A11 Congested networks and induced traffic

A11.1 Introduction

Introduction

This appendix provides guidance on the evaluation of congested networks and induced traffic effects

In this appendix

This appendix contains the following topics:

A11.2 Applying growth constraint techniques

When to use

Growth constraint techniques are to be considered where high levels of congestion apply in the do minimum network and/or where a stable network representation in which supply and demand are in broad equilibrium cannot be achieved.

Growth constraint techniques constrain traffic growth in peak period matrices in highly congested conditions. With fixed trip matrix methods, the adjusted matrix is used for both the do minimum and project option.

General guidance

Any one of the procedures listed below are available for traffic growth constraint, however it is advised that the shadow network technique be used with caution.

Peak spreading may be used on its own, or with any of the other procedures detailed here.

Procedure

Having decided that there is insufficient capacity in the do minimum to carry the forecast travel demands, and that a realistic forecast of the future scenario requires the use of a matrix growth constraint technique, follow the steps below to apply growth constraint to the trip matrix.

<table>
<tr><th>Step</th><th colspan="2">Action</th></tr>
<tr><td>1</td><td colspan="2">Determine whether to consider peak spreading (appendix A3.20). If so, apply peak spreading to modify the matrix and peak period (appendix A11.3).

If the matrix results in a realistic assignment to the do minimum network, no further capping need be considered. Otherwise go to step 2.</td></tr>
<tr><td rowspan="8">2</td><td colspan="2">Select an appropriate method to cap the matrix:</td></tr>
<tr><th>Selected method</th><th>Go to</th></tr>
<tr><td>Matrix scaling</td><td>Appendix A11.4</td></tr>
<tr><td>Incremental matrix capping</td><td>Appendix A11.5</td></tr>
<tr><td>Shadow network</td><td>Appendix A11.6</td></tr>
<tr><td>Elasticity methods (FTM)</td><td>Appendix A11.7</td></tr>
<tr><td>Demand models (FTM)</td><td>Appendix A11.8</td></tr>
<tr><td colspan="2">Automated growth constraint methods, such as the ME2 matrix capping technique contained in the SATURN modelling package, may also be used.</td></tr>
</table>

A11.3 Applying peak spreading

When to use	Peak spreading procedures may be used to spread traffic from the busiest part of the peak period to the peak shoulders.
General guidance	At present, there are no universally established procedures for peak spreading. Discretion is recommended in developing a peak spreading method, but ensure that the resulting retiming of trips is reasonable. As a general guide, the following points should be kept in mind: • Decide whether to apply peak spreading uniformly or only to specific parts of the trip matrix. This decision will largely depend on the extent of congestion in the network. • Unless evidence suggests otherwise, it is recommended that the transfer of trips from the peak to interpeak or off-peak periods be not more than 5% of the total peak period traffic. • If appropriate, the traffic profile during the peak period may be adjusted, but it is advisable that the reduction of the peak traffic intensity be no more than 10%. • It is recommended that information on local traffic profiles and trends in traffic growth for different time periods, such as peak shoulder and business periods, be sought to support assumptions.
Checking reasonableness	Checks for the reasonableness of peak spreading outcomes are given in appendix A11.13.

A11.4 Applying the matrix scaling method

When to use

Matrix scaling procedures may be used to constrain growth in the trip matrix. If congestion is widespread, the entire matrix may be scaled or, if congestion is confined to a particular area, only the corresponding sections of the matrix need be scaled.

General guidance

The final levels of congestion in the network due to the capped matrix should be sensible. When capping the matrix with this procedure only cap the matrix as much as needed. Excess capping will reduce computed project benefits unnecessarily.

Procedure

Follow the steps below to apply matrix scaling.

Step	Action
1	Choose a scaling factor to reduce congestion to acceptable levels in affected parts of the do minimum network. As a general guide, link saturation ratios should be less than 1.1 after the new matrix is assigned. Unless evidence suggests otherwise, the scaling factor would typically be between 0.95 and 1.0 for scaling of the entire matrix, or between 0.9 and 1.0 for scaling of selected sections of the matrix. See also: Computing the volume to capacity ratio in appendix A3.17.
2	Multiply the chosen elements of the matrix by the scaling factor. This matrix will be used with the do minimum and project options.
3	Assign the matrix to the network

A11.5 Applying the incremental matrix capping method

When to use

The incremental matrix capping method may be used to constrain growth in selected cells of the matrix. This method is also known as the 'incremental loading' method, but should not be confused with incremental assignment techniques

Summary of method

In the incremental matrix capping method, choose a series of forecast year matrices and assign these to the do minimum network in chronological order. Once an assignment results in average journey speeds dropping below acceptable limits for a matrix cell (or group of cells), further traffic growth is prevented in the affected cells as later matrices are applied.

This process effectively restricts the growth rate in selected matrix cells to levels corresponding to some earlier year (at which an acceptably realistic traffic assignment could be obtained).

Procedure

Follow the steps below to apply incremental matrix capping.

Step	Action
1	Choose a series of forecast years (say, at 5 year intervals) and generate initial forecast matrices for each of these years.
2	Select minimum allowable overall journey speeds for each origin-destination pair. As a guide, minimum speeds will be in the range 15–25 km/h, depending on the quality of the route and the trip length.
3	Assign the first forecast-year matrix to the do minimum network.
4	Update each matrix cell for the next future year, except those where the speed for the origin-destination pair (obtained from the assignment run) has fallen below the minimum allowable speed. Assign the new matrix to the do minimum network.
5	Repeat step 4 until all future years have been assigned.

A11.6 Applying the shadow network method

When to use

The shadow network method may be used to provide location-specific capping for a trip matrix.

General guidance

The shadow network technique should be used with care. It may take more effort to implement and may risk counter-intuitive results (for example, negative growth in some parts of the matrix).

Procedure

Follow the steps below to apply the shadow network technique.

Step	Action
1	Construct a duplicate 'shadow' network and connect it to the 'real' network at the zone centroids.
2	Select minimum allowable speeds for the links of the shadow network. The choice of this speed will affect the number of trips that are suppressed. As a general guide, minimum speeds will be in the vicinity of 15 km/h for links of average length (On very short road links, junction delays may realistically lead to very low overall link speeds.), but this limit may be varied to suit the particular network context.
3	Assign the matrix to the dual network.
4	Check the results and readjust the shadow network speeds if the results are unreasonable. If the speeds are changed, repeat steps 3 and 4.
5	The real network will now contain normal trips and the shadow network trips considered to be suppressed. To obtain a matrix for economic evaluation, cordon off the matrix assigned to the real network.

A11.7 Applying elasticity methods (FTM)

When to use

Fixed trip matrix (FTM) elasticity methods may be used to constrain growth in the trip matrix. As with other fixed trip methods, the matrix produced by an FTM elasticity approach will be used for the do minimum and project options.

Description

Elasticity methods are based on the principle that the demand for travel between two zones varies according to the cost of travel between the zones. An elasticity method iteratively adjusts the trip matrix by assigning it to the network, measuring the change in costs between the assignment and a reference case, then adjusting the demand according to the cost change.

The inputs to an elasticity approach are:

- A pivot travel cost matrix from which changes in cost are measured. This is derived by assigning the appropriate trip matrix to the network.
- An initial estimate of the do minimum matrix for the forecast year. This will usually be derived either using a growth factor applied to a base matrix or from an external strategic model.
- An elasticity parameter that specifies the sensitivity of travel demand with respect to travel cost.
- An elasticity formulation that expresses the necessary adjustment to the trip matrix as a result of cost changes.

The pivot matrix and network will commonly be those for the base year. But it would be equally appropriate to use the project opening year (if the network was expected to be relatively uncongested at that time) as a pivot for forecasting trip matrices for later years in the project's economic life.

Procedure

Follow the steps below to apply elasticity methods:

Step	Action
1	Assign the trip matrix from the base year to the base network. Obtain a pivot travel cost matrix from the assignment results (c_{ij}^{P}).
2	Take an initial estimate (using suitable prediction methods) of the forecast year matrix T_{ij}^{F} and assign it to the appropriate do minimum network. Obtain an initial cost matrix c_{ij}^{1} from the assignment results.

A11.7 Applying elasticity methods (FTM), continued

Procedure, continued

Step	Action
3	Derive a new matrix T_{ij}^{1} by adjusting each cell in the matrix T_{ij}^{F} according to an elasticity formulation. The power formula is advised for this purpose as follows: $$T_{ij}^{1} = T_{ij}^{F}\left(\frac{c_{ij}^{1}}{c_{ij}^{P}}\right)^{E}$$ Where: T_{ij}^{1} = adjusted number of trips between origin *i* and destination *j* T_{ij}^{F} = initial estimate of the number of trips between *i* and *j* c_{ij}^{1} = forecast journey cost (or time) between *i* and *j* c_{ij}^{P} = pivot journey cost (or time) between *i* and *j* *E* = elasticity of demand with respect to journey cost (or time). Note that the elasticity, *E*, will be negative. Convergence may be assisted by using a damping process, and taking the average of the matrices produced by the two previous iterations: ie, replace T_{ij}^{1} by $½\left[T_{ij}^{F} + T_{ij}^{1}\right]$
4	Assign the new matrix T_{ij}^{1} to the network, producing a new cost c_{ij}^{2} matrix. Ensure that the assignment converges satisfactorily.
5	Using the power formula, compute a new trip matrix T_{ij}^{2} equal to: $$T_{ij}^{2} = T_{ij}^{F}\left(\frac{c_{ij}^{2}}{c_{ij}^{P}}\right)^{E}$$ Damp as required, by replacing T_{ij}^{2} by $½\left[T_{ij}^{1} + T_{ij}^{2}\right]$.
6	Repeat steps 4 and 5 until the process converges, that is, trip and cost matrices produced on successive iterations are sufficiently similar.

The final matrix produced by the elasticity formulation must reasonably represent the demand. It may be appropriate to exclude some matrix cells from the elasticity adjustments - for example, those that exhibit negative growth (generally it is undesirable to have cases where traffic volumes between an origin and destination pair decrease between successive forecast years), unreasonably high growth or those that represent external trips.

A11.7 Applying elasticity methods (FTM), continued

Elasticities

Elasticities used with an elasticity method must be consistent with the travel costs used in the elasticity formula. For example, if c_{ij}^{n} and c_{ij}^{p} are expressed as journey times, then the elasticity, *E*, should be specified with respect to journey time.

The successful application of elasticity methods depends on elasticities being available for the model's study area and the transport model being able to model travel costs realistically. Values below, derived from UK research may be used.

Period	Journey time elasticity
Peak period	-0.20
Peak hour	-0.33 (includes peak spreading)
Off peak	-0.24

The suggested elasticities correspond to the long-run low modal competition values derived from UK research. In part, they derive from data on the effects of fuel prices on traffic levels, for which there is some evidence of comparability between the UK and New Zealand contexts.

These elasticities could be increased by 25% in corridors to major city central business districts where public transport has a significant modal share.

If it is more convenient to use generalised costs extracted from the model than journey times, then an equivalent generalised cost elasticity can be calculated. If the model assigns on the basis of a generalised cost of $t + k.d$ then the equivalent generalised cost elasticity is obtained by multiplying the journey time elasticities by the factor (1 + $k.v$), where v is average study area journey speed (in units of kilometres per minute).

If the model generalised cost is $t + k.c$, where c is some perceived operating cost, then the equivalent generalised cost elasticity is obtained by multiplying the journey time elasticities by (1 + $k.\rho$) where ρ is the average perceived operating cost per minute for the study area.

A11.8 Applying demand models (FTM)

When to use	Demand models are commonly used to derive matrices or matrix growth factors that are sensitive to road network journey times.
Description	Demand models refer to one or more of the standard generation, distribution and mode split models handled by most proprietary transport modelling packages or custom-built spreadsheet models. In Auckland, Wellington and Christchurch, demand models are commonly used to generate matrices within more general strategic models. Some project models are also capable of modelling variable travel demands (for example by using trip distribution models).
Procedure	The forecast matrices derived from city strategic models are modified appropriately for the local project model and used in standard FTM project evaluation procedures. Project demand models can be applied in a similar way to elasticity methods (see appendix A11.7) using the demand model to adjust the trip matrix, rather than an elasticity formulation. In both options, the resulting matrix should be a reasonable representation of demand, and the demand models should be properly validated (see worksheet 8.5).

A11.9 Applying variable trip matrix techniques

When to use

Variable trip matrix (VTM) techniques should be used to model the effects of induced traffic where high levels of congestion are expected in both or either the do minimum or project option networks. Variable matrix methods differ from conventional fixed trip matrix techniques in that demand in the project option matrix is generally higher than that in the do minimum matrix for a given forecast year. VTM methods also require more complex procedures to evaluate net project benefits than fixed matrix methods.

VTM methods may not be necessary if induced traffic is expected to have similar effects on the economic performance of each project option being compared. If this exceptional case is considered to apply, advice should be sought from Land Transport NZ or Transit NZ as to whether VTM methods should be used.

General guidance

The purpose of variable matrix methods is to provide estimates of the effects of a project on travel patterns (that is, the difference between the do minimum and project option matrices) and on the benefits of the scheme. Because these effects may be small and the estimates should be unbiased, methods relying heavily on professional judgement (such as many of the growth constraint techniques) are inappropriate. Two variable matrix methods based on analytical techniques are recommended: elasticity methods and demand models.

The options are:

(a) using these methods consistently for both the do minimum and project option matrices or

(b) using growth constraint methods to establish the do minimum matrix and variable matrix methods for estimating the effect of the project option on the trip matrix (as an adjustment to the do minimum).

For demand modelling approaches, where the source of data is a strategic city model, it may be considered unlikely that the strategic model will have sufficient sensitivity to measure the impact on the trip matrix of a single scheme, and the use of such models will therefore generally not be feasible. Elasticity methods are therefore likely to be needed to supplement the strategic model.

For project demand models, it is likely that these would generally be applied consistently for the do minimum and project option matrices.

Whatever method is applied, its results should be verified by comparison with an FTM evaluation based on the do minimum trip matrix.

A11.9 Applying variable trip matrix techniques, continued

Procedure

Having decided that congestion will be significant in both the do minimum and project option for a forecast year, follow the steps below to apply variable matrix methods.

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>1</td><td>Select an appropriate method to adjust the do minimum and project option matrices:
<table>
<tr><th>Method</th><th>Description</th><th>Go to</th></tr>
<tr><td>A</td><td>Use elasticity methods for both the do minimum and project option matrices.</td><td>Appendix A11.10</td></tr>
<tr><td>B</td><td>Use other growth constraint techniques (appendix A11.2) for the do minimum matrix and elasticity techniques to estimate the effects of the project option on the trip matrix.</td><td>Appendix A11.10</td></tr>
<tr><td>C</td><td>Use the project demand model for both the do minimum and project option matrices.</td><td>Appendix A11.11</td></tr>
</table>
Alternatively, use a fixed matrix approach, then apply a predetermined correction factor to adjust benefits for variable matrix effects.

Note that project benefits will need to be calculated using a consumer surplus evaluation and reported in worksheet 3.</td></tr>
<tr><td>2</td><td>Conduct a fixed matrix analysis (see appendix A11.2) and compare the results with those obtained from the variable matrix analysis.</td></tr>
</table>

A11.10 Applying elasticity methods (VTM)

When to use

Variable trip matrix (VTM) elasticity methods are referenced in appendix A11.9 (methods A and B). The two recommended applications are:

(a) where the do minimum and project option matrices are both estimated using elasticity methods, or

(b) where the do minimum matrix is first established using growth constraint techniques and elasticity methods are used to estimate the effect on this matrix of the project option.

Description

Elasticity methods are based on the principle that the demand for travel between two zones varies according to the cost of travel between the zones. An elasticity method iteratively adjusts a trip matrix by assigning it to the network, measuring the change in costs between the assignment and a reference case, then adjusting the demand according to the cost change.

The inputs to an elasticity approach are:

- A pivot travel cost matrix from which changes in cost are measured. This is generally derived by assigning the appropriate matrix to the network;
- An initial estimate of the trip matrix for the forecast year;
- An elasticity parameter that specifies the sensitivity of travel demand with respect to travel cost.
- An elasticity formulation that expresses the necessary adjustment to the trip matrix as a result of cost changes.

In appendix A11.7 there is a full description of elasticity methods, emphasising the estimation of the do minimum matrix. The process is illustrated using the base matrix and network as the pivot point, and the unconstrained forecast matrix (produced by growth factor techniques or an external model) as the initial matrix estimate.

Method A procedure

For method A, the processes described in appendix A11.7 are applied separately but consistently for the do minimum and project option matrices. For example, if the method is pivoted on the base year matrices, then steps 1-6 in procedure A11.7 are applied first using the do minimum network (in step 2 for c'_{ij} and subsequent steps) and then repeated using the project option network (in step 2 for c'_{ij} and subsequent steps).

A11.10 Applying elasticity methods (VTM), continued

Method B procedure

Step	Action
1	Assign the do minimum matrix to the do minimum network for the relevant forecast year. Obtain a pivot travel cost matrix from the assignment results (c_{ij}^{P}).
2	Use the do minimum matrix as the initial estimate of the forecast year matrix T_{ij}^{F} and assign it to the project option network. Obtain an initial cost matrix c_{ij}^{1} from the assignment results.
3	Derive a new matrix T_{ij}^{1} by adjusting each cell in the matrix T_{ij}^{F} according to an elasticity formulation. The power formula is advised for this purpose as follows: $$T_{ij}^{1} = T_{ij}^{F}\left(\frac{c_{ij}^{1}}{c_{ij}^{P}}\right)^{E}$$ where: T_{ij}^{1} = adjusted number of trips between origin *i* and destination *j* T_{ij}^{F} = initial estimate of the number of trips between *i* and *j* c_{ij}^{1} = forecast journey cost (or time) between *i* and *j* c_{ij}^{P} = pivot journey cost (or time) between *i* and *j* E = elasticity of demand with respect to journey cost (or time). Note that the elasticity, *E*, will be negative. Convergence may be assisted by using a damping process, and taking the average of the matrices produced by the two previous iterations: ie, replace T_{ij}^{1} by $\frac{1}{2}\left[T_{ij}^{F} + T_{ij}^{1}\right]$.
4	Assign the new matrix T_{ij}^{1} to the project option network, producing a new cost matrix c_{ij}^{2}. Ensure the assignment converges satisfactorily.
5	Using the power formula, compute a new trip matrix equal to: $$T_{ij}^{2} = T_{ij}^{F}\left(\frac{c_{ij}^{2}}{c_{ij}^{P}}\right)^{E}$$ Damp as required, by replacing T_{ij}^{2} by $\frac{1}{2}\left[T_{ij}^{F} + T_{ij}^{2}\right]$.

A11.10 Applying elasticity methods (VTM), continued

Method B procedure, continued	Automated application of elasticity methods (for example SATURN's elastic assignment) may be used as an alternative to the manual method given above. For method B, the do minimum matrix may be determined using any of the growth constraint techniques in appendix A11.2. As for FTM elasticity methods, the final matrix produced by the elasticity formulation (in either methods A or B) should be a reasonable representation of demand. It may be appropriate to exclude some matrix cells from the elasticity adjustments - for example, those that exhibit negative growth, unreasonably high growth or those that represent external trips. The convergence requirements for VTM methods are, however, significantly more onerous: the stability and convergence requirements of the combined VTM/assignment procedures are the same as for the simpler FTM assignment-only procedures (see worksheet 8.4, part D).
Elasticities	Refer to appendix A11.7 for a discussion of suggested elasticities.

A11.11 Applying project demand models (VTM)

When to use

Variable trip matrix (VTM) project demand models may be used to estimate trip matrices differentiated between the do minimum and project option. As with other VTM approaches, these guidelines should be used only when high levels of congestion exist in both the do minimum and project options.

General guidance

Project demand models would usually be limited to trip distribution methods. Where considered appropriate, these models may be used to forecast scheme-induced traffic by estimating separate do minimum and project option matrices. In determining appropriateness, it would be necessary to demonstrate that the model could be reliably applied to the appraisal of individual schemes

In such cases variable trip matrix (VTM) evaluation procedures would be used. The stability and convergence requirements are the same as for VTM elasticity methods (appendix A11.10). The validation of such models is discussed in worksheet 8.5 part C.

A11.12 Conducting cost benefit analyses using variable matrix methods

When to use

Where significant amounts of induced traffic are expected as the result of a project, variable trip matrix (VTM) methods (refer appendix A11.9) may need to be applied. Variable matrix methods require more complex economic calculations than fixed trip matrix (FTM) methods in order to determine project benefits. This appendix gives advice on the calculations required, and shall be used as a guide to summarising the net benefits and costs of the project options in worksheet A11.3.

Background

For fixed matrix evaluations, the benefits are the change in resource costs between the do minimum network and the option. Where variable matrices are involved, the benefits of the additional journeys must be included. Since the decision to make additional journeys is based on the costs perceived by car users, the measure of the benefits is also based on perceived user costs, and is usually computed as the change in road user surplus. It is also necessary to include a correction term to compute the total social benefits, since road users do not take full account of the effects of their decisions on resource consumption. This additional term is often referred to as the resource cost correction.

The resulting formula for the net project benefit is computed for each cell of the matrix individually (for a given time period) and is:

$$\text{Benefit} = \underbrace{\tfrac{1}{2}\,(T_{OPT} + T_{DM}) \times (U_{DM} - U_{OPT})}_{\text{'change in road user surplus'}} + \underbrace{T_{OPT}\,(U_{OPT} - R_{OPT}) - T_{DM}}_{\text{'resource cost correction'}}$$

or, rearranging terms:

$$\text{Benefit} = \underbrace{(R_{DM}T_{DM} - R_{OPT}T_{OPT})}_{\text{'change in resource costs'}} + \underbrace{\tfrac{1}{2}\,(U_{DM} + U_{OPT}) \times (T_{OPT} - T_{DM})}_{\text{'adjustment for variable trip matrix'}}$$

Where:

T_{DM} = Number of trips in the do minimum.

T_{OPT} = Number of trips in the project option.

U_{DM} = User cost of travel in the do minimum.

U_{OPT} = User cost of travel in the project option.

R_{DM} = Resource cost of travel in the do minimum.

R_{OPT} = Resource cost of travel in the project option.

The implied subscripts i and j have been omitted for clarity.

For a fixed matrix evaluation when T_{DM} equals T_{OPT}, the second term is zero and this formula becomes the simple difference in resource costs (the first term in the formula). While this first term can be computed using matrix manipulations, it is standard practice to accumulate the resource costs over the network links and use network statistics to estimate total network-wide resource costs in both the do minimum (the term $R_{DM}\,T_{DM}$) and option (the term $R_{OPT}\,T_{OPT}$). This is termed a link-based evaluation.

A11.12 Conducting cost benefit analyses using variable matrix methods, continued

Background, continued

The values of time and vehicle costs given in the appendices are resource costs (which are the actual costs of travel excluding taxation and other non-resource costs). Estimate user costs directly from resource costs according to the table A11.1.

Table A11.1 Guidelines for estimating user time and vehicle operating costs

Cost component	Obtain resource costs from …	To derive the user cost …
Value of time (working)	Tables A4.1 – A4.4	User cost = resource cost
Value of time (non-working)	Tables A4.1 – A4.4	User cost = resource cost × 1.15
Vehicle operating cost (in urban networks):		
Tables and graphs of cost by average speed and gradient	Tables and figures A5.1 – A5.11	User cost = resource cost × 1.2
Tables and graphs of additional costs for roughness	Tables and figures A5.12 – A5.15	User cost = resource cost × 1.125
Tables of fuel costs due to bottleneck delay	Tables A5.16 – A5.23	User cost = resource cost × 2.0
Graphs of additional costs for speed change cycles	Figures A5.24 - A5.43	User cost = resource cost × 1.9

A11.12 Conducting cost benefit analyses using variable matrix methods, continued

Matrix-based computation

For a variable matrix evaluation, adopt either of the following two methods to accumulate the net benefits of project options:

(a) a matrix-based analysis, where an average cost is computed for each origin-destination pair; or

(b) a link-based analysis, where costs are computed separately for each link (or groups of links).

Choose the most convenient method for the software used.

Create the matrices of trips and costs required to compute the benefits as itemised in table A11.2.

Using matrix manipulations, compute the benefit matrix (for a single time period) using the formula:

For each *i,j* pair,

$$B_{ij} = \left(R_{ij}^{DM} T_{ij}^{DM} - R_{ij}^{OPT} T_{ij}^{OPT} \right) + ½ \left(U_{ij}^{DM} + U_{ij}^{OPT} \right) \text{x} \left(T_{ij}^{OPT} - T_{ij}^{DM} \right)$$

The total project benefit B is then given by the matrix total ($\Sigma_{ij} B_{ij}$) summed over all matrix cells. For use with this worksheet, the formula should be applied to travel time and vehicle operating costs only.

Table A11.2 Required cost and trip matrices

Data	Symbol	Comment
Trip matrices	T_{ij}^{DM}, T_{ij}^{OPT}	Available from the model
Resource and user cost matrices	R_{ij}^{DM}, R_{ij}^{OPT} U_{ij}^{DM}, U_{ij}^{OPT}	The constituent times and distances by link type are skimmed from the networks and the costs subsequently computed. The same paths (and link speeds) should be used for both resource and user costs. If in this process the precision of the representation of vehicle operating costs is much reduced, the link based method may be preferred.

A11.12 Conducting cost benefit analyses using variable matrix methods, continued

Link-based computation

Link-based computation of project benefits is currently standard practice with the change in resource costs determined by summing link benefits over the network but, as may be seen from the benefit formula, to the standard calculation of the change in resource costs should be added a variable matrix term. This can be calculated from overall network statistics, but requires some additional network processing, as follows.

First, the extra term can be expanded to 4 terms to read:

$$\tfrac{1}{2}\left[\underbrace{U_{OPT}T_{OPT}}_{\text{'I'}} - \underbrace{U_{DM}T_{DM}}_{\text{'II'}} + \underbrace{U_{DM}T_{OPT}}_{\text{'III'}} - \underbrace{U_{OPT}T_{DM}}_{\text{'IV'}}\right]$$

where each of these four terms (I-IV) may be computed from network statistics.

'I' This is the total user cost for the option network, and may be calculated in the same manner as the resource costs but using the cost weights in table A11.1.

'II' This is the total user cost for the do minimum network, and may be calculated in the same manner as the resource costs but using the cost weights in table A11.1.

Terms III and IV are unusual and require a particular network/assignment procedure called a 'crossload':

'III' This term uses the do minimum network, but the user costs must be weighted by the trips in the project option matrix; this is achieved by loading the project option matrix on the do minimum network keeping the paths and link speeds unchanged (that is, there are no speed or path-building iterations and the paths and speeds are those determined from assigning the do minimum matrix); network statistics are then extracted and processed using standard techniques.

'IV' this term uses the project option network, but the user costs must be weighted by the trips in the do minimum matrix; this is achieved by loading the do minimum matrix on the project option network keeping the paths and speeds unchanged; network statistics are then extracted and processed using standard techniques.

For the computation of variable matrix benefits using link-based evaluation, assignment software must be able to handle 'crossloads'.

Having summed items I - IV and halved the result to obtain the 'adjustment for variable trip matrix', then add the change in resource costs, ($R_{DM}T_{DM} - R_{OPT}T_{OPT}$) as described in the above. The result should be entered into item 5 on the worksheet. Note that for use with this worksheet, the road user surplus and resource cost formulas should be applied to travel time and vehicle operating costs only (other benefits are assumed to be unaffected by road user surplus issues). The remaining resource costs associated with accidents and vehicle emissions will be entered separately in items 6 and 7 on worksheet 3.

A11.13 Checking growth constraint or variable matrix methods

When to use

These checks are related to the procedures in appendix A3.3 and may be used to check the appropriateness of growth constraint or variable matrix methods for dealing with suppressed and induced traffic. The checks supplement the general model validation guidelines given in worksheet 8.

Suggested checks

Suggested checks include.

Method used	Suggested information
The capacity of the do minimum network was upgraded	• demonstration that the capital cost of do minimum improvements is less than 10-15% of the project option cost • indication of adequate capacity (see below).
A growth suppression technique was used (eg, matrix scaling, incremental matrix capping, shadow network, elasticity method on the do minimum)	• indication of adequate capacity (see below) • details on the size and location of the suppressed travel • evidence, where feasible, of network performance before and after growth suppression • details of the methodology applied.
Peak spreading was used	• evidence of current variations in peak proportions: (a) within the study area, in the base year and historically (b) between cities or across New Zealand. • based on this evidence, an indication that current traffic profiles in the study area are relatively peaked • forecasts of a decline in peak period speeds relative to the interpeak (because peak spreading is more likely to occur when peak speeds deteriorate faster than interpeak speeds).
A variable matrix technique was used (eg elasticity method on both the do minimum and project option)	• indication of adequate capacity • differences between the do minimum and project option matrices • evidence of the convergence of the method (ie, stable estimates of costs and matrices), or other evidence to justify reliance on forecasts (see worksheet 8.4, part D • details of the methodology applied.

A11.13 Checking growth constraint or variable matrix methods, continued

Checking capacity in the do minimum and project option

To check the do minimum and project option capacity, the following performance indices may be used. If the indices suggest congestion over large or significant parts of the network, judged on the basis of at least one hour of flow, then the network should be considered as congested. If, however, the congestion occurs only in the later years of the economic life of the scheme (which contribute very little to the BCR), these effects may be ignored where reasonable.

Performance indices	Indicator of significant congestion
Level of service.	Level of service E or F*.
Matrix feasibility.	Network model is unable to achieve a stable realistic assignment.
Plots of link volume to capacity ratios or manual calculation of the ratio (see appendix A3.17).	Ratios consistently higher than 1.0.
Link speed plots.	Speeds consistently below realistic values (15-25 km/h) for links of average length.
Junction delay statistics.	Delays consistently longer than 5 minutes per junction or queues 'blocking back' to upstream links.

* Level of service E occurs when traffic volumes are at or close to capacity, and there is virtually no freedom to select desired speeds or to manoeuvre within the traffic stream. Level of service F is in the zone of forced flow where the amount of traffic passing a point exceeds that which can pass it. Queuing, delays and flow breakdown occur at these flow levels. (Source: Austroads).