Chapter II

THE RTIM COMPUTER MODEL

Structure of the Model

The program of the RTIM Model is written in FORTRAN IV which is a computer language that can be transferred amongst a large number of different computers. It was developed on the ICL 4/70 computer at the Transport and Road Research Laboratory. The total size of the program is about 229-k bytes and consists of 10,190 statement cards. The program is written in the following five sections:

Root segment	:	main program control and service routines;
Segment 1	:	input of alignment and construction details;
Segment 2	:	calculation of construction costs;
Segment 3	:	input of vehicle and road maintenance data;
Segment 4	:	year-by-year analysis and determination of road user and maintenance costs.

Description of the Model

The Model consists of three sub-models which are the construction sub-model, the road deterioration and road user sub-model, and the maintenance sub-model. Whenever a complete analysis of a road project is required, and whenever a stage construction policy is examined, all the sub-models are used. The Model makes all estimates in terms of physical quantities and calculates the cost by applying unit rates to them, so it can be used with any monetary system. A typical run of the Model begins with construction. For each year in which construction or reconstruction occurs, the Model calculates the quantities and thus the costs of earthworks, pavement, drainage and site clearance. Then it estimates the deterioration of the road which is a function of the initial construction specification, the maintenance policy selected, the rainfall and the traffic flow. Having predicted the conditions of the road, the Model estimates the vehicle performance by using details of the road condition together with details of the geometry of the road to predict vehicle speeds for each type of vehicle. Fuel consumption, tyre wear, vehicle maintenance and vehicle depreciation costs are then calculated; these costs used in conjunction with traffic forecasts to give the total vehicle operating costs for the analysis year. Journey times are found from the route length and the speed of vehicles and these are used to cost passenger or cargo time. Road maintenance costs are estimated for each year of the analysis period depending on the condition of the road. If the user specifies that stage construction, upgrading, or reconstruction be examined, the Model will compare the road condition and the traffic volumes with the values set by the user itself. If required, these operations of stage construction are costed and the Model will specify the condition of the upgraded or new road and continue with its year-by-year analysis. The costs calculated for each year of the analysis period are then discounted back to the base year at the discount rate specified by the user, and total costs can be obtained by summing these discounted costs. The Model is flexible that each sub-model can be used separately, for example: to estimate construction quantities and costs for a new route without calculating vehicle operating and road maintenance costs or to look at the road deterioration, road user cost and road maintenance cost of an existing road with no construction costs.

Introduction to Input

Data are input to the Model on cards punched in fixed format. Numerical information is generally input in fixed fields of ten columns width and should be punched with a decimal point to reduce the possibility of errors. Textual information is usually required to be punched in a certain fixed field and columns 71-80 are always left free for the user to punch his own identifier. The program will terminate if there are errors in the input data caused by the user. Metric units are used throughout the Model and other units are used according to the detailed data requirements. A summary of data required by the Model is shown in Table 1.

Table 1 Summary of Input Data Required by the Model

Card type	
	Basic Run Data
1.1	Run identifier
1.2	Job identifier
1.3	Output options
1.4	Currency
1.5	Economic data
	Alignment Data
2.1	Horizontal alignment
2.2	Vertical alignment
2.6	Geometric design standards
	Construction Data
3.1	Ground data
3.3	Road cross-section
3.5	Soil characteristics
3.6	Cost of earthworks excavation and loading
3.7	Cost of earthworks spreading and compaction
3.8	Cost of earthworks haulage
3.9	Cost of earthworks borrow
3.10	Cost of earthworks spoil
3.11	Slope stability
3.12	Retaining wall dimensions
3.13	Cost of retaining walls
3.14	Ground cover
3.15	Clearance costs
3.16	Pavement type
	EITHER
3.17	Earth pavement
	OR
3.18	Gravel pavement
3.19	Gravel paving costs
3.20	Gravel shoulders
3.21	Gravel shoulder costs
	OR
3.22	Paved road
3.23	Pavement layer
3.24	Pavement layer costs
3.25	Paved road shoulders
3.26	Paved shoulder layer
3.27	Paved shoulder layer costs
3.28	Paved road base drainage

Table 1 Summary of Input Data Required by the Model (Continued)

Card type	Construction Data (Continued)
3.29	Cost of grips
	THEN
3.30	Rainfall
3.31	Culverts
3.32	Cost of pipes
3.34	Extension beyond shoulder
3.35	Cost of headwalls
3.36	Crossflow drains
3.37	Minor river crossings
3.39	Major river crossings
3.40	Miscellaneous costs
3.41	Overheads and supervision costs
3.42	Foreign exchange component of construction
3.43	Construction time
	Vehicle Operation Data
4.1	Interest rate on capital
4.2	Market prices (fuels, etc)
4.3	Economic prices (fuels, etc)
4.4	Vehicle types
4.5	Vehicle description
4.6	Power and weight
4.7	Market prices (vehicles, etc)
4.8	Economic prices (vehicles, etc)
	EITHER
4.9	Traffic growth
	OR
4.10	Annual traffic
	THEN
4.12	Foreign exchange component of vehicle operating cost
	Road Maintenance Data
5.1	Road surface condition
5.2	Plant hire rates
5.3	Labour rates
5.4	Costs of materials
5.5	Transport distances
5.6	Maintenance package
5.10	Grading or surface dressing frequencies
5.11	Overlaying

Table 1 Summary of Input Data Required by the Model (Continued)

Card type	Road Maintenance Data (Continued)
5.12	Pavement type switch
5.13	Overlay material
5.14	Overlay costs
5.15	Overheads and supervision
5.16	Foreign exchange component of maintenance
	Stage Construction
6.1	Strategy heading
6.2	Upgrading switches
6.3	Revised output options
6.4	Revised vertical alignment
6.8	Geometric design standards
6.9	Revised road cross-section
6.11	Revised cost of earthworks excavation and loading
6.12	Revised cost of earthworks spreading and compaction
6.13	Revised cost of earthworks haulage
6.14	Revised cost of earthworks borrow
6.15	Revised cost of earthworks spoil
6.16	New pavement layers
	EITHER
6.17	Earth pavement
	OR
6.18	Gravel pavement
6.19	Gravel paving costs
6.20	Gravel shoulders
6.21	Gravel shoulder costs
	OR
6.22	Paved road
6.23	Pavement layer
6.24	Pavement layer costs
6.25	Paved road shoulders
6.26	Paved shoulder layer
6.27	Paved shoulder layer costs
	OR
6.28	Induced traffic
6.29	Maintenance package
6.33	Grading or surface dressing frequencies
6.34	End of stage construction strategy
6.35	End of all stage construction strategies

Introduction to Output

The Model enables the user to choose the level of output specified on card type 1.3 for construction, deterioration and maintenance, and vehicle operation. Output from the Model is shown in five sections:

1) Echo-print and interpretation of alignment and construction input data,
2) Construction costing,
3) Echo-print and interpretation of vehicle and maintenance input data
4) Year-by-year analysis of road deterioration, road user and road maintenance costs,
5) Total construction, maintenance and road user costs.

During execution of the program, there are three types of message which may be output. The first type comprises informative messages used to print out certain data inputs, the second type are warning messages where it is suspected that an error has occurred which is not serious enough to terminate execution of the program, the third type of message would be shown if there are errors in the input data and cause immediate termination of the program.

Limitations of the Model

Most of the relationships used in the RTIM Model are derived from field work in Kenya which is typical of developing countries. The user should be aware of the environment in which the Model is to be used, it should be similar to that of Kenya. The Model can calculate the road costs for any project. It cannot compare and select the best option from a number of alternative routes, but it supplies the information for the user to make such a decision. So, in its simplest form, the Model could be used as a tool to determine the minimum total cost of transport from a set of alternative road investments. The Model can generate its own vertical alignment, but will not ensure this to be an optimum alignment. The Model was not developed to take into account the costs or benefits arising from agricultural production, neither can it take account of secondary economic effects or social benefits. The Model cannot investigate road networks, unless the networks are broken down into individual links. In addition to the several minor limitations already stated, there are limitations on the number of variables and on the problem size in the Model as shown in Table 2.

Table 2 Limitations on Parameters and Conditions of Application of the Model

Basic Run Data	Minimum	Maximum
Analysis period, duration (years)	1	24
Construction period, duration (years)	0	4
Projects or schemes, number that can be considered with one program run	1	unlimited
Stage construction strategies, number that can be considered within one project or scheme	0	unlimited
Alignment Data		
Altitude (m)	0	2,500
Fall: mean on paved roads (m/km) mean on unpaved roads (m/km)	0 0	85 80
Horizontal alignment, average degree of curvature: on paved roads (degrees/km) on unpaved roads (degrees/km)	 0 0	 200 250
Intersection points, vertical alignment	3	50
Vertical curves	1	48
Construction Data		
Culvert sizes, number of	1	5
Dry season, duration (months)	1	11
Ground cross-sections, number of	2	500
Ground cross-sections, spacing of (m)	1	120
Layers, number of pavement or shoulder: earth gravel paved	 0 1 1	 0 1 6
Minor river crossings, number of	0	10
Rainfall, annual (mm)	400	2,000
Road closure, annual (days)	0	364
Vegetation types, number of	1	5
Wet season, duration (months)	1	11

Table 2 Limitations on Parameters and Conditions of Application of the Model (Continued)

Vehicle Operation Data	Minimum	Maximum
Axle loading:		
'S'-type roads (10^6 of std.axles)	0	2.5
'P'-type roads (10^6 of std.axles)	0	5.0
Fuel consumption (litres/1000 km)	3	unlimited
Gross vehicle weight:		
light commercial (tonnes)	0	2.5
heavy commercial (tonnes)	3.5	40
Power to weight ratio (bhp/tonne)	5	40
Speed: (km/h)		
buses on paved roads	5	100
on unpaved roads	5	90
cars on paved roads	20	140
on unpaved roads	20	110
heavy commercial vehicles,		
on paved roads	5	100
on unpaved roads	5	90
light commercial vehicles,		
on paved roads	10	110
on unpaved roads	10	100
Vehicle age: (km)		
buses	0	$1{,}110\times10^3$
cars and light commercials	0	160×10^3
heavy commercials	0	400×10^3
Vehicle flow (pcu/day)	0	3,000
Road Condition		
Looseness, unpaved roads (mm)	0	20
Moisture content, unpaved roads (%)	0	30
Roughness, paved roads (mm/km)	1,500	4,000
unpaved roads (mm/km)	2,000	14,000
Rut depth, paved roads (mm)	0	25
unpaved roads (mm)	0	75