CHAPTER II

THE RTIM COMPUTER MODEL

Description of the Model

The Road Transport Investment Model was developed to serve as an aid to decision - making the road sector. It calculates road user, road construction, and road maintenance costs , but does not evaluate either secondary economic effects (eg, increases in agricultural output) nor social benefits (eg, increased mobility). In its simplest form, the model can be used to select the minimum total cost of transport from a set of alternative road investments. It can be used to determine the minimum sum of construction, maintenance,and road user costs that would be incurred over the " life " of the alternatives. Simple manipulation of the results will produce estimates of net present value for each of the options.

Construction costs will be incurred during the period that the road is being built, whereas road user and road maintenance costs will be incurred during each year that the road is open to traffic. To consider the economic consequences over a period of time for such a road, one can look at these costs within the simple frame work shown in Fig. 1.

Clearly, there is considerable interaction between the various cost components. The rate at which the road surface will deteriorate will depend on the environment in which the road is built, the standards to which the road

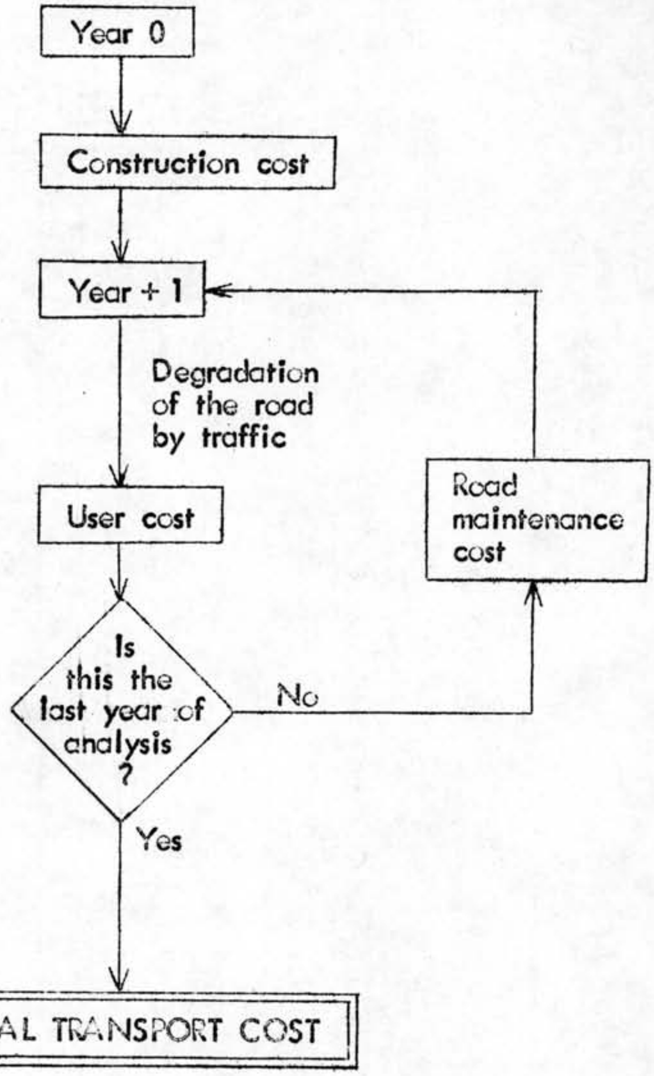

Fig. 1 Framework for Determining Total Road Transportation Cost

has been constructed, the number and types of vehicles using the road, and the degree of road maintenance that is performed each year. In turn, the road user costs will depend on the design standards of the road, the numbers and types of vehicles using it, and on the condition and type of road surface. Finally, the road maintenance costs will depend on the environment, the construction standards, and the condition of the road surface.

This interaction has been simulated in the RTIM computer model. The operation of the model is based on the flow chart shown in Fig. 2 which shows some of the items costed, and the capability of analyzing the consequences of stage construction. This model is based on the results of developmental research and on the results of recent experimental and survey work carried out in Kenya by the Overseas Unit of the Transport and Road Research Laboratory. The model uses physical relationships to which any system of prices or costs can be applied. As such, it is a powerful tool for the transport planner. In addition to supplying information upon which engineering decisions can be made, the model can be of great value in testing the practical implications of various economic policies. It can be used to study many aspects of a road investment project, such as the optimum geometric design standards to be selected for the road, the best choice between an earth, gravel or bituminous pavement, the choice between labour or plant intensive methods of construction, and the benefits of adopting any of a number of different stage construction alternatives. The model will also allow the planner to

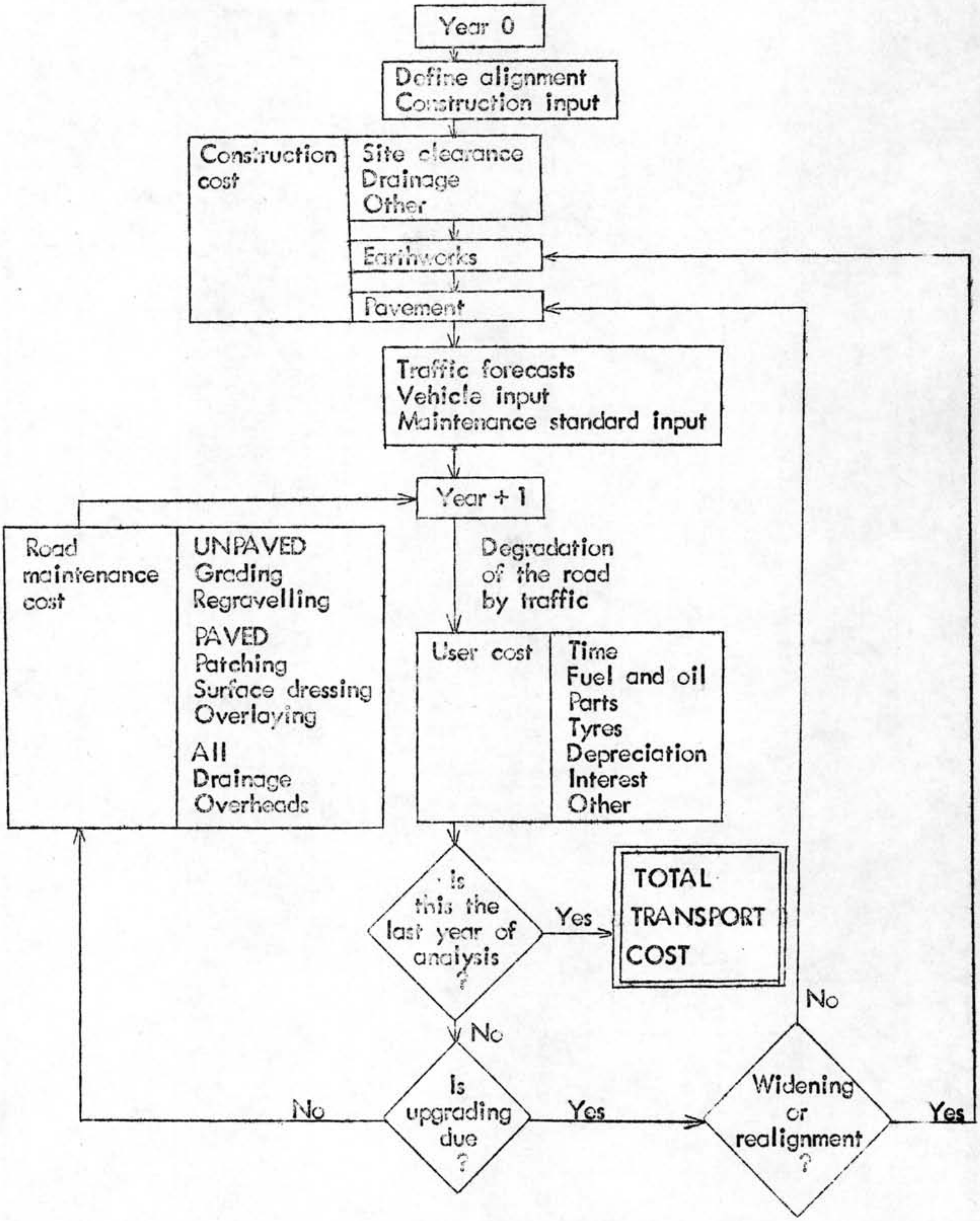

Fig. 2 Flow Chart of Road Transport Investment Model Showing Costs and Upgrading

study the consequences of uncertainties in such items as the traffic forecast or the discount rate.

However, the model must obviously be used with judgment and caution in relation to the environment, and the results obtained must be interpreted in the light of economic and social policies. As with all models, its successful application will depend finally on the quality of data that are presented. It is of particular importance to know the level of accuracy of the data in order to establish the probable level of accuracy of the results obtained; thus, realistic sensitivity analyses must be undertaken as part of any application of the model as a decision - making tool. Certain areas of the model can operate at different levels of data requirements, but accuracy obviously decreases as the data become coarser.

Although the model is relatively sophisticated, the experience of the present research has demonstrated that it is easy to use and that its application and data requirements are well within the capability of potential users such as engineering consultants and public works agencies. It is believed that the model represents a major advance in road planning that should lead to lower transport costs and thus assist in promoting economic and social betterment in the developing world.

The computer model is written in Fortran computer language and requires basic inputs in the following categories : (1) route location ; (2) road design standards ; (3) terrain information ; (4) properties of construction materials ; (5) construction unit costs ; (6) environmental factors ; (7) vehicle operation unit costs ; (8) traffic volumes ; (9) traffic composition ; (10) vehicle loads and equivalence factors ; (11) maintenance policy ; and (12) maintenance unit costs.

A typical run of the model will begin with the construction sub - model. For each year in which construction or reconstruction occurs, the sub -model calculates the quantities and thence the costs of earthwork, pavement, drainage, and site clearance. Having estimated construction costs, the deterioration of the road is estimated in relation to the initial construction specifications, the maintenance policy that is selected, and the rainfall and traffic flow. The sub -model for estimating vehicle performance uses the details of the road condition obtained from the deterioration sub -model together with details of the geometry of the road to predict vehicle speeds of each type of vehicle. Fuel consumption, tyre wear, vehicle maintenance and depreciation costs are then calculated and are used in conjunction with traffic forecasts to give the total vehicle operating costs for the year in question. Road maintenance costs also depend upon the condition of the road so these maintenance costs are estimated by the model for each year of the analysis period.

The costs calculated for each year of the analysis period are discounted back to the year zero at a discount rate specified by the user. The total costs, obtained from the sum of these discounted costs, are then printed out. The model can readily calculate the total costs in this way for a large number of alternative schemes and therefore enable selection of the lowest cost scheme. However, should the lowest cost not be the main criterion of interest to the user, the model can provides outputs on road maintenance requirements, the amount of foreign exchange needed, average market prices of transport operations, any many other areas of specific interest.

An important characteristic of the model is that all estimates are made in terms of physical quantities. Costs are obtained by applying unit rates to these quantities. For example, petrol consumption is measured in liters per 1000 km, and this is multiplied by the cost per liter to obtain the cost of the petrol consumed per 1000 km. The model can thus be used for any monetary system and for varying the cost of any parameter.

The model has an additional facility which enables an examination of the economics of different stage construction procedures. Many options are available : upgrading an earth road to a gravel or paved road on an existing alignment, or on a new alignment; widening a road; providing a pavement overlay, or complete reconstruction. At the end of each year, the road condition and the traffic volume are compared with the values set by the user as being those at which upgrading or reconstruction should take place. If the limiting conditions which were specified are exceeded, these operations are costed, and the condition of the new road is determined before the model continues with the year-by-year analysis.

Individual sub-models can be used separately. For example, the construction sub-model can be used to estimate costs and quantities for various projects, and the deterioration and vehicle performance sub-models can be used to determine the deterioration and vehicle operating costs on an existing road.

The model is extremely flexible and with little effort can be used to investigate a large number of routes, maintenance programmes, stage construction options, or combinations of these, which would otherwise be extremely time-consuming and costly to perform.

Limitations of the Model

The point has been made that the model does not take account of secondary benfits. There are, in addition, several minor limitations of which the user should be aware. There are discussed below.

(a) Kenya data : Most of the relationships have been derived from field work in Kenya. Before using the model in a different environment, the user should study the data employed to derive the model's internal relationships to ensure that : (1) the intended relationships are within the range of the Kenya data, (ie, extrapolation of the data is not occurring), and (2) the environment in which the model is to be used is similar to that of Kenya.

(b) Minimizing total cost : As stated earlier, the model calculates the total transport costs for each of the alternative proposals and thus, in its simplest form, is used to select the best option from a number of alternative solutions. It is important to realise that the minimum cost solution is valid only when the estimated demands are identical for all alternatives. If the number of vehicles on a particular alignment is predicted to be less than that for another alternative, then minimizing the total cost may be an inappropriate method of choosing the best solution. However, the output from the model is divided into construction, maintenance, and vehicle operating costs and these can be studied independently to select the best alternative in the solution. Using the same breakdown of total cost, the model can easily be used to rank schemes in order of priority.

(c) Optimization of alignment : If a vertical alignment has been previously developed by external means, these data can be fed to the model as inputs. If no vertical alignment is available the model utilizes a sub-model Venus II (ROBINSON, 1972) to provide a vertical alignment. This alignment is subjected to constraints of design speed (which fixes minimum acceptable length of curve), minimum length of curve, radius of vertical curves (different values for sags and for summits), maximum gradient, and absence of overlap of vertical curves. The objective function of the Venus II submodel is to minimize the sum of center-line cuts and fills, subject to the stated constraints.

(d) Road networks : In the form tested in the present research, the model investigates the cost of an individual road link. It is not possible to use the model to investigate road networks, although the network can be broken down into individual links and these can be summed to give some measure of network effects.

(e) Prediction of traffic growth : It is necessary for the model user to supply information on the expected growth in traffic and to estimate the additional traffic which might use the road as a result of major improvements (ie, the induced traffic).

Computer Requirements

The program is written in NCC standard Fortran and consists of about 10,000 statement cards. It was developed on the ICL 4/70 computer at the Transport and Road Research Laboratory in the U.K. requires about 140,000 bytes of storage when program segments are overlaid. The program usually runs with two peripherals -- a card reader and a line printer -- but if the stage construction options within the model are used, a slow sequential storage device is needed in addition. The running time of the program is only a few seconds but this is increased whenever a stage construction option is used.

Structure of the Model

The model can be divided in three sub-models (Fig.2.). These are : (1) construction costs ; (2) deterioration of the road and the attendant road user costs ; and (3) road maintenance costs.

All these sub-models are used whenever a complete analysis of a road project is required and whenever a stage construction policy is examined. The construction sub-model can be used on its own to determine the cost of building a new road. In addition, the deterioration sub-model and the maintenance sub-model can be used to predict the performance of an existing road . In this case, the construction sub-model is also used, but the cost of all the construction operations must be set equal to zero.

Three levels of output can be obtained from the model. There are : (1) total costs of operation ; (2) detailed costs of operations and total quantities ; and (3) detailed costs of operations and detailed quantities. Any of these levels of output can be specified for each of the following calculations of costs and quantities : (1) construction and reconstruction ; (2) deterioration and maintenance ; and (3) vehicle operation.