM90138
	FND	PGM90139

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		SUBROUTINE MATCH (NATCH,LIST,K,RK,LABG)		PGM 10001	
		INTEGER BIANK, COMMA, FLUS, MINUS, DP	00000980	PGM10092	
		INTEGER LIST(8)		PGM 10003	
		DIMENSION LET (46), IBUF (80)		PGM10004	
		EATA LEI/*0*,*1*,*2*,*3*,*4*,*5*,*6*,*7*,*8*,*9*,*+*,*-*,*.*,*,*,*		PGM10005	
	•	1 [*] ¹		PGM10006	
	Ĩ	2'K','L','M','N','O','P','Q','R','S','T','U','V','W','X','Y','Z'/		PGM10007	
С			00001010	PGM 10008	
		DATA LASTC, IREAD, IPRNT, BLANK, CCMMA, PLUS, MINUS, DP/80, 5, 6, 14, 13, 10	,00001020	PGM10009	
	4	511,12/	00001030	PGM10010	
С			00001040	PGM 10011	
С		ENTRY POINT-CHECK OP CODE	00001050	PGM10012	
		AN UM $B=0.0$	00001060	PGM10013	
		L=LARG	00001070	PGM10014	
		IF(L.EQ.0) GO TO 110	00001080	PGM 10015	
С		L=1,READ NEW CARD,CONVERT TO DECIMAL CODE,SET BUFFER POINTER IC	00001090	PGM10016	
С		TC FIRST NON-BLANK CHAR.	00001100	PGM 100 17	Ň
		DC 800 ISS=1,80	00001110	PGM10018	Ģ.
		IBUF(ISS) = LET(15)	00001120	PGM 10019	1
	800	CONTINUE	00001130	PGM10020	
		R FA D (IR FA D, 1000, ERR=801, END=802) I BUF		PGM10021	
	1000	FORMAT (80 A 1)	00001150	PGM10022	
		GC TC 801		PGM10023	
	802	NATCH=6		PGM 10024	
		GO TO 280		PGM10025	
	8C 1	DC 101 I=1,80	00001160	PGM 10026	
		DO $102 J = 1,46$	00001170	PGM10027	
		IF (IBUF (I)-LET (J)) 102, 103, 102	00001180	PGM10028	
	10.2	CONTINUE	00001190	PGM10029	
С		NC MATCH-ILLEGAL CHARACIER, SET=50 IN IBUF	00001200	PGM10030	
		IEUF(I) = 50	00001210	PGM 10031	
		GC TO 101	00001220	PGM10032	
С		MATCHED	00001230	PGM 10033	
1	03	IBUF(I) = J - 1	00001240	PGM10034	
	101	CONTINUE	00001250	PGM10035	
С		SET IC AS FIRST NON-BIANK COLUMN	00001260	PGM10036	
			PAG	E 22	

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DC 104 I=1, LASTC
                                                                           00001270 PGM10037
      IF (IBUF (I) - BLA NK) 105, 104, 105
                                                                            00001280 PGM10038
  104 CONTINUE
                                                                            00001290 PGM10039
  105 IC=I
                                                                            00001300 PGM10040
С
                                                                            00001310 PGM10041
      POINTER IS ALWAYS SET TO FIRST CHARACTER OF NEW FIELD ON LEAVING 00001320 PGM10042
С
      MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST
С.
                                                                            00001330 PGM10043
С
      RECOGNIZAELE COLUMN, LASTCC
                                                                            00001340 PGM 10044
110
      ICAR=IBUF (IC)
                                                                            00001350 PGM10045
      IF(IC-LASIC ) 115,115,120
                                                                           00001360 PGM 10046
С
      END OF STATEMENT
                                                                            00001370 PGM10047
  120 NATCH=1
                                                                            00001380 PGM 10048
280
      RETURN
                                                                            00001390 PGM10049
С
                                                                           00001400 PGM10050
Ĉ
      OK-CHECK IF NEW FIELD IS A NUMMER, 0-9, +, -, OR.
                                                                           00001410 PGM10051
  115 IF (ICAR-12) 125, 125, 300
                                                                           00001420 PGM10052 .
C
                                                                           00001430 PGM10053 A
С
                                                                           00001440 PGH10054 T
      NUMBER FOUND-SET INITIAL PARAMETERS
C
      DECIMAL FOINT=NO
                                                                           00001450 PGM10055
  125 IDP=0
                                                                            00001460 PGM10056
C
      NEGATIVE=NO
                                                                            00001470 PGM 10057
      ISGN=0
                                                                            00001480 PGM10058
С
      NO GIGNIFICANT DIGIT YET
                                                                            00001490 PGM 10059
      ISIG=0
                                                                            00001500 PGM10060
С
      NUMERICAL VALUE OF NUMBER (REAL OR INTEGER)
                                                                           00001510 PGM10061
      NUM B=0
                                                                           00001520 PGM10062
      SAVE START OF NUMBER
C
                                                                            00001530 PGM10063
      ICSTR = IC
                                                                           00001540 PGM10064
С
      IS FIRST CHAR A PLUS SIGN-IGNORE IF YES
                                                                           00001550 PGM10065
      IF (ICAR-PLUS) 126, 130, 126
                                                                           00001560 PGM10066
С
      CHECK IF MINUS SIGN-SET ISIGN=1 IF YES
                                                                           00001570 PGM10067
  126 IF (ICAP-MINUS) 135, 127, 135
                                                                           00001580 PGM10068
127
      ISGN=1
                                                                            00001590 PGM10069
      LEADING FLUS OR MINUS SIGN-BUMP CARD COLUMN POINTER-CHECK
С
                                                                           00001600 PGM10070
С
      IF END CF FIELD
                                                                           00001610 PGM10071
С
      THIS IS GENERAL CC BUMPER SECTION OF CODE
                                                                           00001620 PGM10072
                                                                                 PAGE 23
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130	IC=IC+1
	ICAR=IBUF(IC)
	IF (IC-LASTC) 135,135,140
С	CHECK IF CC IS BLANK OF COMMA
135	IF (ICAR-ELANK) 145,140,145
145	IF (ICAR-COMMA) 150.140.150
С	NOT END OF FIELD-IS IT A DIGIT
150	IF (ICAR-9)155,155,160
С	DIGIT 0-9, DECIAML POINT VET
155	IF (IDP-1) 165, 170, 165
С	ALREADY HAVE DP, N IS THUS NEGATIVE, NUMBER IN A NUMB
170	ANUMB=ANUMB+FLOAT (ICAR) * (10. **N)
	N=N-1
	GC TO 130
С	NC DP YET, IS DIGIT A ZERO
165	IF (ICAR) 175, 180, 175
C	NOT ZERC, THUS IT IS SIGNIFICANT
175	ISIG=1
	GO TO 185
С	ZERO-CHECK IF SIGNIFICANT, IF NOI SKIP
180	IF(ISIG-1)130,185,130
185	NUMB=10*NUMB+ICAR
	GO TO 130
С	
С	CHARACTER NOT DIGIT IS IT DE
160	IF (ICAB-DP) 195, 190, 195
С	YES, WAS ONE GIVEN PREVICUSLY
190	IF (IDP-1)200,99,200
200	N=-1
	IDP=1
	A N U M B= N U M E
	GC TO 130
C	
C	NCT DIGIT OR DP, IS IT E, IF NOT, ERROR (99)
195	IF (ICAR-24) 99,205,99
С	E FORM-E(PLUS OR MINUS) N1, (N2)

00001630 PGM10073 00001640 PGM10074 00001650 PGM10075 00001660 PGM10076 00001670 PGM10077 00001680 PGM10078 00001690 PGM10079 00001700 PGM10080 00001710 PGM 10081 00001720 PGM10082 00001730 PGM10083 00001740 PGM10084 00001750 PGM10085 00001760 PGM10086 00001770 PGM10087 00001780 PGM10088 00001790 PGM10089 00001800 PGM10090 00001810 PGM10091 00001820 PGM10092 00001830 PGM10093 00001840 PGM 10094 00001850 PGM10095 00001860 PGM10096 00001870 PGM10097 00001880 PGM10098 00001890 PGM10099 00001900 PGM10100 00001910 PGM10101 00001920 PGM10102 00001930 PGM 10103 00001940 PGM10104 00001950 PGM 10105 00001960 PGM10106 00001970 PGM10107 00001980 PGM10108 PAGE 24

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205	IF (IDP-1) 210, 214, 210
С	NO DP YET,FLCAT NUMBER
210	A NU MB = NUMB
	[DP=1
214	I=1
С	SIGN OF EXPONENT=PLUS
	IEP=+1
С	VALUE OF EXPONENT=0
	IE X=0
С	NEXT COLUMN
215	IC=IC+1
	ICAR=IBUF (IC)
	IF (IC-LASTC) 216, 216, 99
216	IF (ICAR-BLANK) 217,99,217
217	IF (ICAR-COMMA) 218,99,218
218	GO TO (220,225),I
C	CHARACTER AFTER E, IS IT PLUS, MIMUS, OR DIGIT
220	IF (ICAR-PIUS) 226,230,235
235	1F(ICAR-MINUS) 99,240,99
C	MINUS SIGN
240	TWAL-1
C	HERE FOR PLUS SIGN ALSO
L 226	RESET SWITCH AND GET NEXT COLUMN
2.30	1-2 CO TRO 315
\sim	START OF CHR OF THO FYECHENT DICITS
225	TRADE OF ONE ON TWO EXPONENT DIGITS $TR(TCNP=Q)226, 226, QQ$
225	TFY-TCNP
220	
223	IC= TC+1
<u> </u>	ICAR=IBUF (IC)
	TF(TC-LASTC) 231.231.250
231	TF(TCAR-BTANK) 227,250,227
227	IF (ICAR-CCMMA) 228,250,228
228	GO TO (224,99), I
224	IF (ICAE-9) 229, 229, 99

00001990	PGM 10 10 9
00002000	PGHIUIIU
00002010	PGMIUIII
00002020	PGM10112
00002030	PGMIUIIS
00002040	PGHI0114
00002030	PCM10116
00002050	PCM10117
00002070	PCM10118
00002000	DCM10110
00002090	DCN10120
00002100	DCM10121
00002170	PGM10127
00002120	DGN10122
00002100	PGM10120
00002150	PGN 10 125
00002160	PGM10126
00002170	PGN 10 127
00002180	PGM10128
00002190	PGM10129
00002200	PGM 10 130
00002210	PGM10131
00002220	PGM10132
00002230	PGM10133
00002240	PGM 10 134
00002250	PGM10135
00002260	PGM10136
00002270	PGM10137
00002280	PGM10138
00002290	PG M1 01 3 9
00002300	PGM 10 140
00002310	PGM10141
00002320	PGM10142
00002330	PGM10143
66662340	PGM10144
PAGI	z 25

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229	I=2	00002350	PGM10145
	IEX=10*IEX+ICAR	00002360	PGM 10 146
	GC TO 223	00002370	PGM10147
C	END OF E FORM-MULTIPLY NUMBER BY EXPONENT	00002380	PG M10148
250	ANUMB=ANUMB* (10.** (IEP*IEX))	00002390	PGM10149
С		00002400	PGM10150
C	END OF NUMBER, POINTER AT BLANK, CCMMA, OR ECC	00002410	PGM10151
140	IF (ISGN-1) 144, 141, 144	00002430	PGM10152
С	ILP=0, INTEGER IN NUMB-ILP=1, PEAD IN ANUMB	00002420	PGM 10 153
C	NEGATE-CHECK IF INTEGEE CR REAL	00002440	PGM10154
141	IF(IDP) 142, 143, 142	00002450	PGM 10 155
С	REAL	00002460	PGM10156
142	A NUMB = - A NUM B	00002470	PGM10157
	GO TO 144	00002480	PGM10158
С	INTEGER	00002490	PGM10159
143	NUM B= - NUM E	00002500	PGM10160 .
144	NATCH=IDP+2	00002510	PGM10161 N
	K= NUMB	00002520	PGN 10 162
	R K = A NUMB	00002530	PGN10163
С		00002540	PGM 10 164
С	POINTER AT BLANK, COMMA, CR EOC-BUMP TO A NON-BLANK, NON-COMMA	00002550	PGM10165
С	CHARACTER OR LEAVE AT FOC-THIS SECTION OF CODE IS USED	00002560	PGM10166
С	BEFORE RETURNING	00002570	PGM10167
270	IF (IC-LASTC) 271, 271, 280	00002580	PGM10168
271	IC=IC+1	00002590	PGM 10 169
	IF (IC-LASTC) 272, 272, 280	00002600	PGN10170
27.2	IF (IBUF (IC) - BLANK) 273, 271, 273	00002610	PGM 10 17 1
273	IF (IBUF (IC) - COMMA) 280, 271, 280	00002620	PGM10172
С		00002630	PGM 10 17 3
С		00002640	PGM10174
С	FIRST CHAR IS NOT EOC, NUMBER-IS IT \$	00002650	PGM10175
300	IF(ICAR - 17) 330, 120, 330	00002660	PGM10176
С		00002670	PGN10177
С		00002680	PGM10178
С	BY ELIMINATION, THE FIELD IS A WORD-SAVE IC AND GET END OF WORD.	00002690	PG M10179
С	FCFM FACKED WORD IN FECIMAL CODE TO COMPARE AGAINST LIST-NEED	00002700	PGM 10 180
		PAGI	E 26

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С
      FIRST WORD IN LIST AS NUMBER OF CHARS IN WORD.
С
      BLANK PAD ON RIGHT.
  330 \text{ ICSTR} = \text{IC}
  410 IC=IC+1
      ICAR=IBUF (IC)
      IF(IC-LASTC) 415, 415, 420
  415 IF (ICAR-COMMA) 405, 420, 405
  405 IF (ICAR-BLANK) 410, 420, 410
С
      END OF FIELD
  420 IFND=IC-1
С
      USE LIST FIRST
      NC = LIST(1)
С
      GET CHARACTERS IN WORD
      NCW=IEND+1-ICSTR
      NCW1 = NCW + 1
      I 1 D=0
C
      CHECK IF FIELDS IS SHORIER THAN DICT. WORDS
      IF (NCW-NC) 440,455,455
      SHORTER-BLANK PAD
C
  440 DO 445 I=1,NCW
      IJK=ICSTR +I-1
445
      IND=100*IND+IBUF (IJK)
      DO 450 I=NCW1, NC
      GC TO 465
450
      IWD=100*IWD+BLANK
С
      NCW.GE.NC
  455 DC 460 I=1.NC
      IJK=ICSTE +I-1
460
      I WD = 100 \times I WD + I EUF (IJK)
С
      NOW IWD CONTAINS NC CHARACTERS TO COMPARE
С
C
      TO DICTICNARY WORDS
465
      NWDS=LIST(2)
      DC 475 I=1, NWDS
      IF(IWD-LIST(I+2))475,480,475
  475 CONTINUE
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00002710	PGM10181	
00002720	PGM10182	
00002730	PGM10183	
00002740	PGM 10 184	
00002750	PGM10185	
00002760	PGM 10 186	
00002770	PG M1 01 87	
00002780	PGM 10 188	
00002790	PGM10189	
00002800	PGM 10 190	
00002810	P GM 10 19 1	
00002820	PGM10192	
00002830	PGM10193	
00002840	PGM10194	,
00002850	PGN 10 195	
00002860	PGM10196	
00002870	PGM 10 197	2
00002880	PGM10198	ŗ,
00002890	PGM 10 199	1
00002900	PGM10200	
00002910	PGM10201	
00002920	PGM10202	
00002930	PGM10203	
00002950	PGM 10 20 4	
00002940	PGM1 02 05	
00002960	PGM 10 20 6	
00002970	PGM10207	
00002980	PGM10208	
00002990	PGM10209	
00003000	PGM10210	
00003010	PGM10211	
00003020	PGM10212	
00003030	PGM 10213	
00003040	PGM10214	
00003050	PGM10215	
00003060	PGM10216	
FAGI	E 27	

С	WORD NOT FOUND IN DICTICNARY	00003070 PGM10217
	NATCH=4	00003080 PGM10218
	K=ICSTR	00003090 PGN 10219
	GO TO 270	00003100 PGM10220
С	WORD FOUND IN DICTIONARY	00003110 PGM10221
480	K=I	00003120 PGN10222
	NATCH = 5	00003130 PGM10223
	GO TO 270	00003140 PGM10224
С		C0003150 PGM10225
C		00003160 PCM10225
Č	ERROR IN NUMBER FIELD	00003100 Pon 10220
99	WRITE (TERNT, 999)	00003170 PG110227
	K=TCSTR	
		00003190 PGM10229
		00003200 PGM10230
	GO TO 270	00003210 PGM10231
999	FORMAT (25H ERROR IN NUMERIC FIELD.)	00003220 PGN10232
С		00003230 PGN10233 N
С		COCO3240 PGM10234 စိ
	RETURN	PGN 10235
	END	00003250 PGM10236

<pre>SUBROUTINE INITIA COMMON/AVE/ GEO1(10,20),GECO2(10,20),GEPO1(10,20),GEPC2(10,20), 1GESK1(13,20),GESK2(10,20) CCMMON/CCM/ KOMPTE,KOMIIM COMMON /CCM/ KOMPTE,KOMIIM COMMON /CCM/ KOMPTE,KOMIIM COMMON/LIK/ COSTMA (10,20),FOCAMA (10,20),SKLAMA (10,20) COMMON/LIK/ COSTMA (10,0), FOCAMA (10,20),SKLAMA (10,20) CCMMON /FAR/ COST(20,100),FOCEIG(20,100),SKILLE (20,100) CCMMON/FAR/ COST(20,100),FOCEIG(20,100),SKILLE (20,100) CCMMON/FAR/ FOCOST (20,0),FOCEIG(20,100,20),RESKIL (30,10,20) CCMMON/FAR/ FECOST (30,10,20),KEFCRE (30,10,20),RESKIL (30,10,20) CCMMON /FAR/ NERA (102,20),KEFCRE (30,10,20),RESKIL (30,10,20) CCMMON /FAR/ NERA (102,20),NEFCRE (30,10,20),RESKIL (30,10,20) CCMMON /FAR/ NUMAX COMMON /FAR/ NUMAX COMMON /FAR/ NUMAX,NUMLIM,NADD COMMON /FAR/ NUMAX COMMON /FA</pre>	PG M10001 PGM10002 PGM10003 PGM10005 PGM10006 PGM10007 PGM10008 PGM10009 PGM10010 PGM10011 PGM10012 PGM10013 PGM10015 PGM10015 PGM10016 PGM10017 PGM10019 PGM10020 PGM10020 PGM10021 PGM10022 RA PGM10023 PGM10025 PGM10025 PGM10026 PGM10027 PGM10027 PGM10027 PGM10028 PGM10027 PGM10027 PGM10027 PGM10027 PGM10027 PGM10031 PGM10031 PGM10033 PGM10035 PGM10036 PGM10036
--	--

	DC 51 I=1,30	PGM 10037
	IAA(I)=0	PGM10038
	51 CONTINUE	PGM10039
	DO 61 I1=1,30	PGM10040
	DC = 62 = N = 1,20	PGM10041
	TCOST(I1,N)=0.	PGM 10042
	62 CONTINUE	PGM10043
	61 CCNTINUE	PGM 10044
С	ASSIGN DATA TO THE VARIABLES	PGM10045
С	READ THE BASIC FILE	PGM10046
	READ (10 ° 1) NLINK, NODE, NREG, NY, JIM, RATE, VCAP, LDUM, LST, MDIS, COSTMA, FO	PGM10047
	1CAMA, SKLAMA	PGM10048
	10 CALL MATCH (ITYPE, IDICT, K, RK, 1)	PGM10049
	GC TO (100,100,100,100,18,95),ITYPE	PGM10050
	18 IK1=K	PGM 10051
	GO TO (20,30,50,70,80,40,90),IK1	PGM10052
С	NETWORK SIFATEGIES	PGM 10053 .
	20 CALL MATCH (ITYPE, IDICT, K, RK, O)	PGM10054 Å
	GO TO (10,25,110,20,20),IIYPE	PGM 10055 T
	25 NUMLIM=K	PGM10056
	GC TO 10	PGM10057
С	OBLIGATORY LINKS	PGM10058
	30 KK=0	PGM10059
	35 CALL MAICH(ITYPE,IDICI,K,RK,O)	PGM 10060
	GO TO (39,38,120,35,35),ITYPE	PG M1 0 06 1
	38 KK=KK+1	PGM 10062
	IAA(KK) = K	PGM10063
	GC TO 35	PGM10064
	39 ILIM=KK	PGM10065
	JMAX=ILIM	PGM10066
	GO TO 10	PGM10067
С	INCREMENTAL SLIPPAGE	PG M10068
	40 CALL MATCH(ITYPE, IDICT, F, RK, 0)	PGM 10069
	GO TO (10,48,45,40,40),ITYPE	PG M1 0 0 7 0
	45 K=BK	PGM 10071
	48 NADD=K	PGM10072
		PAGE 30

	GO TO 10	PGM10073
C OP	IONAL IINKS	PGM10074
50	K K = 0	PGN 10075
55	CALL MATCH (ITY PE, IDICT, K, RK, 7)	PGM10075
	GC TO $(60, 58, 130, 55, 55)$. TTYPE	PGM 10077
58	K K + 1	PCM10077
	J=ILIM+KK	PGM10079
	IAA(J) = K	PGM10080
	GC TO 55	PGN 10081
60	JMAX=ILIM+KK	DCN10007
	GC = TO = 10	PCM10002
C PE	CENTAGE CF N.S.	DCM 1008/
7.0	CALL MATCH (ITYPE_TDICT_K_RK_O)	DCN10095
	GC = TO = (10.140.75.70.70) - TTYPF	PG110005
75	PERCE=RK	PGH 10000
	GC TO 10	PGM10088 .
80	CALL MAICH (TTYPE, IDICT, K, RK, O)	PGN10089 2
	GC TO (10.85.150.80.8C). TTYPE	PGN 10090
85	MINCRI=K	PGN10090
	GC TC 10	DGM10097
100	WRITE (6, 105)	PGN10092
105	FOFMAT (/, ' FRROR IN COMMAND CARD ')	PGN10094
	GC TO 10	PGM 10095
110	WRITE (6,115)	PGM10096
115	FORMAT (/, ' ERROR IN NETWORK CARD')	PGM 10097
	GO TO 10	PGM10098
120	WFITE(6, 125)	PGM 10099
125	FORMAT (/, ' ERROR IN CBLIGATORY LINKS CARD')	PGM10100
	GC TO 10	PGM 10 10 1
130	WRITE (6,135)	PGN10102
135	FOFMAT(/, ' ERROR IN OPTIONAL LINKS CARD')	PGM10103
	GO TO 10	PGM10104
140	WBITE(6,145)	PGM 10 105
145	FORMAT (/, ' ERROR IN FERCENTAGE CARD')	PGM 10 10 6
	GO TO 10	PGM 10107
150	WRITE (6,155)	PGM10108
		PAGE 31
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15 5	FORMAT(/, ' ERROR IN CRITICAL INDEX CARD')	PGM 10 10 9
	GO TO 10	PGM10110
95	CALL EXIT	P GM 10 111
90	CONTINUE	PGM10112
	CALL BUDGET (JMAX)	PGM10113
	$N \cup M \subset \bigcup M (1) = 1$	PGM 10 114
	DO 250 I=1, J MA X	PGM10115
	LINK=IAA(I)	PGM10116
	NUMBER $(I) = LST (LINK)$	PG M 1 0 1 1 7
	NN = NUMBEF(I)	PGM 10 1 18
	NUMCUM(I+1) = NUMCUM(I) + NN	PGM10119
	LAUC=10*(LINK-1)	PGM 10 120
	DO 240 II=1,NN	PGM10121
	LAU=LAUC+II	PGM10122
	READ(11'LAU) DUMMY, ETC, FTC, SKL, FOR, DUM, ISTR, NCRIT, NSLIM	PGM10123
	J = NUMCUP(I) - 1 + II	PG № 10124 №
	DO $230 \text{ K} = 1, \text{NY}$	PGM10125 🖗
	CCST(K, J) = FTC(K)	PGM10126
	FCREIG(K, J) = FOR(K)	PGM 10 127
	SKILLE(K, J) = SKL(K)	PGM10128
230	CCNTINUE	PGM 10 129
	NSLIMA (J) = NSIIM	PGM10130
	NCRITI (J) =NCRIT	PGM10131
	NSLIM=0	PGM10132
	NCRIT=0	PGM10133
	DO 225 $K = 1, NY$	PGM10134
	FTC(K) = 0.	PGM10135
	FCR(K) = C.	PGM 10 136
	SKL(K) = 0.	PGM10137
225	CCNTINUE	PGM 10 138
240	CONTINUE	PGM10139
250	CONTINUE	PGM10140
	N 1 = NUMCUM (JMAX + 1) - 1	PGN10141
	DO 2 J=1, NREG	PGM10142
	DO $3 I = 1, NY$	PGM10143
	GECO1(J,I) = 0.	PGM10144
		PAGE 32

	GEFO1(J,I) = 0.	PGM10145
	GESK1(J,I) = 0.	PGM10146
	$\operatorname{RECOST}(1, J, I) = 0.$	PGM 10 147
	REFORE $(1, J, I) = 0$.	PG M10148
	RESKIL $(1, J, I) = 0$.	PGM 10 149
3	CONTINUE	PGM10150
2	CCNTINUE	PGM 10 15 1
	DC 6 J=1, JMAX	PGM10152
	CC 5 J=1,NUMLIN	PGN10153
	N KSTRA (J, I) = 0	PGM10154
5	CCNTINUE	PGM10155
6	CONTINUE	PGM10156
	NUMAX=NUMIIM*PERCE	PGM10157
	RETURN	PGM 10 158
	END	PGM10159

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	SUBROUTINE ZERO	PGM 1000 1
	CCMMON/AVE/ GEC C1 (10,20), GECO2 (10,20), GEFO1 (10,20), GEFO2 (10,20),	PGM10002
	1GESK1(10,20), GESK2(10,20)	PGM10003
	COMMON /BEG/ NREG	PGM10004
	CCMMON /YEA/ NY, NUMDIS	PGM 10005
	DC = 20 K = 1, NREG	PG M1 0006
	DC 19 $I=1, NY$	PGN 10007
	GECO1(K,I)=0.	PGM10008
	GECO2(K, I) = 0.	PGM10009
	GEFO1(K,I)=0.	PGM10010
	GEFO2(K, I) = 0.	PGM10011
	GESK1(K, I) = 0.	PGM 10012
	GFSK2(K, I) = 0.	PGM10013
19	CCNTINUE	PGM 10014
20	CONTINUE	PGM10015
	RETURN	PGM10015
	END	PGM10017
		r GHIVVI/

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	SUB ROUTINE BUDGET (JMAX)	PGM 1000 1
	COMMON/IIM/ COSTMA (10,20), FOCAMA (10,20), SKLAMA (10,20)	PGM10002
	CCMMON/LYS/NSLIMA (10C), NUMBER (3C), MDIS (3C)	PGM 10003
	COMMON/FILE/ NLINK, NREG, LST (30), IAA (30)	PGM 10004
	CCMMON /YEA/ NY, NUMDIS	PGM10005
	COMMON/EXP/TCOST (30,20), BCOST (20)	PGM10006
	INTEGER*2 IAA	PGM10007
	DIMENSION DUMMY(420), ETC(20), FTC(20), SKL(20), FCR(20), DUM(80)	PGM10008
	DO 10 I=1, NY	PGM10009
	BCCST(I) = 0.	PGM 100 10
10	CCNTINUE	PGM10011
	DC 100 I=1,NLINK	PGM 100 12
	LAUC=10*(I-1)	PGM10013
	LAU = LAUC + 1	PGM10014
	DC 30 $K = 1, 20$	PGM10015
	S K L (K) = 0.	PGM10016
	FCR(K) = 0.	PGM 100 17 N
	FTC(K) = 0.	PGM10018 4
	EIC(I) = 0.	PGM10019
30	CONTINUE	PGM 10020
	READ(11'IAU)DUMMY, ETC, FIC, SKL, FOR, DUM, ISTR, NCRIT, NSLIM	PGM10021
	L=MDIS(I)	PGM 10022
	DC = 50 KK=1, NY	PGM10023
	BCOST(KK) = BCOST(KK) + FTC(KK)	PGM 10024
	A=COSTMA (I, KK)	PGM10025
	A = A - FTC (KK)	PGM 10026
	IF(A1.LE.O.) GC TO 200	PGM10027
	COSTMA(L,KK) = A 1	PGM10028
	B=FOCAMA(L,KK)	PGM10029
	B1 = B - FOR(KK)	PGM10030
	IF(B1.LE.0.) GO TO 210	PGM10031
	FCCAMA(L,KK) = B1	PGM10032
	E = SKLAMA(L, KK)	PGM 10033
	D1=D-SKI(FK)	PGM10034
	IF(D1.LE.O.) GO TO 220	PGM 10035
	SKLAMA(I,KK) = D1	PGM10036
		PAGE 35

50 CONTINUE	PGM10037
100 CONTINUE	PGM10038
GO TO 250	PGM 10039
200 WRITE (6,205) L,KK	PGM10040
205 FCRMAT(/, ' THE AVAILAELE BUDGET FOR REGION ', 12, ' AND THE YEAR	PGM 10041
1', I2, ' HAS BEEN EXHAUSTED')	PGM10042
GO TO 240	PGN 10043
220 WRITE(6,225) L,KK	PGM10044
225 FCRMAT(/, ' THE AVAILABLE SKILLED LABOR FOR REGION ', 12, ' AND YE	PGM10045
1AR ', 12, ' HAS BEEN EXHAUSTED')	PGM10046
GC TO 240	PGM 10047
210 WRITE (6,215) L,KK	PGM10048
215 FORMAT (/, ' THE AVAILABLE FOREIGN EXCHANGE FOR REGION ', 12, ' AN	PGM10049
ID YEAR ', 12, ' HAS BEEN EXHAUSTED')	PGM10050
240 CONTINUE	PGM 10051
CALL EXIT	PGM10052
250 CUNTINUF	PGM10053
K ST UR N	PGM10054 '
	PGN10055

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NETWROK STRATEGIES EVALUATOR

С	THIS PROGRAM EVALUATES NEIWORK SIRATEGIES	PGM 1000 1
	DEFINE FILE 10 (6,900, U, INF)	PGM10002
	DEFINE FILE 11(300,583,U,LAU)	PGM 10003
	DEFINE FILE 12 (30,448,U,JIMC)	PGM10004
	CCMMON/GEN/NLINK, NODE, JIM, NS, VTIME (30,7), FALOD (30,7), BCOST (20), LBE	PGM10005
	1G (30), LEND (30), LOD (30, 3C), LLA (3C, 3C), VCAP(7), ICPT, IVF, ISIM (20), IG	PGN10006
	2 RAF (20)	PGM10007
	COMMON/CD/IPATH(7,30,15),VEC(30,7),VFC(30,7)	PGM 10008
	COMMON/INK/TT (30,7), CFC (30,7), EOPC (30,7), CAP (30), SPD (30,7), RLEN (30	PG M10009
	1), TRAFF (30), TEF (30,7), RAFF (30), VEHTRA (30,7), DSPR (30)	PGM 100 10
	COMMON/ZEL/ATT (20,7), ECC (20,7), FOC (20,7), FTC (20), DIS (20), CP (20), ET	PGM10011
	1C(20), RAF(20), DSP(20)	PGM 10012
	COMMON/ZED/DEMAND (20,7), ELA (7), PRICE (7), VALT (7), BVEC (20,7), BVFC (20	PGM10013
	1,7)	PGM 100 14
	DIMENSION IDICT (9), LST (30), MDIS (30), COSTMA (10,20), FOCAMA (10,20), SK	PGM10015
	1LAMA(1C, 2C), NETS(30)	PGM10016
	DIMENSION NRANK (30), NWSTR (30, 30), NWSL (30, 30), TCOST (30, 20), IAA (30	PGM 10017
	2), SPEED (7), TCTBEN (30), FLOAD (7), FOR (20), SKL (20), DUM (420), ETCB (20)	PGN10018
	INTEGER*2 IAA	PGM10019 N
С	WORDS IN IDICT: A NALYSIS, EVALUATE, ALL, SIMULATION, DELETE, RANK, PRINT	PGN10020 5
	DATA IDICT/3,7,203320,244120,203131,382832,232431,372033,353728/	PGM 10021 '
	DATA NEIS/30*0/	PGM10022
	DC 10 I=1,30	PGM 10023
	DO 8 $K=1,7$	PGM10024
	V II M E (I, K) = 0.	PGM 10 02 5
	FALOD(I,K)=0.	PGM10026
	8 CONTINUE	PGM10027
	10 CCNTINUE	PGM 10028
	DO 11 I=1,20	PG M1 0 02 9
	ISIM(I) = 0	PGM 100 30
	IGRAF(I) = 0	PGM10031
	11 CONTINUE	PGM10032
	READ (10 * 1) NLINK, NODE, NREG, NY, JIM, RATE, VCAP, LBEG, LEND, LST, MDIS, COST	PGM 10033
	1 MA, FOCA MA, SKLAMA, IOPT, NRANK	PG M 10034
	READ (10 º 2) LLA	PGM10035
	R EA E (10'3) LOD	PGM10036
		PAGE 1

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READ (10 '4) NWSTR PGM10037 READ (10 * 5) NWSL PGM10038 READ (10.6) TCOST, BCOST, IAA PGM10039 BRTE=BATE/100.PGM 10040 M I = 0PGM10041 I BA NK = 0PGM10042 IEASE=0PGM10043 LASTNS=0PGN10044 DO 17 I=1.7 PGM10045 IF (VCAP (I). E0.0) GO TC 16 PGM10046 **17 CONTINUE** PGM 10047 GO TO 20 PGM10048 16 IVF=I-1 PGM10049 20 CALL MATCH (ITYPE, IDICT, F, RK, 1) PGM 10050 GO TO (100,100,100,100,22,150),ITYPE PGM10051 22 IK1=K PGM 10052 GC TO (25,30,30,70,50,60,150),IK1 PG M1 0 05 3 C ANALYSIS OF EASE NETWORK PGM 10054 | PGM1 0055 0 25 IBASE=1GO TO 20 PGM10056 i 30 CALL MATCH (ITYPE, IDICT, K, RK, 0) PGM10057 GO TO (38,37,35,30,40),ITYPE PGM10058 C N.S. TO EE EVALUATED PGM10059 35 K = RKPGM10060 37 MI=MI+1 PGM 10061 NETS (MI) = KPGM10062 LASINS=MI PGM 10063 GO TO 20 PGM10064 38 IF (I.EQ.C) GO TO 110 PGM10065 GO TO 20 PGM10066 EVALUATE AIL STRATEGIES GENERATED C PGM10067 40 CALL MATCH (ITYPE, IDICT, K, RK, 0) PGM10068 GO TO (20,47,45,40,40), ITYPE PGM10069 45 K=RKPGM10070 47 LASTNS = KPGM10071 DO 48 IK=1,LASTNS PGM 10072 PAGE 2

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NETS(IK) = IK	PG M1 0 0 7 3
48 CONTINUE	PGN 10074
GO TC 20	PGM10075
C YEARS OF SIMULATION	P GM 10076
70 KK=0	PGM10077
71 CALL MATCH (ITYPE, IDICT, K, RK, O)	PGM10078
GO TO (20,77,75,71,71),ITYPE	PGN10079
75 K=RK	PG N1 0080
77 KK=KK+1	P GM 1008 1
ISIM(KK) = K	PGM10082
GC TO 71	PGM10083
C DELETE THE STORED RANKING OF N.S.	PGM10084
50 DO 55 II=1,30	PGM10085
NRANK (II) = 0	PGN10086
55 CONTINUE	PGM10087
GO TO 20	PGN10088
60 IRANK=1	PGM10089 🐰
GO TO 50	PGM 10090 8
C ERROR FORMATS	PG M1 0 0 9 1
100 WRITE(6,105)	PGM 10092
105 FORMAT(/* EPROR IN FCRMATS*)	PGM10093
GO TO 20	PGM 10094
110 WRITE (6,115)	PGM10095
115 FCEMAT(/ NONE N.S. NUMBER')	PGM10096
GC TO 20	PGM10097
C YFARS TO BE PRINTED	PGN 10098
150 KK=0	PGM10099
152 CALL MATCH (ITYPE, IDICT, K, RK, O)	PGM10100
GO TO (151,157,155,152,152),ITYPE	PGM10101
155 K=RK	PGM10102
157 KK=KK+1	PGM 10 10 3
I GRAF(KK) = K	PGM10104
GO TO 152	PGM10105
151 CONTINUE	PGM10106
DO 180 I=1,JIM	PGM10107
DO 165 IV=1,7	PGM10108
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	VALT(IV) = 0.	PGM 10 109
	FLOAD(IV) = 0.	PGN10110
165	CONTINUE	PGM10111
:	JIMC=I	PGM10112
	READ (12'JIMC) DEMAND, FLA, FRICE, VALT, FLOAD	PGM10113
	DO 170 $IV = 1,7$	PGM10114
	FALOD(I, IV) = FLOAD(IV)	PGN10115
	VTIME(I, IV) = VALT(IV)	PGN 10 116
170	CONTINUF	PGM10117
180	CCNTINUE	PGM 10 118
C STA	RT ANALYSIS OF THE EASE NETWORK	PGM10119
	IF (IBASE.FQ.0) GO TO 200	PGM10120
	CALL EASENE (NY)	PGM 10 121
C STA	RT ANAIYSIS OF EACH N.S.	PGM10122
200	CONTINUE	PGM10123
	DO 1000 LJ=1, LASTNS	PG M10124
	I=NETS(LJ)	PGM 10 125
1	WRITE (6,600) I	PGM10126 👸
600	FCRMAT(///,30X, 'NETWORK STRATEGY',12,/,30X,18('*'))	PGM 10 127 T
	ISTR=0	PGM10128
:	ACBEN=0.	PGM10129
	DO 80C IYR = 1, NY	PGM10130
	EXP=0.	PGM10131
	BENEF=0.	PGN 10 132
	WRITE (6,666) IYR	PGM10133
666	FORMAT(/, 3X, "YEAR", I5, /, 3X, 9 ("-"))	PGM 10 134
	DO 995 IL=1,30	PGM10135
	DC 994 $LK = 1,7$	PGM10136
	VEHTEA(LL,LK)=0.	PGM10137
994 (CCNTINUE	PGM10138
995	CONTINUE	PGM 10 139
	IF (IYR.EQ.1) GC TC 205	PG M10140
	II=IYB-1	PGM 10 14 1
	DIF=TCOST (I, IYR) - TCOST(I, II)	PG M10142
	IF(DIF.GE.1000.) GO TC 205	PGM 10 143
	IF (DIF.IE1000.) GO TO 205	PGM10144
		PAGE 4

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	DO 166 $JJ=1,20$	PGM10145
	IF (ISIM (JJ) . EQ.IYR) GC TO 205	PGM10146
	IF (IGRAF (JJ). EQ. IYR) GC TO 205	PGM10147
	166 CCNTINUE	PGN10148
	GC TO 400	PGM 10 149
	205 CONTINUE	PGN10150
С	ZERO ARBAYS OF VEHICLE COSTS	PGN 10 151
	DO = 215 J=1,30	PGM10152
	DO 210 $IV = 1,7$	PGM10153
	VEC(J, IV) = 0.	PGN10154
	VFC(J,IV) = 0.	PGN10155
	210 CONTINUE	PGM10156
	215 CONTINUE	PGM10157
	DO = 216 = 1,7	PGM 10 158
	DO 217 J=1,30	PG M1 0159
	DC 218 JJ=1,15	PGM 10 160 .
	IPATH(IV, J, JJ) = 0	PGM10161 N
	218 CONTINUE	PGM10162 9
	217 CONTINUE	PGM10163
	216 CONTINUE	PG M 10 164
С	ZERO ARRAYS	PGM10165
	DO 230 J=1,30	PGM10166
	RLEN(J) = C.	PGM 10 167
	RAFF(J) = 0.	PGM10168
	DSPR(J) = 0.	PGM10169
	IRAFF(J) = 0.	PGM10170
	CAP(J) = 0.	PGM10171
	DO 235 IV=1,7	PGM 10 17 2
	TEF $(J, IV) = 0$.	PGM10173
	TT(J,IV) = 0.	PGM 10 174
	ECPC(J, IV) = 0.	PG M10175
	OFC(J, IV) = 0.	PGM 10 176
	SPD(J,IV) = 0.	PGM10177
	235 CONTINUE	PG M10178
	230 CONTINUE	PGM 10 179
	DO 300 KK=1, NLINK	PGM10180
		PAGE 5

	CALL ZEIINK	PGM10181
	DC 240 $JJ=1,30$	PGM 10 182
	IB=IAA (JJ)	PGM10183
	IF (IB. FQ. KK) GO TO 245	PG M10184
240	CONTINUE	PGM 10 185
	IK=IYR	PG M10186
242	LAUC = 10 * (KK - 1)	PGM10187
	LAU=LAUC+1	PGM10188
	READ(11'LAU) ATT, EOC, FOC, ETC, FTC, SKL, FOR, DIS, CP, RAF, DSP	PGM 10 189
	GC TC 260	PGN10190
245	ISTR=NWSIF(I,KK)	PGM 10 19 1
	LAUC = 10 * (KK - 1)	PGM10192
	LAU=LAUC+ISTR	PGM10193
	READ(11'LAU) ATT, EOC, FOC, ETC, FTC, SKL, FOR, DIS, CF, RAF, DSP	PGM10194
	IF (NWSL (I,KK).NE.O) GO TO 250	PGM10195
	IK=IYR	PGN10196
	GO TO 260	PGM10197
250	ISL = NWSL(I, KK)	PGN 10 198 0
	IF(IYR.GT.ISI) GO TC 255	PG M1 01 99 1
	K = FTC (1)	PGM 10 200
	K2=FTC(2)	PGM10201
	IF (K1.GT.K2) GO TO 248	PGM10202
	IK = 1	PGM10203
	GC TC 260	PG M 1 0 2 0 4
248	IK= 1	PGM10205
	GO TO 242	PGM10206
255	IK=IYB-ISL	PGM 10 20 7
260	CONTINUE	PG M1 02 08
	DC 265 IJ=1,7	PGM 10 20 9
	SPEED $(IJ) = 0$.	PGM10210
265	CCNTINUE	PGM10211
	DO 270 IV = 1, IVF	PGM10212
	TT(KK,IV) = ATT(IK,IV)	PGM10213
	OPC(KK, IV) = FOC(IK, IV)	PGM10214
	BOPC(KK, IV) = ECC(IK, IV)	PGM10215
	$IF(ATT(IK, IV) \cdot EQ.0.)$ GC TO 270	PGM 10216
		PAGE 6

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	SPEED(IV)=DIS(IK)/ATT(IK,IV)	PGM10217
	SPD(KK, IV) = SPEED(IV)	PGM10218
270	CONTINUE	PGM10219
	CAP(KK) = CP(IK)	PGM10220
	RAFF(KK) = RAF(IK)	PG M 10221
	DSPR(KK) = DSP(IK)	PGM 10 222
	RLEN(KK) = DIS(IK)	PGM10223
290	CCNTINUE	PGM 10 2 2 4
	RDI=3.67-0.027*DSP(IK)	PGN10225
	RCC=RDI*RAF(IK)	PGM10226
	RK 1 = SPEED (1)	PGM10227
	DC 425 IV=2,IVF	PGN10228
	IF(SPEED(IV).EQ.O.) GO TO 425	PGM10220
	RK2 = SPEED(IV)	PG M10230
	TEF(KK, IV) = (FOC*(RK1-RK2)/10.)+2.	PGM10231
425	CCNTINUE	PG M1 0232
	TEF(KK, 1) = 1.	PGN 10233 1
300	CONTINUE	PGN10234 8
C CC	MPUTE TEANSPORT COSIS	PGM10235
	NS=I	PGM10236
	DC 320 $IV=1, IVF$	PGN10237
	CALL ROUTE (IYR, IV)	PGN 10238
320	CONTINUE	PG M10239
325	CALL COST (IYR)	PGM10240
400	CS=0.	PG M1 0241
	IF (IOPT.EC.1) GO TO 2000	PGM 10242
	DO 500 $J=1,JIM$	PGM10243
	JIMC=J	PGM10244
	CALL ZEDEM	PGM10245
	R EA D (12'JIMC) DE MA ND, ELA, FRICF, VAL 1, FLOAD, BVEC, BVFC	PGM10246
	IF (BVEC (IYR, 1).GE.PRICE (1)) GO TO 480	PGM10247
	DC 450 IV=1, IVF	PG M1 02 48
	DIF=BVEC(IYR,IV)-VEC(J,IV)	PGM 10 249
	IF (DIF.GT.0.0 .OR. DIF.IE90) GO TO 451	PGM10250
	CS=CS+0.	PGM 10 25 1
	GO TO 450	PGM10252
		PAGE 7

451	DEM=0.	PGN 10253
	IF (DEMAND (IYR, IV).EQ.O.) GC TC 450	PG M1 0254
	DEM=DEMAND(IYR, IV)*((VFC(J, IV)/BVFC(IYR, IV))**(-ELA(IV)))	PGM 10255
	IF(IV.GT.2) GO TO 455	PGM1 0256
	A=365.*0.5* (DEM+DEMAND (IYR, IV))* (BVEC (IYR, IV) - VEC (J, IV))	PGM 10257
	CS=CS+A	PGM10258
	GC TO 450	PGM10259
455	A=365.* (0.5* (DEM+DEMAND (IYR, IV)) * (BVEC (IYR, IV) - VEC (J, IV)))/(VCAP (I	PGM10260
	1V) * FALOE (J, IV))	PG M 10261
	CS=CS+A	PGM 10 26 2
450	CONTINUE	PG M1 026 3
	GO TC 500	PGM 10264
480	DC 485 IV=1,IVF	PGM10265
	IF(VEC(J,IV).GE.PRICE(IV)) GO TO 500	PGM 10266
481	DEM=0.	PGM10267
	IF (DEMAND (IYR, IV). EQ. 0.) GO TO 485	PGM 10268
	DEM=DEMAND(IYR,IV)*((VEC(J,IV)/PRICE(IV))**(-ELA(IV)))	PGM10269
	IF (IV.G1.2) GO TO 482	PGN10270 🖁
	A=365.*0.5* (DEMAND (IYR, IV) + CEM) * (PRICE (IV) - VEC (J, IV))	PGN 10 27 1 4
	CS=CS+A	PGM10272
	GO TO 485	PGM10273
482	A=365.* (0.5* ((DEMAND (IYF, IV) +DEM) / (VCAP (IV) *FALOD (J, IV))) * (PRICE (I	PGM10274
	1V) - VEC(J, IV)))	PGN 10 27 5
	CS=CS+A	PGM1 0276
485	CCNTINUE	PGM 10 277
500	CONTINUE	PGM10278
	GC TO 599	PGM10279
2000	CONTINUE	PGM10280
	DO 2500 J=1,JIM	PGN10281
	JIMC=J	PGM 10 28 2
	CALL ZEDEM	PGM10283
	READ(12'JINC) DEMAND, ELA, PRICE, VALT, FLOAD, BVEC, BVFC	PGN 10 284
	IF (BVEC (IYR, 1).GE.PRICE (1)) GC TO 2480	PG M1 02 85
	DO 2450 $IV=1, IVF$	PGM 10286
	DIF=BVEC(IYR,IV)-VEC(J,IV)	PGM10287
	IF (DIF.GT.0.0 .OR.DIF.LE0.9) GO TO 2451	PGM10288
		PAGE 8

g g g g r r r r r r r

CS=CS+0.	PGM10289
GC TO 2450	PGM 10 290
2451 DEM=0.	PGM10291
IF (DEMAND (IYE, IV). EQ. 0.) GO TO 2450	PGM 10292
DEM=DEMAND (IYR, IV) * ((VFC (J, IV) / BVFC (IYR, IV)) ** (-ELA (IV)))	PGM10293
A=365.*0.5*(DEM+DEMAND(IYR,IV))*(BVEC(IYR,IV)-VEC(J,IV))	PGM 10294
CS=CS+A	PGM10295
2450 CCNTINUE	PGM10296
GO TO 2500	PGM10297
2480 DC 2485 IV=1,IVF	PGM10298
IF(VEC(J,IV).GE.PRICE(IV)) GO TO 2500	PGM10299
2481 DEM=0.	PGM10300
IF (DEMAND (IYE, IV) . EQ. C.) GO TO 2485	PGM 10301
DEM=DEMAND (IYR, IV) * ((VEC (J, IV) / FRICE (IV)) ** (-ELA (IV)))	PGM10302
A=365.*0.5* (DEMAND(IYR, IV) + DEM) * (PRICE(IV) - VEC(J, IV))	P GM 10 30 3
CS=CS+A	PGM10304
2485 CCNTINUE	PGM10305 .
2500 CONTINUE	PGM10306 🕅
599 IT=IYR-1	PGM10307 T
EXP=TCOST(I, IYR)-BCOST(IYR)	PGM10308
EENEF=CS-EXP	PGM10309
ACBEN=ACEEN+BENEF* ((1.+R R TE)** (-IT))	P GM 10.3 10
603 WRITE (6,601)	PGN10311
601 FCRMAT(8X, BENEFITS', 15X, EXPENDITURES', 13X, NET BENEFITS',	9X, ACC PGM 10 312
1UMULATED NET BENEFIIS(NEV)")	PGM10313
WRITE(6,602) CS,EXP,BENEF,ACBEN	PGM 10314
602 FORMAT (2x, 3 (F20.5, 5x), 9x, F20.5)	PGM10315
800 CONTINUE	PGM10316
TOTBEN (I) = ACBEN	PGM10317
WRITE (6,622) TOTBEN (I)	PGM10318
622 FORMAT(/2X, 'THE TOTAL NIT BENEFITS(NPV) ARE: ', F20.5)	PGN 10319
1000 CONTINUE	PGM10320
C BANK	PGM 10 321
IF (IRANK.EQ.0) GO TC 1300	PG M1 0322
N N = O	PGM 10 323
K K= 1	PGM10324
	PAGE 9

	R = -100000000.	PGM 10 325
115 0	DO 1200 MM=1, LASTNS	PGM10326
	II=NEIS (MM)	PGM10327
	DO 1450 K=1,KK	PGM10328
	IF (NRANK (K) . EQ.II) GO TO 1200	PGM10329
1450	CONTINUE	PGM10330
	R2=TOTBEN(II)	PG M10331
	IF(R1.GE.F2) GO TO 1200	PGM 10332
	IMAX=II	PGM10333
	R1=TOTBEN(II)	PGN 10334
	GO TO 1200	PGM10335
1200	CONTINUE	PGM10336
1 10 0	CONTINUE	PGM10337
	N N = N N + 1	PGN10338
	K K = N N	PGN 10 339
	NRANK(KK) = IMAX	PG M1 034 0
	IF(KK.EQ.LASINS) GO IC 1250	PGM 10341
	R1 = -100000000.	PGM10342
	GC TO 1150	PGM 10343
1250	WRITE (6,605)	PGM10344
605	FORMAT (///40x, 'RANK OF THE NETWORK STRATEGIES', /, 10x, 'RANK', 5x, 'N.	PGM10345
	1S.º,5X,ºICTAL NET BENEFITS(NPV)º)	PGM10346
	DO = 1230 LJ = 1, LASTNS	PGM 10 347
	IN=NRANK (LJ)	PGM10348
	WRITE (6,610) LJ, IN, TOTBEN (IN)	PG M10349
610	FORMAT (11X, 12, 7X, 12, 6X, F15. 5)	PGM10350
1230	CONTINUE	PGM10351
1.300	CONTINUE	PGM 10352
	WRITE (10'1) NLINK, NODE, NEEG, NY, JIM, RATE, VCAP, LEEG, LEND, LST, MDIS, COS	PGM10353
	1TMA, FOCAMA, SKLAMA, IOPT, NRANK	PGM 10 354
	CALL EXIT	PGM10355
9999	SICF	PGM 10 356
	END	PGM10357

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SUBROUTINE EASENE (NY)	PGM 2000 1
ANALYZE BASE NETWORK	PG M20002
COMMON/GEN/NLINK, NODE, JIM, NS, VTIME (30, 7), FALCD (30, 7), BCOST (20), LBE	PGM20003
1G(30), LEND(30), LOD(30,30), LLA(30,30), VCAP(7), IOPT, IVF, ISIM(20), IG	PGM20004
2RAF (20)	PGM20005
COMMON/INK/TT (30,7), CPC (30,7), EOPC (30,7), CAP (30), SPD (30,7), RLEN (30	PGM20006
1), TRAFF (30), TEF (30, 7), RAFF (30), VEHTRA (30, 7), DSPR (30)	PGM 20007
COMMON/CD/IPATH (7,30,15), VEC (30,7), VEC (30,7)	PGM20008
CCMMON/ZEL/ATT (20.7) . EOC (20.7) . FOC (20.7) . FTC (20) . DIS (20) . CP (20) . ET	PGM 20009
1C(20), RAF(20), DSP(20)	PGM20010
CCMMON/ZED/DEMAND(20.7), ELA(7), PRICE(7), VALT(7), BVEC(20.7), BVFC(20	PGM20011
1.7)	PGM20012
DIMENSION SPEED(7), SKL (20), FOR (20), FLOAD (7)	PGM20013
WRITE(6,400)	PGM20014
400 FORMAT (///30X. BASE NETWORK ANALYSIS ./. 30X. 21(***))	PG M20015
NS=0	PGM20016
DO $300 \text{ IYB}=1.\text{NY}$	PGN20017 N
DC 992 LL=1.30	PGM 20018 6
DO 991 LK=1.7	PGM20019
VEHTBA(LL.LK) = 0 .	PGM20020
991 CONTINUE	PGM20021
992 CONTINUE	PG M20022
IF(IYR.EO.1) GO TO 40	PGN20023
II = IYR - 1	PG M2 0 02 4
DIF=BCOST(IYR)-BCOST(II)	PGM 200.25
IF (DIF.GE.1000.) GO TC 40	PG M2 0 026
IF(DIF.LE1000.) GO TO 40	PGM20027
DO = 166 JJ = 1.20	PGM20028
IF (ISIM (JJ) . EO.IYR) GO TO 40	PGM 20029
166 CONTINUE	PGM20030
GO TO 150	PGM20031
40 CONTINUE	PGM20032
DC 167 $JJ=1.20$	PG M2 0 0 3 3
IF (IGRAF (JJ) . EQ. IYR) GC TO 41	PGM 20034
167 CONTINUE	PG M2 0 03 5
GC TO 42	PGM 20036
	PAGE 11
	SUBROUTINE PASENE (WY) ANALYZE BASEN NETWORK COMMON/GEN/NLINK,NODF,JIM,NS,VTIME(3C,7),PALCD(30,7),BCOST(20),LBE 1G (30), LEND(30),LOD(3C,3C),LLA(30,30),VCAP(7),IDPT,IVF,ISIM(2C),IG CAMFON/GEN/NLINK,NODF,JIM,NS,VTIME(3C,7),IDPT,IVF,ISIM(2C),IG CAMFON/LCL/BATH(7,3C,7),FCC(30,7),CAP(30),SDP(3C,7),RLEN(30) 1),TRAFF(3C),TFF(30,7),RAFF(3C),VEC(30,7),VCC(30,7) CCMMON/CL/PATH(7,3C,15),VFC(30,7),VFC(30,7) CCMMON/ZEL/ATT(2C,7),EOC(2C,7),FCC(20,7),FTC(20),DIS(20),CP(20),ET 1C(20),RAF(20),DSP(20) CCMMON/ZEL/ATT(2C,7),ELA(7),PFICE(7),VALT(7),BVEC(20,7),BVFC(20) 1,7) DIMENSICN SFEED(7),SKL(2C),FOF(2C),FLOAD(7) WRITR(6,4C0) 400 FORMAT(///3CX,'BASE NETWORK ANALYSIS',/,30X,21('*')) NS=0 DO 300 IYP=1,NY DC 992 LL=1,30 DO 300 IYP=1,NY DC 992 LL=1,30 DO 300 IYP=0. FIGURAT(JLK)=0. 991 CONTINUE 992 CONTINUE 992 CONTINUE 1F(DIF,LE,-1000,) GO TO 40 IF(DIF,LE,-1000,) GO TO 40 IF(DIF,LE,-1000,) GO TO 40 IF(DIF,LE,-1000,) GO TO 40 1F(DIF,LE,-1000,) GO TO 40 1F(ISIM(JJ).EO,IYR) GO TO 40 165 CONTINUE 90 CONTINUE

41	WRITE (6,666) IYF	PGM20037
666	FORMAT(/, 3X, "YEAR", 15, /, 3X, 9("-"))	PGM 20038
C ZE	RO ARRAYS	PGM20039
42	DO 45 J=1,30	PGN 20040
	DO 48 $IV=1,7$	PGM20041
	$V \in (J, IV) = 0$.	PGM20042
	VFC(J,IV) = 0.	PGM 2004 3
48	CCNTINUE	PGM20044
45	CCNIINUE	PGM 20045
	DO 50 IV=1,7	PG M2 0 0 4 6
	DO 55 J=1,30	PGM 20047
	DO 60 $JJ=1,15$	PGM20048
	IFA IH (IV, J, JJ) = 0	PGM20049
60	CONTINUE	PGM20050
55	CONTINUE	PGM20051
50	CONTINUE	PGM20052
	DO 70 J=1,30	PGM20053 8
	RLEN(J) = C.	PGM 20054 7
	RAFF(J) = 0.	PGM20055
	DSPR(J) = 0.	PGM20056
	TRAFF(J) = 0.	PGM20057
	CAP(J) = C.	PG M 20058
	DO 65 IV = 1,7	PG#20059
	SPD(J,IV) = 0.	PG M 2 0 0 6 0
	TEF(J, IV) = 0.	PGM 2006 1
	TT(J,IV) = 0.	PG M2 0 06 2
	EOPC(J, IV) = 0.	PGM 20063
	OPC(J,IV) = 0.	PGM20064
65	CONTINUE	PGM20065
70	CONTINUE	PGM20066
	DO 100 KK=1, NLI NK	PGM20067
	CALL ZELINK	PGM20068
	DO 105 IV=1,7	PG M2 006 9
	SPEED(IV) = 0.	PGM 20070
105	CONTINUE	PGM20071
	LAU = 10*(KK - 1) + 1	PGM 20072
		PAGE 12

	READ (11'LAU) ATT, FOC, FOC, ETC, FTC, SKL, FOR, DIS, CP, RAF, DSP	PG M2 0 0 7 3
	DO 110 IV=1, IVF	PGM 20074
	TT(KK, IV) = ATT(IYR, IV)	PG M2 0075
	OFC(KK,IV) = FOC(IYR,IV)	PGM20076
	EOPC(KK, IV) = EOC(IYR, IV)	PGM20077
	IF (ATT (IYF, IV) . EQ.C.) GO TO 110	PGM20078
	AT=ATT (IYB, IV)	PGM20079
	SPEED (IV) = DIS (IYR) /AT	PG M 20080
	SPD(KK, IV) = SPEED(IV)	PGM20081
110	CCNTINUE	PGM20082
	$\mathbf{RAFF}(\mathbf{KK}) = \mathbf{FAF}(\mathbf{IYR})$	PGM 2008 3
	DSPR(KK) = DSP(IYR)	PGM20084
	CAF(KK) = CF(IYR)	PGM20085
	RLEN(KK) = DIS(IYR)	PGM20086
	RDI=3.67-0.027*DSP(IYR)	PGM20087
	ROC=RDI*RAF (IYR)	PGM20088
	RK1 = SPEED(1)	PG M20089 😓
	DC 425 $IV=2, IVF$	PGM 20090 🖗
	IF (SPEED (IV) .EQ.9.) GO TO 425	PGM20091
	RK2=SFEED(IV)	PGM 20092
	TEF $(KK, IV) = (ROC * (RK1 - RK2) / 10.) + 2.$	PGM20093
425	CONTINUE	PGM20094
	$T \in F(KK, 1) = 1.$	PGN20095
100	CCNTINUE	PGM20096
	DO 120 $IV=1, IVF$	PGM20097
	CALL ECUTE (IYR, IV)	PGM200 98
120	CCNTINUE	PGM 20099
125	CALL CCST (IYR)	PG M2 01 0 0
	GC TC 200	PGM 20 10 1
150	CCNTINUE	PGM20102
	DO 190 I=1,JIM	PG M 20 10 3
	JIMC=I	PGM20104
	CALL ZEFEM	PGM20105
	READ(12'JIMC) DEMAND, ELA, PRICE, VAIT, FLOAD, BVEC, BVFC	PGM 20 106
	II = IYR - 1	PGM20107
	DC 170 IV=1,IVF	PGM 20 10 8
		PAGE 13

	R1=0.	PGM20109	
	R 2= 0.	PGM20110	
	R1 = BVEC(II, IV)	PGM20111	
	R2 = BVFC(II, IV)	PGM20112	
	BVEC(IYR, IV) = R1	PGM20113	
	BVFC(IYR,IV) = R2	PGM20114	
170	CONTINUE	PGM20115	
	JIMC=I	PGM20116	
	WFITE(12'JIMC) DEMAND, ELA, PRICE, VALT, FLOAD, BVEC, BVFC	PGM 20 117	
190	CONTINUE	PGM20118	
	GC TO 360	PGM20119	
200	CONTINUE	PGM20120	
	DC 290 I=1,JIM	PGM20121	
	JIMC=I	PGM20122	
	CALL ZEDEM	PGM20123	
	READ(12'JIMC) DEMAND, ELA, PRICE, VALT, FLCAD, BVEC, BVFC	PGM 20 124	
	II=IYR-1	PGM20125	l,
	DO 280 IV=1, IVF	PGM 20 126	ίõ.
	BVEC(IYE,IV) = VEC(I,IV)	PGM20127	ĩ
	BVFC(IYE,IV) = VFC(I,IV)	PGM20128	
	IF (IYR. EQ. 1) GO TO 280	PGM20129	
	DEMAND (IYE, IV) = DEMAND (IYE, IV) * ((BVFC (IYE, IV) / BVFC (II, IV)) ** (-ELA (I	PGM20130	
	1V)))	PGM 20 13 1	
280	CONTINUE	PGM20132	
281	JIMC=I	PGN 20 133	
	WRITE (12'JIMC) DE MAND, ELA, PRICE, VALT, FLOAD, BVEC, BVFC	PGM20134	
	IF (IYR. EQ. 1) GO TO 290	PGN 20 135	
	DO 320 KO=1, NODE	PGN20136	
	DC 310 KD=1,NODE	PGM20 137	
	IF (LOD (KO,KD).EQ.I) GC TO 33C	PGM20138	
310	CONTINUE	PGM20139	
320	CONTINUE	P GN 20 140	
	GO TO 290	PGM20141	
330	WRITE(6,335) KO, KD, $(IV, IV=1, IVF)$	PGM 20 14 2	
3.3.5	FORMAT (/, 10X, 'THE DEMAND OF O-D', 12, '-', 12, ' HAS CHANGED', //, 30X,	PGN20143	
	1'VEHICLE TYPES',/,10X,7(5X,12,8X))	PGM 20 144	
		PAGE 14	

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BGWS0120 ΠNΕ 60102N9a RETURN 5 CW 20 148 300 CCNLINDE 290 CONTINUE MEITE (6,340) (DEMAND (ITE,IV),IV=1,IVE) MEITE (6,340) (DEMAND (ITE,IV),IV=1,IVE) FGM20147 56W 20 1#6 50102NDd

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	SUBROUTINE ROUTE (IYE, IV)	PGM30001
С	THIS SUBFOUTINE SEARCHES FOR THE MINIMUM CCST ROUTE	PGM 30002
	COMMON/GEN/NLINK, NODE, JIM, NS, VTIME(30, 7), FALOD(30, 7), BCOST(20), LBE	PG M30003
	1G (30), LENE (30), LOD (30,30), LLA (30,30), VCAP (7), IOPT, IVF, ISIM (20), IG	PGM 30004
	2RAF (20)	PGM30005
	CCMMON/OD/IPATH (7,30,15), VEC (30,7), VEC (30,7)	PGM30006
	COMMON/LNK/TT (30,7), OPC (30,7), EOPC (30,7), CAP (30), SPD (30,7), RLEN (30	PGN30007
	1), TRAFF (3C), TEF (30, 7), RAFF (30), VEHTRA (30, 7), DSPR (30)	PGM30008
	COMMON/ZED/DEMAND (20,7), FLA (7), PRICE (7), VALT (7), BVEC (20,7), BVFC (20	PGM 30009
	1,7)	PGM30010
	DIMENSION CROUTE (30,30), TROUTE (30,30), LROUTE (30,30)	PGM 30011
С	CONSTRUCT IEE COST AND LABEL MATRICES	PG M30012
	DC 10 KO=1,30	PGN 300 13
	DO 8 KD=1,30	PGM30014
	CROUTE (KO,KD) =10000000.	PGM30015
	TROUTE(KO, KD) = 10000000.	PGN30016
	8 CONTINUE	PGM30017
	10 CCNTINUE	PGM 300 18
	DC 20 I=1, NIINK	PGM30019 🗄
	KC = LBEG(I)	PGN30020 1
	KD=LEND(I)	PGM30021
	IF (OPC (I, IV) \mathbb{E} O.O.) GO TO 20	PGM30022
	CROUTE (KC, KD) = OPC (I, IV)	PGM30023
	CROUTE(KC,KC) = OPC(I,IV)	PGM30024
	TROUTE(KO, KD) = TT(I, IV)	PGN30025
	TROUTE (KD, KC) =TT (I, IV)	PGM30026
	20 CCNTINUE	PGM 300 27
	DC = 40 KC = 1, NODE	PG M3 0 02 8
	DC = 30 KD = 1, NODE	PGM 30029
	LROUTE (KC, KD) = KO	PGM30030
	30 CONTINUE	PGM30031
	40 CONTINUE	PGM30032
С	START SFARCH OF MINIMUM PAIH	PGM30033
	DO 100 IP=1,NODE	PGM30034
	DO 90 KC=1, NODE	PGM30035
	IF(KO.EÇ.IP) GO TO 9C	PGM30036
		PAGE 16

	DO 80 KE=1,NODE	PGM30037
	IF (KD.EQ.IP) GO TO EC	PGM30038
	IF (KD.EQ.KO) GO TO 80	PGM30039
	C1=CROUTE (KO, IP) + CROUTE (IP, KE)	PGM30040
	C2=CROUTE (KO, KD)	PGN30041
	IF(C1.GE.C2) GO TO 80	PGN30042
	CROUTE(KC, KD) = C1	PG M30043
	LRCUTE(KO, KD) = IP	PGM 30044
	TROUTE (KO, KD) = TROUTE (KC, IP) + TROUTE (IP, KD)	PGM30045
80	CONTINUE	PGM30046
90	CONTINUE	PGM30047
100	CONTINUE	PGM30048
	DO 200 KO=1, NODE	PGN30049
	DO 190 KD=1, NCDE	PG M3 0 05 0
	I=LCD(KC,KD)	PGM30051
	IF(I.EQ.0) GO TO 190	PGN30952
	K = 16	PGM30053
	IO=KO	PGM30054 N
	II=KD	PGM30055 2
1 8 0	J=LROUTE (IO, ID)	PGM30056
186	CONTINUE	PGM30057
	IK=LLA(ID,J)	PGN30058
	IF(IK.NE.0) GO TO 185	PG M3 0 05 9
	J 1=J	PGM 30060
	J2=ID	PGM30061
	J = LBOUTE (J1, J2)	PGM30062
	GO TO 186	PGM30063
185	K = K - 1	PGM30064
	I PATH (I V, I, K) = I K	PGM 30065
	VEC(I, IV) = VEC(I, IV) + ECFC(IK, IV)	PGM30066
	VFC (I, IV) = VFC (I, IV) + OPC (IK, IV)	PGM 30067
	$IF (J \cdot EQ \cdot KC) GO TO 170$	PGM30068
	I C = J	PGM 30069
	GO TO 180	PGM30070
170	A=TROUTE(RC,KD) *VTIME(I,IV) *VCAP(IV) *FALOD(I,IV)	PG M 30071
	VEC(I, IV) = VEC(I, IV) + A	PGM30072
		FAGE 17

		$U = C (T - T U) + U = C (T - T U) + \lambda$	nav 31071
	4 0 5	$V_{\Gamma} (1, 1, V) = V_{\Gamma} ((1, 1, V)) + A$	PGE 37073
	190	CONTINUE	PGM30074
	200	CCNTINUE	PGM 30 0 75
С	ASS	SIGN TRAFFIC ON LINKS	PGM30076
		DO 300 I=1,JIM	PG M30077
		DO 310 II=1,20	PGM30078
		DO 305 JJ=1,7	PG M3 0 07 9
		DEMAND(II, JJ) = 0.	PGM30080
	305	CONTINUE	PGM30081
	310	CCNTINUE	PGM 30(82
		JIMC=I	PGM30083
		READ (12 JIMC) DEMAND. FLA. PRICE	PGN30084
		IF(VEC(I,IV), GT, PRICE(IV)) GO TO 300	DG#30085
		TF(TOPT, FQ, 1) GO TO 275	PGM30086
		TF(TV, GT, 2) GD TO 270	DCM30087
	275	$\frac{1}{1} \left(\frac{1}{1} + \frac{1}{1} + \frac{1}{1} + \frac{1}{1} \right)$	PCH30002
	285	DO 280 KK-1 15	ruaj00000
	600	$y = 1 C \nabla y$	PG130089
		N=10-NN TR(TR)TR(TR)TR() TO 20 TO 200	PGN30090
		$IF(IPATH(IV, I, K) \cdot EQ \cdot 0)$ GC TO 300	PGM 300 9 1
		LINK=IPAIH (IV,I,K)	PG M3 0 092
		TRAFF(LINK) =TRAFF(LINK) +TRAF*TEF(LINK,IV)	PGM 30093
		VEHTRA (LINK, IV) = VEHTRA (LINK, IV) + TRAF	PGM30094
	280	CCNTINUE	PGM 30095
		GO TO 300	PGM30096
	270	ITRAF=(LFMAND(IYR,IV)/(VCAP(IV)*FALOD(I,IV)))+1	PGM30097
		TRAF=ITRAF	PGM30098
		GC TC 285	PGN30099
	300	CCNTINUF	PGM 30 100
		BETHRN	DCM30100
		La 17 17	PGAJUIUZ

	SUBROUTINE COST (IYR)	PGM40001
2	COMPUTES THE NEW COST IF CONGESTION OCCURS IN A LINK	PG M 40002
	COMMON/GEN/NLINK, NODE, JIM, NS, VTIME (30, 7), FALOD (30, 7), BCOST (20), LBE	PGM40003
	1G (30), LEND (30), LOD (30, 3C), LLA (30, 30), VCAP (7), IOPT, IVF, ISIM (20), IG	PGM40004
	2RAF (20)	PGM 4000 5
	COMMON/CD/IPATH (7,30,15),VEC(30,7),VFC(30,7)	PGM40006
	COMMON/LNK/TT (30, 7), OPC (30, 7), EOPC (30, 7), CAP (30), SPD (30, 7), RLEN (30	PGM 40007
	1), TRAFF (30), TEF (30, 7), RAFF (30), VEHTRA (30, 7), DSPR (30)	PGM40008
	DIMENSION VOL (5), VEHNO (5), PCVEH (5), AAT (30,7), IROUTE (30), AT (5)	PGM40009
	DATA AAT/210*0./	PGM40010
	DC 200 $I=1$, NLI NK	PGM40011
	IF (TRAFF (I) \cdot EQ \cdot 0 \cdot) GO TO 200	PGM40012
	TOTCAP=CAP(I)*16.	PG M4 0013
	VOL(1) = .10 * CAF(I)	PGM40014
	VOL(2) = .30 * CAP(I)	PGM40015
	VOL(3) = .50 * CAP(I)	PGM40016
	VOL $(4) = .70 \times CAP (I)$	PGM40017 .
	VCL(5) = .90 * CAP(I)	PGM40018
	VOLCAP=TRAFF(I)/TOTCAP	PGM40019 🖡
	IF (VOLCAP.GE90) GC IC 90	PGM40020
	IF(VOLCAP.LE10) GO TO 80	PGM40021
	A = .10 * T C T C A P	PGM40022
	RVOL=1.25*(VOLCAP10)	PGM40023
	V = HNO(1) = A * ((1 - RVOL) * * 4)	PGM40024
	$V = 12 \cdot A + RVOL + ((1 - RVOL) + 3)$	PGM 400 25
	VEHNO(3)=30.*A* (RVOL**2)*((1-RVCL)**2)	PGM40026
	$V = H NO(4) = 28 \cdot *A * (RVOL **3) * (1 - RVOL)$	PGM40027
	V = H NO(5) = 9. * A* (R VO L * * 4)	PGM40028
	GO TO 95	PGM40029
9	0 DC 91 IF=1,4	PGM40030
	VEHNO(IF)=C.	PG M4 0 03 1
9	1 CCNTINUE	PGM40032
	VEHNO(5) = TRAFF(I)	PGM40033
	VCL $(5) = TFAFF(I) / 16$.	PGM40034
	GO TO 95	PGM40035
8	0 DC 81 IP=2,5	PGM40036
		PAGE 19

	VEHNO (IF) =0.	PG M4 0 03 7
81	CONTINUE	PGM40038
	$\mathbf{V} \in \mathbf{HNO} (1) = \mathbf{I} \mathbf{R} \mathbf{A} \mathbf{F} \mathbf{F} (\mathbf{I})$	PGM40039
	VCL(1) = IFAFF(I) / 16.	PGM40040
95	CONTINUE	PGM40041
	DO 150 IV=1,IVF	PGM40042
	DO 100 IP=1,5	PGM40043
	PCVEH(IP) =VEHNO(IP)/TRAFF(I)	PG M 4 0 0 4 4
	V = DSPR(I)	PGN40045
	VEL=V-V*VCL(IP)/CAP(I)	PG 140046
	IF(VEL.LI.0.10*V) $VEL=C.10*V$	PGM 40047
	IF (VEL.GI.SPD (I,IV)) GC TG 150	PGM40048
	AT (IP) = (BLEN (I) / VEL) - (RIEN (I) / SPD (I, IV))	PGM40049
	VEHNO (IP) = VEHTRA (I, IV) * PC VEH (IP)	PGM40050
100	CONTINUE	PGN40051
	TOTT=0.	PGM40052 27
	LO 120 IP=1,5	PGM40053 1
	TOTT=TOTT+VEHNO (IP) * AT (IP)	PGM40054
120	CCNTINUE	PGN40055
	AAT(I, IV) = TOTT/VEHIRA(I, IV)	PGM 40056
150	CONTINUE	PGM40057
200		PGM40058
	DO 300 1V=1, IVF	PGM40059
	DO = 166 = JJ = 1,20	PG M40060
6	LF (IGRAF (JJ). EQ. IYR) GC TO 604	PGM40061
166	CONTINUE	PGM40062
1.50	GU TO ESU	PGM40063
604	WRITE(0,000) IV	PG M40064
600	FORMAT(/20X, MINIMUM COST ROUTES OF VEHICLE TYPE: ",15,/,1/X, "O-D P	PGM 40065
650	TAIR #", TUX, "ROUTE (LINKS NUMBERS)")	PGM40066
050	DO 290 I = 1, JIM	PGM40067
	DC = 220 LO = 1, NODE	PGM40068
	$\frac{1}{10} \text{LD} = 1 \text{, NUDE}$	PGM40069
2.10	$\frac{1}{2} \left(\frac{1}{2} \cdot \frac{1}{2} \left(\frac{1}{2} \cdot \frac{1}{2} \right) \right) = \frac{1}{2} \left(\frac{1}{2} \cdot \frac{1}{2} \right)$	PG M 400 70
210		PGM40071
220		PGM40072
		PAGE 20

215	DO $270 L = 1,30$	PGM40073
	IROUTE $(I) = 0$	PGM40074
2 7 0	CCNTINUE	PGM40075
	к к= С	PGN40076
	DC 280 K=1,15	PGM40077
	IF (IPATH (IV, I, K).EQ.0) GO TO 280	PGM40078
	KK=KK+1	PGM40079
	IROUTE (KK) = IPATH (IV, I, K)	PGN40080
	LINK=IPATH(IV,I,K)	PGM40081
	IF (AAT (LINK, IV) . FQ. 0.) GO TO 280	PGN40082
	A=AAT (LINK, IV) *VTIME (I, IV) *VCAP (IV) *FALOD (I, IV)	PGM40083
	VEC(I,IV) = VEC(I,IV) + A	PGN40084
	VFC(I,IV) = VFC(I,IV) + A	PGM4 0085
280	CCNTINUE	PGM40086
	DO 167 $JJ=1,20$	PGM40087
	IF (IG RAF (JJ) . EQ.IYR) GC TO 605	PGM40088
167	CONTINUE	PGM40089 🐰
	GC TC 290	PGM40090 6
605	WRITE $(6, 610)$ IV, LO, LD, (IBOUTE (K) , $K=1$, KK)	PGM40091
610	FORMAT (8X,12,9X,12,'-',12,13X,1512)	PG M4 0 0 9 2
290	CONTINUE	PGM 40093
300	CONTINUE	PGM40094
	DO 168 $JJ=1,20$	PGM40095
	IF (IGRAF (JJ).EQ.IYR) GC TO 301	PGM40096
1 68	CONTINUE	PGM40097
	GO TO 500	PGM40098
301	WRITE $(6, 615)$ (IV, IV = 1, IVF)	PG M40099
615	FORMAT (/20X, "ECONOMIC VEHICLE OPERATING COSTS", /, 20X, "VEHICLE TYPE	PGM40100
•	1S',/,4X,'O-D #',6X,7(4X,I2,4X))	PGM40101
	DO = 410 LO=1, NODE	PGM40102
	DC = 420 LD = 1, NODE	PGM40103
	I=LOD(LC,ID)	PGM40104
	IF (I.EQ.C) GC TO 420	PG M 40 105
	WRITE(6, 620) LO, LD, (VEC(I, IV), $IV=1$, IVF)	PGM40106
620	FCRMAT(4x, 12, '-', 12, 6x, 7(F10.4))	PGM40107
420	CCNTINUE	PGM40108
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410 CONTINUE	PGM40109
WRITE $(6, 625)$ (IV, IV=1, IVF)	PGM40110
625 FOPMAT (/20X, *FINANCIAL VEHICLE OPERATING COSTS*, /, 20X, *VEHICLE TYP	PGM40111
$1ES^{,},4X, O-D \#^{,},6X,7(4X,I2,4X))$	PGM40112
DO 450 IO=1,NCDE	PGM40113
DC = 460 LD = 1, NODE	PGM40114
I=LCD(LO,LD)	PGM40115
IF(I.FQ.C) GC TO 460	PGM40116
WRITE $(6, 630)$ LO, LD, (VFC (I, IV) , $IV=1$, IVF)	PGM40117
630 FORMAT (4X, I2, '-', I2, 6X, 7 (F10.4))	PGM40118
460 CENTINUE	PGN40119
450 CONTINUE	PGM40120
WRITE(6, 640) (L,L=1,IVF)	PGM40121
640 FORMAT (/30X, 'TOTAL TRAFFIC ON LINKS', /, 2X, 'LINK', 5X, 'IN PCU', 5X, 7 (PGM40122
1*CF TYPE: *, 12, 3X))	PGM40123
DC = 500 I = 1, $NLINK$	PGM40124
WFITE(6, 645) I, TFAFF(I), (VEHTRA(I, IV), $IV=1$, IVF)	PGM40125
645 FORMAT (3X, 12, 3X, F10.3, 4X, 7 (F8.0, 5X))	PGM40126
500 CONTINUE	PGM40127
RETURN	PGM40128
END	PGM40129

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	SUBROUTINE ZELINK	PGM 50001
	COMMON/ZEI/ATT (20,7), ECC (20,7), FOC (20,7), FTC (20), DIS (20), CP (20), ET	PGN50002
	1C (20), RAF (20), DSP (20)	PG M50003
	DO 50 I=1,20	PGM50004
	FTC $(I) = 0$.	PGN50005
	ETC(I) = 0.	PGN50006
	DIS $(I) = 0$.	PGM50007
	RAF(I) = 0.	PGM 50008
	DSP(I) = 0.	PGM50009
	C F (I) = 0.	PGM 500 10
	DO 20 J=1,7	PGM50011
	AII(I,J) = 0.	PGM 50012
	EOC(I,J)=0.	PGM50013
	FOC(I, J) = 0.	PGM50014
20	CONTINUE	PGM50015
50	CONTINUE	PGM50016
	RETURN	PGM50017
	END	PGM50018

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	SUBFOUTINE ZEDEM	PGM 60001
	COMMON/ZED/DEMAND (20,7), ELA (7), PRICE (7), VALT (7), BVEC (20,7), BVFC (20	PGM60002
	1.7)	PGM60003
	DO 50 I=1,20	PGM60004
	DC 30 J=1.7	PG M60005
	DEMAND(I,J) = 0.	PGM60006
	EVEC(I, J) = 0.	PG M6 0007
	BVFC(I,J) = 0.	PGM60008
30	CONTINUE	PGM60009
50	CCNTINUE	PGN60010
	DO 20 I=1,7	PGM60011
	ELA(I) = C.	PGM60012
	VALT(I) = 0.	PGM60013
	PRICE(I) = 0.	PGM60014
20) CCNTINUE	PGM60015
	RETURN	PG N6 0016
	END	PGM60017 I
		9 I

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SUBROUTINE MATCH (NATCH, LIST, K, RK, LARG)	00000010 PGM70001
	00000060 PGM70002
MATCH READS A CARD IN 80A1 FORMAT INTO JBUF, CONVERTS EACH	00000070 PGM70003
COLUMN TO AN INTEGER COLF IN IBUF, AND DECODES EACH LOGICAL	00000080 PGM70004
FIELD ON THE CARD. THE LAST USEABLE COLUMN IS INDICATED BY THE	00000090 PGM70005
EATA SPECIFICATION FOR 'LASTCC'.	00000100 PGM70006
EACH CODE NUMBER REPRESENTS A CHARACTER AND IS FORMED	00000110 PGM70007
INTO LIST WORDS BY COMBINING THE CODE TIMES SOME	00000120 PGM70008
POWER OF 100. THUS IF A WORE MAY CONTAIN 4 CHARACTERS.	00000130 PGM70009
(LIST (1) =4) . AND THE WORD 'THE' IS TO BE REPRESENTED. THE CODED	00000140 PGM70010
WORD TS 39272414. BLANK PADDED (14) ON THE RIGHT	00000150 PGM70011
LIST=DICTIONARY ADDRESS (INTEGER ARRAY)	00000160 PGM70012
LIST $(1) = \text{NHMBER}$ OF CHARACTERS/NORD	00000170 PGM70013
LIST(2) =NUMBER OF LIST WORDS IN DICTIONARY	00000180 PGM70014
LIST (3) TO LIST (N) ARE COLED WORDS	00000190 PGM70015
TOTAL LENGTH=LIST(2) + 2 INTEGER WORDS	00000200 PGM70016
	00000210 PGN70017
ΝΑΤΓΟΗ=	00000220 PGM70018 N
1_ FND OF STATEMENT	00000230 PGM 70019 8
2. INTEGER NUMBER	00000240 PGM70020
B_RFAL NUMBER	00000250 PGM70021
4. WORD NOT IN DICTIONARY	00000260 PGM70022
5. WORD IN DICTIONARY	00000270 PGM70023
CODE IS INTEGER DECIMAL, 00 TO 45, AS INDICATED BELOW.	00000280 PGM70024
THE CODES ARE AS FOLICWS	00000290 PGN70025
CCDE CHARACTER REPRESENTED	00000300 PGM70026
	00000310 PGN70027
1 1	00000320 PGM70028
	00000330 PGM70029
3 3	00000340 PGM70030
	00000350 PGM70031
ч ч ч	00000360 PGM70032
5 5	00000370 PGM70033
$\frac{3}{7}$ $\frac{3}{7}$	00000380 PGM70034
, , F 8	00000390 PGM70035
9 9	00000400 PGM70036
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10	+	00000410	PGM70037
10	· -	00000410	PGM70038
12		00000420	PGN 70039
13	•	00000430	PGN70040
14	BI ANK	00000450	PGM70041
15	*	00000450	PGN70042
16		00000470	PGM70043
17	/ \$	00000480	PGM70044
18	=	00000490	PGM70045
19	11	00000500	PGM 70046
20	Δ	00000510	PGM70047
21	B	00000520	PGM70048
22	Č	00000530	PGM70049
23	D	00000540	PGM70050
24	् स्	00000550	PGN70051
25	P	00000560	PGM70052
26	G	00000570	PGM70053
27	Н	00000580	PGM70054
28	T	00000590	PGN70055
29	J	00000600	PGM70056
30	ĸ	00000610	PGM70057
31	L	00000620	PGN70058
32		00000630	PGM70059
33	N	00000640	PGM70060
34	0	00000650	PGM70061
35	P	00000660	PGM70062
36	0	00000670	PGM70063
37	R	00000680	PGM70064
38	S	00000690	PGN70065
39	Т	00000700	PGM70066
40	U	00000710	PGN70067
41	V	00000720	PGM70068
42	W	00000730	PGM70069
43	X	00000740	PGM70070
44	Y	00000750	PGM70071
4.5	Ζ	00000760	PGM70072
		PAG	E 26

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C		00000770	PGM70073
C	K=POSTTION OF WORD IN DICTIONARY (EXCLUSIVE OF FIRST 2 CONTROL	00000780	PGM70074
c	WORDS) TF MATCH=5	00000790	PGM70075
č	=NUMBER TF MATCH= 2	00000800	PGM70076
č	=SUBSCRIPT IN JBHF OF FIRST CHARACTER OF UNRECOGNIZED WORD	0000810	PGM 70077
C	TF MATCH= 4	00000820	PGM70078
c	RK=REAT NUMBER TE NATCH=3	00000830	PGM70079
c	NEWARD PORPOR IN INTON 2	00000840	PGN70080
č	LARGED READ NEXT FIELD (N CARD	00000850	PGM70081
č	=1. READ NEW CARD-FIRST FIFLD	00000860	PGM70082
c		00000870	PGM70083
č	I SI TS CONTINUATION CARD MARK	00000880	PGM70084
c -	ϕ 15 CONTROLLON CASE MAIN ϕ TN CC1 TS A COMMENT CASE	00000890	PGM70085
č		00000900	PGM 70086
	THE MAXIMUM NUMBER OF CHARACTERS PER WORD DEPENDS ON THE	00000910	PGM70087
č	ATLOWABLE NUMBER OF DECIMAL DIGITS PER INTEGER WORD.	00000920	PGM70088
č	IN SUPROUTINE CODES	00000930	PGM70089 N
č	THE ABOVE CODES ARE SET BY A DATA SPECIFICATION FOR LET (1-46)	00000940	PGM70090 N
Č	LET (T) HAS THE CHARACTER REPRESENTATION (1H) OF THE CHARACTER	00000950	PGM70091
č	with code $T-1$. Thus LET (21) = 1HA.	00000960	PGM70092
c	WIN CODE I (* 1865 DELLOT) TARE	00000970	PGM70093
C			PGM70094
	INTEGER BLANK COMMA_PLUS_MINUS_DP	00000980	PGM70095
	DIMENSION LET (46) IBUR (80)		PGM70096
			PGM70097
			PGM70098
			PGM70099
C		00001010	PGM 70 100
C	DATA LASTC. TREAD TORNT, BLANK, COMMA, PLUS, MINUS, DP/80, 5, 6, 14, 13, 10.	.00001020	PGM70101
	s11 12/	00001030	PGM70102
\sim		00001040	PGM70103
ĉ	TNTRY DOTNT-CHECK OD CODE	00001050	PGM70104
C	ANIMB=0 A	00001060	PGN70105
		00001070	PGN70106
	$T_{\mathbf{F}}(\mathbf{T} = \mathbf{F} \cap A) c \cap T \cap 110$	00001080	PGM70107
C	I I READ NEW CARD CONVERT TO DECIMAL CODE.SET BUREER POINTER IC	00001090	PGM70108
C	H- FREED WER CARDFOORTHET TO PECHAR CODEFEET DEFER TOTATER TO	PAGI	27

C TO FIRST NON-ELANK CEAS. 00001100 PGR70109 00001120 PGR70113 BUP (ISS)=LET (15) 00001120 PGR70113 BOD CONTINUE READ(IFEAL, 1000, PER=801, END=802) IBUF 00001120 PGR70113 DOG FORMAT (80A1) 00001120 PGR70113 GC TC 601 PGR70115 BOD 101 I=1,80 00001160 PGR70117 DO 101 I=1,80 00001170 PGR70120 DO 102 J=1,46 00001170 PGR70120 IEUF (IJ=50 00001180 PGR70120 IEUF (IJ=50 00001190 PGR70120 C NATCH=LLEGAL CHARACTEP, SET=50 IN IBUF 0000120 PGR70122 IEUF (IJ=50 0000120 PGR70124 0000120 PGR70124 C MATCHEL 0000120 PGR70124 0000120 PGR70127 C SET IC NS FIFST NON-BLANK CCLUMN				
DO RÓO ISS=1,80 C0001110 PCM70111 BOD CONTINUE 00001120 PCM70111 PEAD(IFEAL,1C00,ERE=801,END=802)IBUF PCM70112 PEAD(IFEAL,1C00,ERE=801,END=802)IBUF PCM70113 DO CCMAT(80A1) 00001150 PCM70114 GC TC E01 PCM70114 BOD 102 J=1,46 PCM70117 DO 102 J=1,46 00001160 PCM70118 DO 102 J=1,46 00001180 PCM70120 C NO MATCH=ILLEGAL CHAFACTEP,SET=50 IN IBUF 00001100 PCM70121 IEUF(I)=50 00001200 PCM70123 GC TO 101 00001200 PCM70124 J BUF(I)=51 00001200 PCM70123 GC TO 101 00001200 PCM70124 C MATCH=D 00001200 PCM70124 J CONTINUE 00001200 PCM70124 C MATCH=D 00001200 PCM70124 J CONTINUE 00001200 PCM70124 C SET IC AS FIFST NON-BLANK CCLUMN 00001200 PCM70126 J IP (IBUP(I)=51ANK)105,104,105 00001260 PCM70126 IO 104 CCNTINUE 00001280 PCM70131 IO 5 IC=1 00001280 PCM70131 C POINTER IS ALWAYS SET TC PIRST CHARACTER OF NEW PIELD CN LERVING 00001320 PCM70132 <td>С</td> <td>TO FIRST NON-BLANK CHAR.</td> <td>00001100</td> <td>PGM70109</td>	С	TO FIRST NON-BLANK CHAR.	00001100	PGM70109
TEUP (ISS) = LET (15) 00001120 PGR70111 900 CCNTINUE 00001130 PERT0112 PEAD (IPEAE, 1C00, PRR=801, END=802) IBUF PGR70113 1006 CCRMAT (80A1) 09001150 PGR70114 GC TC 601 PGR70115 901 D0 101 I = 1,80 00001160 PGR70118 D0 102 J=1,46 00001160 PGR70118 D0 102 J=1,46 00001180 PGR70122 102 CONTINUE 00001180 PGR70122 102 CONTINUE 00001180 PGR70122 102 CONTINUE 00001180 PGR70122 103 LDD (1) I = 1,80 00001180 PGR70122 104 CONTINUE 00001130 PGR70122 105 CONTINUE 00001130 PGR70122 106 CT 0 101 PGR70122 110 CONTINUE 0000120 PGR70122 103 CONTINUE 00001230 PGR70125 M 104 CONTINUE 00001250 PGR70126 105 CONTINUE 00001260 PGR70132 106 CONTINUE 00001260 PGR70132 107 CONTINUE 00001260 PGR70132 108 CONTINUE 00001260 PGR70132 109 TOTINUE 00001280 PGR70132 100 TOTINUE 00001280 PGR70132 101 CONTINUE 0000130 PGR70133 <		DO 800 ISS=1,80	00001110	PGM70110
90 CONTINUE 00001130 FGN70112 PGR70113 1000 FCRMAT (BOA1) GC TC E01 00001150 FGN70112 PGR70115 302 NATCH=6 PGN70115 GC TO 280 00001160 FGN70117 301 D0 101 I=1,80 00001160 FGN70118 D0 102 J=1,46 00001190 FGN70122 IP (IBUF (I) - LET(J)) 102,103,102 00001180 FGN70122 102 CONTINUE 00001190 FGN70122 C NO MATCH-ILLEGAL CHAPACTEP,SET=50 IN IBUF 00001200 FGN70122 IEUF (I) =50 90001200 FGN70122 G C TO 101 0000120 FGN70122 V MATCHED 0000120 FGN70123 113 IEUF (I) =J-1 00001250 FGN70125 104 IEI, LASTC 00001250 FGN70125 105 IECI 0000120 FGN70132 104 CONTINUE 0000120 FGN70132 105 ICI 0000120 FGN70133 C POINTYR IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 0000130 FGN70133 C POINTYR IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 FGN70133 C POINTYR IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 FGN70133 C PROFNIZAELE COLUMN, LASTCC 00001330 FGN70135 C FRCORNIZAELE		IBOF(ISS) = LET(15)	00001120	PGM70111
PERD(IPEAR, 1000, ERR=801, END=802) IBUF PGR70113 1000 FCRMAT(80A1) 00001150 PGM70114 gC TC E01 PGM70117 802 NATCH=6 PGM70117 gC TO 280 PGM70117 901 D0 101 I=1,80 00001160 PGM70118 D0 102 J=1,46 00001180 PGM70120 102 CONTINUE 00001180 PGM70121 C NO MATCH-ILLEGAL CHAPACTEP,SET=50 IN IBUF 00001200 PGM70122 gC TO 101 SET IC AS FIRST NON-BLARK CCLUMN 00001220 PGM70122 G SET IC AS FIRST NON-BLARK CCLUMN 00001260 PGM70126 D0 104 I=1,LASTC 00001260 PGM70126 D1 105 IC=I 00001260 PGM70129 C PGM7017 PGM70130 C SET IC AS FIRST NON-BLARK CCLUMN 00001260 PGM70126 D1 100000000000000000000000000000000000	800	CCNTINUE	00001130	PGM70112
1000 PCRMAT (80A1) 00001150 PGM70114 GC TC 801 PGM70115 302 NATCH=6 PGM70117 GC TO 280 PGM70116 GC TO 280 PGM70117 90 D0 101 I=1.80 00001170 PGM70118 D0 102 J=1.46 00001190 PGM70120 IF (IBUF (I) - LET(J)) 102,103,102 00001180 PGM70120 102 CONTINUP 00001180 PGM70120 C NG MATCH-FLLEGAL CHARACTEP, SET=50 IN IBUF 00001200 PGM70124 J BUF (I) = JO 0000120 PGM70124 00001220 PGM70124 C MATCHEB 0000120 PGM70124 00001220 PGM70124 C MATCHEB 0000120 PGM70126 00001220 PGM70126 00001220 PGM70124 C SET IC AS FIEST NON-BLANK CCLUMN 00001220 PGM70126 00001220 PGM70126 00001220 PGM70126 00001220 PGM70126 00001220 PGM70126 0000120 PGM70126 0000120		READ(IFEAD, 1000, ERR=801, END=802) IBUF		PGM70113
GC TC 601 PGM70115 B32 NATCH=6 PGM70116 GC TC 280 PGM70116 301 DC 101 I=1,80 00001160 PGM70118 DO 102 J=1,46 00001170 PGM70119 It (BUF (I) - LET (J)) 102,103,102 00001180 PGM70120 122 CONTINUE 00001190 PGM70121 C MATCH-ILLEGAL CHARACTEP,SET=50 IN IBUF 00001200 PGM70122 GC TO 101 00001200 PGM70124 102 CONTINUE 00001200 PGM70124 GC TO 101 00001200 PGM70124 103 IBUF (I) =J-1 00001200 PGM70125 M 103 IBUF (I) =J-1 00001200 PGM70126 M 104 CONTINUE 00001200 PGM70126 M C STT IC AS FIFST NON-BLANK CCLUMN 00001260 PGM70132 104 CONTINUE 00001280 PGM70132 105 IC=I 00001300 PGM70133 C MATCH OR SF READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001300 PGM70133 C MATCH OR SF READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001300 PGM70136 C MATCH OR SF READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001300 PGM70136 C AMATCH OR SF READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001300 PGM70136 C END OF	1000	FCRMAT (80A1)	00001150	PGM70114
802 NATCH=6 PGR70116 GC TO 280 PGR70116 901 D0 101 I=1,80 00001160 PGR70118 D0 102 J=1,46 00001170 PGR70118 00001170 PGR70120 102 CONTINUE 00001190 PGR70121 00001190 PGR70123 00001120 PGR70123 GC GC TO 1010 PGR70124 00001220 PGR70124 GC GC TO 10110 PGR70124 GC GC GC TO GC TO 10110 PGR70124 GC		GC TC E01		PGM70115
GC TO 280 PGN70117 931 DO 101 I=1,80 00001160 PGN70118 DO 102 J=1,46 0000117C PGN70117 IF (IBUF(I)-LET(J))102,103,102 00001180 PGN70122 102 CONTINUE 00001190 PGN70122 103 CONTINUE 0000120 PGN70122 GC TO 0000120 PGN70122 IEUF(I)=50 0000120 PGN70122 0000120 GC TO 0000120 PGN70122 MATCHED 00001230 PGN70125 00001230 103 IBUF(I)=J-1 00001230 PGN70128 01 CONTINUE 00001260 PGN70128 00 104 CONTINUE 00001260 PGN70132 105 IC=I 0000120 PGN70133 105 IC=I 00001300 PGN70133 C POINTER IS ALWAYS SET TC PIRST CHARACTER OF NEW FIELD CN LEAVING 00001300 PGN70134 C	802	NATCH=6		PGM70116
B01 D0 101 I = 1,80 00001160 PGM70118 D0 102 J=1,46 00001170 PGM70120 IF (BBUF (I) - LET (J)) 102,103,102 00001180 PGM70121 102 CCNTINUE 00001190 PGM70122 C NO MATCH-ILLEGAL CHARACTEP,SET=50 IN IBUF 00001200 PGM70122 GC TO 101 00001220 PGM70122 IEUF (I) = 50 00001200 PGM70122 GC TO 101 00001220 PGM70124 C MATCHED 00001230 PGM70125 M 103 IBUF (I) = J-1 00001250 PGM70127 M 101 CCNTINUE 00001260 PGM70128 D0 104 I =1, LASTC 00001270 PGM70128 D0 104 I =1, LASTC 00001280 PGM70130 104 CCNTINUE 00001280 PGM70132 C SET IC AS FIRST NON-BLANK CCLUMN 00001280 PGM70132 D0 104 I =1, LASTC 00001280 PGM70132 105 IC= I 00001280 PGM70133 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001300 PGM70133 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001340 PGM70133 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001340 PGM70135 C FACCGNIZAELE COLUMN, LASTCC 00001340 PGM70135		GC TO 280		PGM70117
D0 102 J=1,46 0000117C PGR70119 IF (IBUF (I) - LET (J)) 102,103,102 00001180 PGR70120 00001180 PGR70120 102 CONTINUE 00001120 PGR70120 00001120 PGR70122 IEUF (I) = 50 00001200 PGR70123 00001220 PGR70123 GC TO 10 00001200 PGR70124 00001200 PGR70125 C MATCHED 00001200 PGR70124 00001200 PGR70125 103 IBUF (I) = J-1 00001200 PGR70126 00001200 PGR70127 C SET IC AS FIFST NON-BLANK CCLUMN 00001260 PGR70128 00001276 PGR70128 D0 104 I= 1, LASTC 00001280 PGR701318 00001280 PGR70131 105 IC=I 00001280 PGR70131 00001300 PGR70132 C POINTFR IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 PGR70134 C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001330 PGR70134 C F	801	DO 101 I=1,80	00001160	PGM70118
IP (IBUF (I) - LET (J)) 102,103,102 00001180 PGM70120 102 CONTINUE 00001190 PGM70121 C NO MARCH-ILLEGAL CHARACTER, SET=50 IN IBUF 00001200 PGM70122 IEUF (I) = 50 00001220 PGM70123 GC TO 101 00001200 PGM70123 C MATCHED 00001220 PGM70124 103 IBUF (I) = J-1 00001220 PGM70126 101 CONTINUE 00001260 PGM70126 C SET IC AS FIEST NON-BLANK CCLUMN 00001260 PGM70126 D0 104 I= 1, LASTC 00001260 PGM70126 IP (IBUF (I) - BLANK) 105, 104, 105 00001260 PGM70131 105 IC=I 00001300 PGM70132 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 PGM70133 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 PGM70134 105 IC=I 00001330 PGM70135 00001340 PGM70136 C RECOGNIZAELE COLUMN, LASTCC 00001350 PCM70137 00001350 PCM70137 C FIC IC-LASTC) 115, 115, 120 00001360 PGM70138 00001350 PCM70138 C END OF STATEMENT 00001360 PGM70138 00001360 PGM70138		DO 102 J=1,46	00001170	PGM70119
102 CONTINUE 00001190 PGH70121 C NO MATCH-ILLEGAL CHARACTEP, SET=50 IN IBUF 00001200 PGH70122 IEUF(I)=50 00001210 PGH70123 GC TO 1C1 00001230 PGH70124 C MATCHED 00001230 PGH70124 103 IBUF(I)=J-1 00001200 PGH70125 MG 104 I=J,LASTC 00001250 PGH70127 C SET IC AS FIFST NON-BLANK CCLUMN 00001260 PGH70128 D0 104 I=1,LASTC 00001270 PGH70128 D0 104 I=1,LASTC 00001280 PGH70131 105 IC=I 00001300 PGH70131 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001300 PGH70132 C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001300 PGH70135 C RECOGNIZABELE COLUMN, LASICC 00001350 PGH70136 110 ICAR=IRUP(IC) 00001360 PGH70137 00001360 PGH70137 If (IC-LASIC) 115,115,120 00001360 PGH70138 00001360 PGH70139 C END OF STATEMENT 00001380 PGH70139 00001380 PGH70134 120 NATCH=1 00001360 PGH70138 00001380 PGH70144 00001380 PGH70144 280 RETURN 00001360 PGH70143 00001380 PGH70144 00001400 PGH		IF (IBUF (I) -LET (J)) 102,103,102	00001180	PGM70120
C NO MATCH-ILLEGAL CHARACTEP, SET=50 IN IBUF 00001200 PGM70122 IEUF (I) =50 00001210 PGM70123 G TO 1C1 00001220 PGM70125 C MATCHED 00001230 PGM70125 1C3 IBUF (I) = J-1 00001250 PGM70126 1D1 CCNTINUE 00001250 PGM70127 C SET IC AS FIFST NON-BLANK CCLUMN 00001260 PGM70128 D0 104 I=1,LASTC 00001270 PGM70129 IF (IBUF (I) -BLANK) 105,104,105 00001280 PGM70131 105 IC=I 00001300 PGM70132 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 PGM70132 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 PGM70133 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 PGM70134 C RECOGNIZABLE COLUMN, LASICC 00001330 PGM70135 C END OF STATEMENT 00001360 PGM70137 I20 NATCH=1 00001360 PGM70136 C END OF STATEMENT 00001380 PGM70137 I20 NATCH=1 00001300 PGM70143 C END OF STATEMENT 00001380 PGM70144 C0	102	CONTINUE	00001190	PGM70121
IEUF(I)=50 00001210 PGM70123 GC TO 1C1 00001220 PGM70125 C MATCHED 00001230 PGM70125 1C3 IBUF(I)=J-1 00001250 PGM70126 1D1 CONTINUE 00001250 PGM70127 C SET IC AS FIRST NON-BLANK CCLUMN 00001260 PGM70128 DO 104 I=1,LASTC 00001280 PGM70129 IF (IBUF(I)-BLANK)105,104,105 00001280 PGM70130 104 CCNTINUE 00001280 PGM70131 105 IC=I 00001300 PGM70132 C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001320 PGM70133 C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001320 PGM70136 C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001320 PGM70137 C RECOGNIZABLE COLUMN,LASTCC 00001360 PGM70137 IF (IC-LASTC) 115,115,120 00001360 PGM70137 IF (IC-LASTC) 115,115,120 00001360 PGM70137 C END OF STATEMENT 00001380 PGM70140 120 NATCH=1 00001380 PGM70144 280 RETURN 00001380 PGM70142 C OK-CHECK IF NEW FIELC IS A NUMMER, C-9, +, -, OR. 00001380 PGM70142 C OK-CHECK IF NEW FIELC IS A NUMMER, C-9, +, -, OR. 00001400 PGM70142 PAGE 28 28	С	NO MATCH-ILLEGAL CHARACTER.SET=50 IN IBUF	00001200	PGM70122
GC TO 1C1 00001220 PGM70124 C MATCHED 00001230 PGM70125 W 103 IBUP(I)=J-1 00001250 PGM70126 W 101 CONTINUE 00001260 PGM70126 W C SET IC AS FIRST NON-BLANK CCLUMN 00001260 PGM70128 D0 104 I=1,LASTC 00001270 PGM70128 If (IBUF(I)=BLANK)105,104,105 00001200 PGM70132 104 CCNTINUE 00001200 PGM70132 105 IC=I 00001300 PGM70132 C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001320 PGM70133 C RECONTZAELE COLUMN, LASICC 00001330 PGM70135 00001330 PGM70137 If (IC-LASIC) 115,115,120 00001360 PGM70138 00001360 PGM70137 C END OF STATEMENT 00001300 PGM70134 00001300 PGM70137 120 NATCH=1 00001300 PGM70144 00001300 PGM70144 C 0K-CHECK IF NEW FIELE IS A NUMMER, C-9, +, -, OR. 00001400 PGM70142 C OK-CHECK IF NEW FIELE IS A NUMMER, C-9, +, -, OR. 00001400 PGM70144		IEUF(I) = 50	00001210	PGM70123
C MATCHED 00001230 PGR70125 L 103 IBUP (I) = J = 1 00001200 PGM70126 C 101 CCNTINUE 00001250 PGM70127 C C SET IC AS FIRST NON-BLANK CCLUMN 00001260 PGM70128 D0 104 I= 1, LASTC 00001260 PGM70129 IP (IBUF (I) - BLANK) 105, 104, 105 00001280 PGM70130 104 CCNTINUE 00001280 PGM70133 105 IC=I 00001300 PGM70133 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 PGM70134 C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001330 PGM70135 C RECOGNIZABLE COLUMN, LASICC 00001350 PGM70137 110 ICAR=IBUP (IC) 00001350 PGM70137 IF (IC-LASIC) 115, 115, 120 00001360 PGM70139 C END OF STATEMENT 00001380 PGM70140 280 RETURN 00001380 PGM70140 C OK-CHECK IF NEW FIFLE IS A NUMMER, C-9, +, -, OR. 000014100 PGM70142		GC TO 1C1	00001220	PGM70124
103 IBUF(I)=J-1 00001240 PGM70126 00001250 PGM70127 101 CONTINUE 00001250 PGM70127 00001250 PGM70127 C SET IC AS FIRST NON-BLANK CCLUMN 00001260 PGM70128 00001270 PGM70129 D0 104 I=1,LASTC 00001280 PGM70130 00001280 PGM70131 105 IC=I 00001280 PGM70132 00001310 PGM70132 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001310 PGM70133 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 PGM70135 C RECOGNIZAELE COLUMN, LASTCC 00001330 PGM70136 110 ICAR=IBUF(IC) 00001350 PGM70137 IF(IC-LASTC) 115,115,120 00001380 PGM70138 C END OF STATEMENT 00001380 PGM70140 230 RETURN 00001380 PGM70140 C OK-CHECK IF NEW FIELE IS A NUMMER, 0-9, +, -, OR. 00001400 PGM70143 115 IF(ICAR-12) 125, 125, 300 00001440 PAGE 28 </td <td>С</td> <td>MATCHED</td> <td>00001230</td> <td>PGM70125 N</td>	С	MATCHED	00001230	PGM70125 N
101 CONTINUE 00001250 PGM70127 C SET IC AS FIRST NON-BLANK CCLUMN 00001260 PGM70128 D0 104 I=1,LASTC 00001270 PGM70129 IF (IBUF (I)-BLANK) 105,104,105 00001280 PGM70130 104 CCNTINUE 00001290 PGM70131 105 IC=I 00001300 PGM70132 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 PGM70134 C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001330 PGM70135 C RECOGNIZAELE COLUMN, LASICC 00001350 PGM70137 110 ICAR=IBUF (IC) 00001350 PGM70137 IF (IC-LASIC) 115, 115, 120 00001360 PGM70138 C END OF STATEMENT 00001380 PGM70140 280 RETURN 00001380 PGM70141 C OK-CHECK IF NEW FIELD IS A NUMMER, C-9, +, -, OR. 00001400 PGM70143 115 IF (ICAR-12) 125, 125, 300 00001420 PGM70144	103	IBUF(I) = J - 1	00001240	PGM70126 0
C SET IC AS FIRST NON-BLANK CCLUMN 00001260 PGM70128 D0 104 I=1,LASTC 00001270 PGM70129 IF (IBUF (1) - BLANK) 105,104,105 00001280 PGM70130 104 CCNTINUE 00001290 PGM70131 105 IC=I 00001300 PGM70132 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 PGM70133 C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001330 PGM70135 C RECOGNIZABLE COLUMN, LASTCC 00001350 PGM70137 IC IF (IC-LASTC) 115, 115, 120 00001360 PGM70137 C END OF STATEMENT 00001360 PGM70139 120 NATCH=1 00001380 PGM70140 290 RETURN 00001380 PGM70141 C OK-CHECK IF NEW FIFLE IS A NUMMER, C-9, +, -, OR. 00001400 PGM70142 C OK-CHECK IF NEW FIFLE IS A NUMMER, C-9, +, -, OR. 00001400 PGM70144 PAGE 28 28 00001420 PGM70144	10.1	CONTINUE	00001250	PGN70127
D0 104 I=1,LASTC 00001270 PGM70129 IF (IBUF (I) - BLANK) 105,104,105 00001280 PGM70130 104 CCNTINUE 00001290 PGM70131 105 IC=I 00001300 PGM70132 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 PGM70133 C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001300 PGM70135 C RECOGNIZAELE COLUMN, LASICC 00001350 PGM70137 I10 ICAR=IBUF (IC) 00001350 PGM70137 IF (IC-LASIC) 115, 115, 120 00001360 PGM70139 C END OF STATEMENT 00001380 PGM70141 C OK-CHECK IF NEW FIELD IS A NUMMER, 0-9, +, -, OR. 00001400 PGM70143 115 IF (ICAR-12) 125, 125, 300 00001400 PGM70143 00001420 PGM70143	С	SET IC AS FIRST NON-BLANK CCLUMN	00001260	PG M70128
IP (IBUF (I) - BLANK) 105, 104, 105 000012 80 PGM70130 104 CCNTINUE 00001290 PGM70131 105 IC=I 00001300 PGM70132 C 00001310 PGM70133 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 PGM70134 C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001320 PGM70135 C RECOGNIZABLE COLUMN, LASTCC 00001350 PGM70136 110 ICAR=IBUF (IC) 00001350 PGM70137 IF (IC-LASTC) 115, 115, 120 00001350 PGM70137 C END OF STATEMENT 00001380 PGM70139 120 NATCH=1 00001380 PGM70141 C OK-CHECK IF NEW FIFLE IS A NUMMER, 0-9, +, -, OR. 00001400 PGM70143 115 IF (ICAR-12) 125, 125, 300 00001420 PGM70144 PAGE 28		DO 104 $I=1.LASTC$	00001270	PGM70129
104 CCNTINUE 00001290 PGM70131 105 IC=I 00001300 PGM70132 C 00001310 PGM70133 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 PGM70134 C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001330 PGM70135 C RECOGNIZAELE COLUMN, LASICC 00001350 PGM70135 110 ICAR=IBUF (IC) 00001350 PGM70137 IF (IC-LASIC) 115, 115, 120 00001360 PGM70137 C END OF STATEMENT 00001360 PGM70139 120 NATCH=1 00001380 PGM70140 280 RETURN 00001390 PGM70142 C OK-CHECK IF NEW FIELD IS A NUMMER, C-9, +, -, OF. 00001400 PGM70143 115 IF (ICAR-12) 125, 125, 300 0001420 PGM70144		IF (IBUF (I) - BLANK) 105.104.105	00001280	PGM70130
105 IC=I 00001300 PGM70132 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001310 PGM70133 C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001320 PGM70134 C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001330 PGM70135 C RECOGNIZAELE COLUMN, LASTCC 00001350 PGM70136 110 ICAR=IBUF (IC) 00001350 PGM70137 IF (IC-LASTC) 115, 115, 120 00001360 PGM70138 C END OF STATEMENT 00001380 PGM70139 120 NATCH=1 00001380 PGM70140 280 RETURN 00001400 PGM70142 C OK-CHECK IF NEW FIELE IS A NUMMER, 0-9, +, -, OR. 00001400 PGM70143 115 IF (ICAR-12) 125, 125, 300 0001420 PGM70144	104	CCNTINUE	00001290	PGM70131
C 00001310 PGM70133 C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 PGM70134 C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001330 PGM70135 C RECOGNIZAELE COLUMN, LASICC 00001350 PGM70136 110 ICAR=IBUF (IC) 00001350 PGM70137 IF (IC-LASIC) 115, 115, 120 00001360 PGM70138 C END OF STATEMENT 00001380 PGM70139 120 NATCH=1 00001390 PGM70140 280 RETURN 00001400 PGM70142 C OK-CHECK IF NEW FIELE IS A NUMMER, C-9, +, -, OF. 00001400 PGM70143 115 IF (ICAR-12) 125, 125, 300 00001420 PGM70144	105	IC=I	00001300	PGM70132
C POINTER IS ALWAYS SET TC FIRST CHARACTER OF NEW FIELD CN LEAVING 00001320 PGM70134 C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001330 PGM70135 C RECOGNIZAELE COLUMN, LASTCC 00001340 PGM70136 110 ICAR=IBUF (IC) 00001350 PGM70137 IF (IC-LASTC) 115, 115, 120 00001360 PGM70138 C END OF STATEMENT 00001380 PGM70139 120 NATCH=1 00001380 PGM70140 280 RETURN 00001390 PGM70141 C OK-CHECK IF NEW FIELD IS A NUMMER, 0-9, +, -, OF. 00001400 PGM70143 115 IF (ICAR-12) 125, 125, 300 00001420 PGM70144	С		00001310	PGM70133
C MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST 00001330 PGM70135 C RECOGNIZAELE COLUMN, LASTCC 00001340 PGM70136 110 ICAR=IBUF (IC) 00001350 PGM70137 IF (IC-LASTC) 115, 115, 120 00001360 PGM70138 C END OF STATEMENT 00001380 PGM70139 120 NATCH=1 00001380 PGM70140 280 RETURN 00001390 PGM70141 C OK-CHECK IF NEW FIELE IS A NUMMER, 0-9, +, -, OR. 00001400 PGM70143 115 IF (ICAR-12) 125, 125, 300 00001420 PGM70144	C	POINTER IS ALWAYS SET TO FIRST CHARACTER OF NEW FIELD ON LEAVING	00001320	PGM70134
C RECOGNIZAELE COLUMN, LASICC 00001340 PGM70136 110 ICAR=IBUF (IC) 00001350 PGM70137 IF (IC-LASIC) 115, 115, 120 00001360 PGM70138 C END OF STATEMENT 00001380 PGM70139 120 NATCH=1 00001390 PGM70141 280 RETURN 00001400 PGM70142 C OK-CHECK IF NEW FIELD IS A NUMMER, 0-9, +, -, OR. 00001400 PGM70143 115 IF (ICAR-12) 125, 125, 300 00001420 PGM70144	C	MATCH OR BY READING A NEW CARD-IT MAY BE LEFT PAST THE LAST	00001330	PGM70135
110 ICAR=IBUF (IC) 00001350 PGM70137 IF (IC-LASTC) 115,115,120 00001360 PGM70138 C END OF STATEMENT 00001370 PGM70139 120 NATCH=1 00001380 PGM70141 280 RETURN 00001400 PGM70142 C OK-CHECK IF NEW FIELD IS A NUMMER, 0-9, +, -, OR. 00001410 PGM70143 115 IF (ICAR-12) 125, 125, 300 00001420 PGM70144	č	RECOGNIZAELE COLUMN.LASICC	00001340	PGN70136
IF (IC-LASTC) 115, 115, 120 00001360 PGM70138 C END OF STATEMENT 00001370 PGM70139 120 NATCH=1 00001380 PGM70140 280 RETURN 00001390 PGM70141 C OK-CHECK IF NEW FIELD IS A NUMMER, 0-9, +, -, OR. 00001400 PGM70142 115 IF (ICAR-12) 125, 125, 300 00001420 PGM70144	110	TCAR=IBUF(IC)	00001350	PGM70137
C END OF STATEMENT 00001370 PGM70139 120 NATCH=1 00001380 PGM70140 280 RETURN 00001390 PGM70141 C 00001400 PGM70142 C 00001410 PGM70143 115 IF (ICAR-12) 125, 125, 300 00001420 PGM70144 PAGE 28		TF (TC-LASTC) 115, 115, 120	00001360	PGM70138
120 NATCH=1 00001380 PGM70140 280 RETURN 00001390 PGM70141 C 0K-CHECK IF NEW FIELD IS A NUMMER,0-9,+,-,0R. 00001400 PGM70142 115 IF (ICAR-12) 125,125,300 00001420 PGM70144	C.	END OF STATEMENT	00001370	PGM 70139
280 RETURN 00001390 PGM70141 C 00001400 PGM70142 C 0K-CHECK IF NEW FIELD IS A NUMMER, 0-9, +, -, 0R. 00001410 PGM70143 115 IF (ICAR-12) 125, 125, 300 00001420 PGM70144 PAGE 28	120	NATCH= 1	00001380	PGM 70 140
C 00001400 PGM70142 C 00001410 PGM70142 C 00001410 PGM70143 115 IF (ICAR-12) 125,125,300 00001420 PGM70144 PAGE 28	280	RETURN	00001390	PGM70141
C OK-CHECK IF NEW FIELD IS A NUMMER, 0-9, +, -, OB. 00001410 PGM70143 115 IF (ICAR-12) 125, 125, 300 00001420 PGM70144 PAGE 28	c		00001400	PGM70142
115 IF (ICAR-12) 125, 125, 300 PAGE 28	č	OK-CHECK IF NEW FIELD IS A NUMBER.0-9.+OR.	00001410	PGN70143
PAGE 28	- 115	IF (ICAR-12) 125.125.300	00001420	PGM70144
	,,,,,,		PAGE	28

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NUMBER FOUND-SET INITIAL PARAMETERS
С
С
      DECIMAL POINT=NO
  125 IDP=0
С
      NEGATIVE=NO
      ISGN=0
С
      NC GIGNIFICANT DIGIT YET
      ISIG=0
      NUMERICAL VALUE OF NUMBER (REAL OR INTEGER)
\mathbb{C}
      NUM B=0
      SAVE START OF NUMBER
С
      ICSTR = IC
      IS FIRST CHAR A PLUS SIGN-IGNORE IF YES
С
      IF (ICAR-PLUS) 126, 130, 126
С
      CHECK IF MINUS SIGN-SET ISIGN=1 IF YES
  126 IF (ICAP-MINUS) 135, 127, 135
127
      ISGN=1
      LEADING PLUS OR MINUS SIGN-BUMP CARD COLUMN POINTER-CHECK
С
      IF END OF FIELD
С
      THIS IS GENERAL CC BUMPER SECTION OF CODE
C
  130 IC=IC+1
      ICAR = IBUF(IC)
      IF(IC-LASTC) 135, 135, 140
      CHECK IF CC IS BLANK CR CCMMA
C
  135 IF (ICAR-ELANK) 145, 140, 145
  145 IF (ICAR-CCMMA) 150, 140, 150
      NCT END OF FIELD-IS IT A DIGIT...
C
  150 IF (ICAR-9) 155, 155, 160
      DIGIT 0-9, DECIAML POINT YET...
С
  155 IF (IDP-1) 165, 170, 165
      ALREADY HAVE DP,N IS THUS NEGATIVE, NUMBER IN ANUMB
С
 170 ANUMB= ANUMB+FLOAT (ICAR) * (10.**N)
      N = N - 1
      GC TO 130
      NO DP YET, IS DIGIT A ZEFC ...
С
  165 IF (ICAR) 175, 180, 175
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C

00001430 PGM70145 00001440 PGN70146 00001450 PGM70147 00001460 PGM70148 00001470 PGM70149 00001480 PGM70150 00001490 PGM70151 00001500 PGM70152 00001510 PGM70153 00001520 PGM70154 00001530 PGM70155 00001540 PGM70156 00001550 PGM70157 00001560 PGM70158 00001570 PGM70159 00001580 PGM70160 00001590 PGM70161 00001600 PGM70162 🖁 00001610 PGM70163 ⁴ 00001620 PGM70164 00001630 PGM70165 00001640 PGM70166 00001650 PGM70167 00001660 PGM70168 00001670 PGM70169 00001680 PGM70170 00001690 PGM70171 00001700 PGM70172 00001710 PGM 70173 00001720 PGM70174 00001730 PGM70175 00001740 PGM70176 00001750 PGM70177 00001760 PGM70178 00001770 PGM70179 00001780 PGM70180

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С
      NOT ZERC, THUS IT IS SIGNIFICANT
  175 ISIG=1
      GO TO 185
      ZERO-CHECK IF SIGNIFICANT, IF NOT SKIP.
С
  180 IF (ISIG-1) 130, 185, 130
185 NUMB=10*NUMB+ICAR
      GO TO 130
С
      CHARACTER NOT DIGIT IS IT DP ...
С
  160 IF (ICAR-DP) 195, 190, 195
    YES, WAS ONE GIVEN PREVIOUSLY...
C
  190 IF (IDP-1) 200,99,200
200 N=-1
      IDP=1
      A NUMB=NUMB
      GO TO 130
С
      NOT DIGIT OR DP, IS IT E..., IF NOT, FRROR (99)
С
195
      IF (ICAR-24) 99,205,99
      E FORM-E(PLUS OR MINUS)N1, (N2)
С
  205 IF (IDP-1) 210, 214, 210
      NO DP YET, FLOAT NUMBER
С
  210 ANUMB=NUMB
      I D = 1
  214 I=1
С
      SIGN OF EXPONENT=PLUS
      IEP=+1
С
      VALUE OF EXPONENT=0
      IEX=0
C
      NEXT COLUMN
  215 IC=IC+1
      ICAR=IBUF (IC)
      IF (IC-LASTC ) 216,216,99
  216 IF (ICAR-ELANK) 217,99,217
  217 IF (ICAR-CCMMA) 218,99,218
  218 GO TO (220.225).I
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00001790 PGM70181 00001800 PGM70182 00001810 PGM70183 00001820 PGM70184 00001830 PGM70185 00001840 PGM70186 00001850 PGN70187 00001860 PGN70188 00001870 PGM70189 00001880 PGM70190 00001890 PGN70191 00001900 PGN70192 00001910 PGN70193 00001920 PGN70194 00001930 PGM70195 00001940 PGM70196 i 00001950 PGM70197 & 00001960 PGM70198 ĭ 00001970 PGM70199 00001980 PGM70200 00001990 PGN70201 00002000 PGM70202 00002010 PGM70203 00002020 PGM70204 00002030 PGM70205 00002040 PGM70206 00002050 PGM70207 00002060 PGN70208 00002070 PGM70209 00002080 PGM70210 00002090 PGN70211 00002100 PGM70212 00002110 PGM70213 00002120 PGM70214 00002130 PGM70215 00002140 PGM70216 PAGE 30

С CHARACTER AFTER E, IS IT FLUS, MIMUS, OR DIGIT... 220 IF (ICAR-PIUS) 226,230,235 235 IF (ICAR-MINUS) 99,240,99 С MINUS SIGN 240 IEP = -1HERE FOE PLUS SIGN ALSO C. С RESET SWITCH AND GET NEXT CCLUMN 230 I=2GC TO 215 FIRST OF CNE OR TWO EXPONENT DIGITS С IF (ICAR-9) 226, 226, 99 225 226 IFX=ICAR T=1223 IC=IC+1 ICAR=IBUF (IC) IF (IC-LASTC) 231,231,250 IF (ICAR-BLANK) 227, 250, 227 231 227 IF (ICAR-CCMMA) 228,250,228 228 GO TO (224,99),I 224 IF (ICAR-9) 229, 229, 99 229 I=2 IEX=10*IEX+ICAR GC TO 223 C END OF E FORM-MULTIPLY NUMBER BY EXPCNENT 250 ANUMB=ANUMB* (10.** (IEP*IEX)) C C END OF NUMBER, POINTER AT BLANK, COMMA, OR EOC С ICP=0, INTEGER IN NUMB-ICP=1, READ IN ANUMB 140 IF (ISGN-1) 144, 141, 144 С NEGATE-CHECK IF INTEGER OR REAL 141 IF (IDP) 142, 143, 142 С REAL 142 ANUMB = -ANUMEGO TO 144 С INTEGER 143 NUMB=-NUMB

00002150 PGM70217 00002160 PGM70218 00002170 PGM70219 00002180 PGM70220 00002190 PGM70221 00002200 PGN70222 00002210 PGM70223 00002220 PGN70224 00002230 PGM70225 00002240 PGM70226 00002250 PGM70227 00002260 PGM70228 00002270 PGM70229 00002280 PGM70230 00002290 PGM70231 00002300 PGM70232 00002310 PGM70233 I 00002320 PGM70234 8 00002330 PGM70235 T 00002340 PGM70236 00002350 PGM70237 00002360 PGM70238 00002370 PGM70239 00002380 PGM70240 00002390 PGM70241 00002400 PGM70242 00002410 PGM70243 00002420 PGM70244 00002430 PGM70245 00002440 PGM70246 00002450 PGM70247 00002460 PGM70248 00002470 PGM70249 00002480 PGM70250 00002490 PGM70251 00002500 PGM70252 PAGE 31

	144	NATCH=IEF+2	00002510	PGM 70 25 3	
		K=NUMB	00002520	PGM70254	
		RK=ANUMB	00002530	PGM70255	
С			00002540	PGM70256	
С		POINTER AT BLANK, COMMA, CE EOC-BUMP TO A NON-BLANK, NON-COMMA	00002550	PGM70257	
С		CHARACTER OR LEAVE AT ECC-THIS SECTION OF CODE IS USED	00002560	PGM70258	
С		EFFORE RETURNING	00002570	PGM 70259	
	270	IF(IC-LASIC) 271, 271, 280	00002580	PGM70260	
	271	IC=IC+1	00002590	PGM70261	
		IF(IC-LASTC)272,272,280	00002600	PGM70262	
	272	IF (IBUF (IC) - BLANK) 273, 271, 273	00002610	PGM70263	
	273	IF (IBUF (IC) -COMMA) 280, 271, 280	00002620	PGM70264	
С			00002630	PGM70265	
C			00002640	PGM 70266	
Ċ		FIRST CHAR IS NOT ECC, NUMBER-IS IT \$	00002650	PGM70267	
3	00	IF (ICAR-17) 330, 120, 330	00002660	PG M70268	
С			00002670	PGM 70269	
Ċ			00002680	PGM70270	Ň
C		BY ELIMINATION, THE FIELD IS A WORD-SAVE IC AND GET END OF WORD.	00002690	PGM70271	ĩ
С		FORM PACKED WORD IN DECIMAL CODE TO COMPARE AGAINST LIST-NEED	00002700	PGM70272	•
C		FIRST WORD IN LIST AS NUMBER OF CHARS IN WORD.	00002710	PGM70273	
C		BLANK PAD ON RIGHT.	00002720	PGM70274	
	330	ICSTR =IC	00002730	PGM70275	
	410	IC=IC+1	00002740	PGM70276	
		ICAR=IBUF(IC)		PGM70277	
		IF(IC-LASTC) 415, 415, 42C	00002760	PGM70278	
	4 15	IF (ICAR-COMMA) 405, 420, 405	00002770	PGM70279	
	405	IF (ICAR-BLANK) 410, 420, 410	00002780	PGM70280	
С		END OF FIELD	00002790	PGM70281	
	420	IEND=IC-1	00002800	PGM 70282	
С		USF LIST FIRST	00002810	PGM70283	
		NC = LIST(1)	00002820	PGM70284	
С		GET CHARACTERS IN WORD	00002830	PGM70285	
		NCW = IEND + 1 - ICSTR	00002840	PG M70286	
		NCW 1= NCW + 1	00002850	PGM70287	
		I FD=0	00002860	PGM70288	
			PAG	E 32	

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С	CHECK IF FIELDS IS SHORTER THAN DICT. WORDS
	IF (NCW-NC) 440, 455, 455
C	SHORTER-ELANK PAD
440	DO 445 I=1, NCW
	IJK=ICS1F +I-1
445	IWD=100*IWD+IBUF(IJK)
	DC 450 I=NCW1,NC
450	I WD = 100 * I WD + B LA N K
	GC TO 465
С	NCW,GE,NC
455	DO 460 I=1, NC
	IJK=ICSTR +I-1
460	IWD=100*IWD+IBUF(IJK)
С	
С	NOW IWD CONTAINS NO CHARACTERS TO COMPARE
C	TC DICTICNARY WORDS
465	NWDS=LIST(2)
	DC 475 I=1,NWDS
	IF(IWD-LIST(I+2))475,480,475
475	CCNTINUE
C	WORD NOT FOUND IN DICTICNARY
	NATCH=4
	K=ICSTR
	GO TO 270
С	WCRD FOUND IN DICTIONARY
480	K=I
	NATCH=5
-	GO TO 270
C	
С	
C	ERROR IN NUMBER FIELD
99	WRITE(IEENT, 999)
	K=ICSTR
	NATCH = 4
0.0.0	GO TO 270
999	FORMAT (25H EEROE IN NUMERIC FIELD.)

00002870	PGM70289
00002880	PGM70290
00002890	PGM70291
00002900	PGM70292
00002910	PGM 70 29.3
00002920	PGM70294
00002930	PGM70295
00002940	PGM70296
00002950	PGM70297
00002960	PGN70298
00002970	PGM70299
00002980	PGM70300
00002990	PGM70301
00003000	PGM70302
00003010	PGM 70303
00003020	PGM70304 .
00003030	PGM70305 N
0000.3040	PG M 70 30 6 🖗
00003050	PGM70307
00003060	PGM70308
00003070	PGM70309
00003080	PGM70310
00003090	PGM70311
00003100	PGM70312
00003110	PGM 70 313
00003120	PGM70314
00003130	PGM70315
00003140	PGM70316
00003150	PGM70317
00003160	PGM70318
00003170	PGM70319
00003180	PGM70320
00003190	PGM70321
00003200	PGM70322
00003210	PGM70323
00003220	PGM70324
PAGE	33
C C

.

RETURN END 00003230 PGM70325 00003240 PGM70326 PGM70327 00003250 PGM70328

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