NETWORK MANAGEMENT NOTES

# Modelling Issues in a Period of Traffic Restraint

## Why Model?

Growing car use is causing congestion and environmental damage as roads are unable to cope with increasing volumes of traffic. There is thus increasing consideration of ways of restraining traffic. The evaluation of policies encompassing restraint through physical measures (eg, roadspace reallocation), integrated transport strategies and other initiatives needs the development and use of improved appraisal methodologies. Modelling is a key means of pre-implementation evaluation of such strategies, as long as the modelling process can predict the impacts adequately. This presents a significant challenge!

## How do we Model now?

Both fiscal restraint and restraint through traffic management affects the cost (time and money) of travel and brings about different routes through the network as a result. Since the cost (in time and money) of road travel has changed, the differential in travel cost between different modes of transport may also have changed and modal shift may have resulted. Similarly, there may be changes in destination as higher costs make closer destinations relatively more attractive. These basic responses can be addressed by the traditional 4-stage model transport model which incorporates the four separate stages of trip generation, trip distribution, modal split and assignment (see Fig 1).

The aim of the trip generation stage is to estimate the numbers of trips generated by each zone in the study area. The trips rates can be related to various household characteristics such as car ownership, size of household, or income, and to characteristics of the zonal area. The distribution model determines the destination zone of each trip. The modal choice model determines the mode used for each trip. Typically, such models have two levels, with choice between private and public transport at the higher level, and then between different public transport modes at the lower.

The final stage of the 4–stage process is assignment – the determination of routes through the network. It is commonly used on its own in the evaluation of highway infrastructure improvements, and is by far the most well known tool available

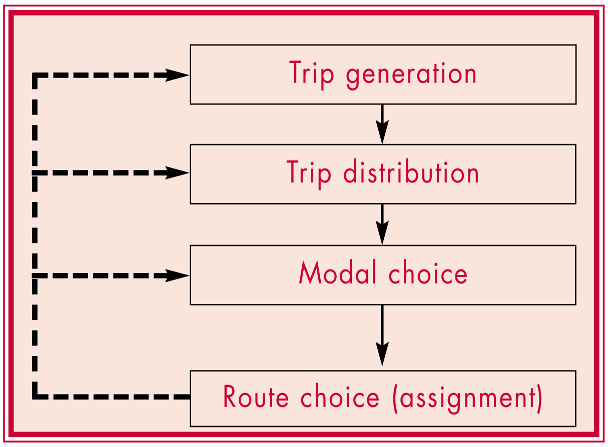


Fig 1: Four–stage transportation Model.

to the modeller, with a number of proprietary software packages being available. The more sophisticated of these include the provision for different assumptions about route choice, the impacts of flows on speeds, queuing, and fuel consumption. In particular, capacity restraint should be an essential feature in the assessment of restraint mechanisms such as user charging.

Until recently, most traffic modelling has adopted a “Fixed Trip Matrix” (FTM) modelling approach, where the new scheme under evaluation is assumed not to affect the number of trips between each Origin and Destination pair. However, schemes providing additional capacity (eg, new road schemes) can often generate (or “induce”) additional trips, as suppressed demand can be released when traffic conditions improve. This applies particularly to congested networks and requires a Variable Trip Matrix (VTM) evaluation. Procedures for this are now well established (Highways Agency, 1997)

Of particular interest here is the impact of traffic restraint on trip rates and traffic levels. New evidence has now been produced that traffic levels in a network often reduce after the implementation of highway capacity reductions (Cairns *et al*, 1998). A VTM approach is therefore also required to model traffic restraint measures and interim recommendations are now available for this process.

## What Models are currently available?

A large range of models are now available for the practitioner needing to evaluate traffic restraint and other policies. Table 1 summarises some of the more commonly used models in the UK, according to their general application area (transport planning, traffic assignment etc), the type of model (strategic, microscopic, etc) and distribution/contact details. It is stressed that this table is illustrative only.

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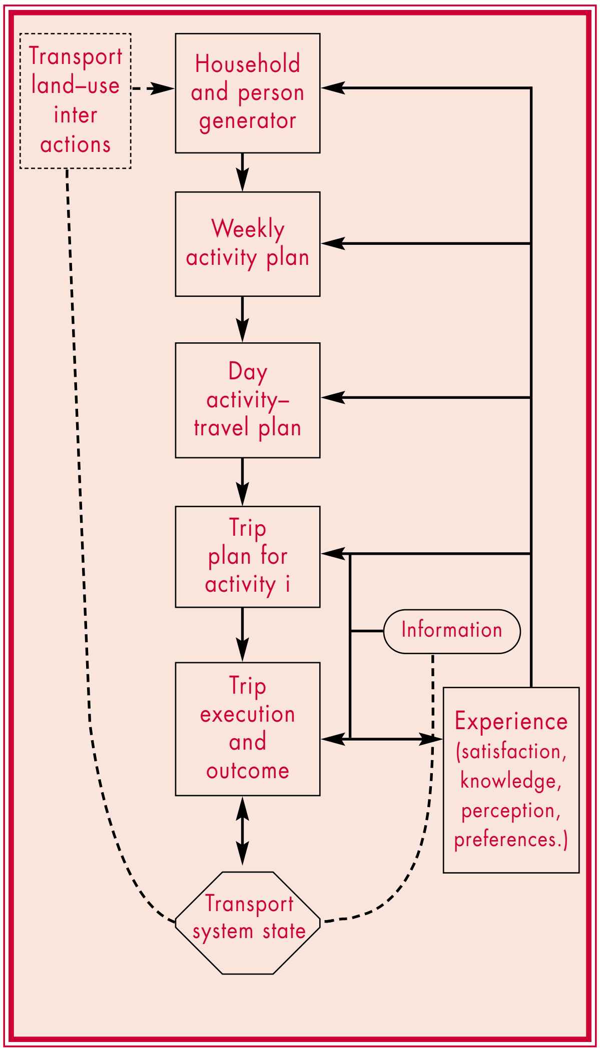


Fig 2: Possible Model Framework for ATT Assessment.

## What new Modelling capabilities do we need?

In response to the need to consider a wider range of policy mechanisms, including traffic restraint, the modelling of travel demand has had to incorporate other possible transport responses in addition to the traditional four responses above.

## Time dependent Modelling

Urban traffic models usually model a peak hour. In many of these models demand is assumed constant throughout the modelled period and trips propagate across the network as soon as they leave their origin. However, over a 16 or 24–hour period demand is obviously not constant - not only does the volume of demand change but the pattern of demand differs. Policies such as road user charging are likely to have a differential impact over the day, and one effect of the application of restraint in peak periods may be to push more traffic towards the shoulders of the peak and the off-peak (ie, “peak spreading”). Thus for an all day model to accurately address restraint issues, it is important to model this changing pattern of demand throughout the day.

The need for time dependent modelling suggests the need of a dynamic assignment approach. An urban peak–hour dynamic assignment model, such as CONTRAM (Table 1), will typically divide the hour up into shorter time slices, say 10 minutes, each with its own (departure time) trip matrix. Vehicles still on the network at the end of a time slice are carried through to the next. True dynamic assignment methods propagate traffic through the network according to journey time and most commercial software packages now include some form of dynamic assignment option, however simple. Dynamic assignment is currently an area of intense research with frequent publication of new ideas, partly as a result of its relevance to transport telematics applications where changes over short timescales have to be predicted e.g. responses to real-time traffic information provided by roadside or in–vehicle systems).

## Strategic Models

The traditional traffic model is often too cumbersome to test out a wide variety of possible policy instruments associated with transport demand management. More strategic models, such as START or STM, have been developed that seek to explore the overall long-term implications of policy and trend scenarios. These strategic models tend to have very simplified supply characteristics, such as area speed/flow curves, and relatively small numbers of zones. With the current interest in integrated transport packages the use of strategic models to address wide–ranging issues is growing. These generally have limited network representation and therefore often do not adequately address traffic restraint issues. In these cases they are often linked with a more detailed network assignment model.

## Disaggregate Modelling

Aggregate demand modelling assumes that travel behaviour can be adequately described for travellers grouped into large segments; disaggregate modelling seeks to model traveller behaviour at the scale at which the determinants of behaviour occur. Disaggregate models make it possible to include much of the interesting variation between subgroups of people that would be obscured by using aggregate zonal data. The particular advantage for modelling restraint (or indeed for any similar policy) is that it allows a more direct evaluation of the “winners” and “losers”.

In practice, most aggregate models provide some segmentation so that they can deal with different groups of people or commodity. The segmentation is generally at least into groups of travellers distinguished by broad household characteristics, such as income and car ownership. Disaggregate modelling tends to be most useful when either there are particular groups of persons that are of interest, or it is believed the underlying mechanisms are non–linear, such as that between car ownership and income.

## Microsimulation

The most direct application of disaggregate models to obtain aggregate forecasts is the microsimulation model. In microsimulation the disaggregate models are used to determine the behaviour of individuals and households and aggregate results are then derived by summing over these. In principle this may be carried out for the whole population in a study area, but this may be prohibitive in its requirements for computational power and sampling approaches are often adopted. However, substantial improvements in computing power now enable relatively large networks to be modelled at the individual vehicle level, providing potentially powerful insights into time–varying traffic operations. Unsurprisingly, this has generated considerable research and development activity (eg, Fox, 2000)

Most microsimulation applications have concentrated on the modelling of time varying flows, queues and delays either with “fixed–route” assumptions or with some form of traffic assignment. For traffic assignment, considerable research effort has been focused on short–term decision making, in particular driver behaviour and route selection.

In such approaches short–term travel decisions are modelled through dynamic microsimulation with behaviourally driven route choice and assignment features. The use of microsimulation systems has been increased by the need to evaluate new technologies, such as Advanced Transport Telematics (ATT) illustrated in Fig 2 (see Chatterjee *et al*, 1999).

## Land–Use/Transport Interaction

In traditional transport models, transport cost changes do not influence the distribution of land use. However, land–use transport interactions can be particularly important to model where longer term transport planning options are being evaluated and new approaches are being developed for this purpose.

The modelling of land–use effects inevitably adds complexity to the traditional modelling processes. This is because of the need to be able to predict the more direct effects of land-use planning as well as being able to take account of the longer–term spatial effects of policies. If restraint policies, such as road user charging and parking restrictions, significantly change the relative attractiveness of the area under restraint, the longer term response may well be a move of home or job, and the general decentralisation of activities. This is an area of research where, at present, there is no great body of evidence to rely on.

## Reliability

Another important issue is reliability. Variability in travel times has been shown to be an important dimension in travel behaviour, and reductions in variability could lead to significant benefits. The introduction of traffic restraint mechanisms could affect the variability and reliability of journey times on both private and public transport. Regularity (adherence to schedule) is a further key issue for public transport. The incorporation of these performance measures in the appraisal process is now becoming increasingly important.

## Tours (linked trips)

Several new developments, in both aggregate and disaggregate modelling, have involved the use of tours (that is, the whole trip chain from home back to home again) rather than individual trips. This follows recognition that the mode used on the homeward leg depends on the mode used on the outward leg, and that original start and final end times are similarly dependent. This is particularly important in the face of restraint policies. Linked trips (trip chaining) in a multi-modal environment should also be considered, since demand management policies may induce changes in the composition of journeys – park and ride is one example.

## Information

Technological developments are bringing new and improved opportunities for the provision of information to travellers, and systems such as Variable Message Signing (VMS) are found increasingly on the urban and inter–urban network. Information is likely to be a necessary component of integrated transport policies involving restraint. Not surprisingly, given the level of interest in route choice and assignment techniques, there have been attempts to develop modelling frameworks which enable such calculations to be carried out, at least for road travel. The recent increase in the provision of information systems is enabling new understandings of behavioural response to be developed, although their quantification remains an issue.

## Walking and Cycling

Discouragement of the use of the car raises greater awareness in the performance of alternatives. The alternative to the car is commonly regarded as public transport, and many models that have a modal split component consider only the choice between car and public transport. However, policies now make it increasingly important to consider non-motorised alternatives - walking and cycling. Data availability can be a problem, but strategic models, in particular, tend to include all modes in estimating travel demand.

## Summary and Recommendations

Future car restraint, both as an outcome and as a policy measure, means that there is a need to model the behaviour of travellers under a wider variety of situations than was previously the case. This is true whether the restraint is due to greater congestion or through the impact of new factors that need to be considered by the traveller as a result of policies aimed at travel demand management. There is also a greater requirement for the policy maker to be sure of both the direct and indirect impacts of policies. Table 2 gives an indication of the features required to address different policy measures. There is an urgent need to address the impacts arising from restraint measures and increased emphasis needs to be given to the robust modelling of land-use effects. Other modelling issues requiring particular attention include 'time of day' modelling, trip chaining and the effects of increased information provision and use.

| Model | Type of model | Distributor (UK unless stated) | Web addresses (as of 30/10/01) |
|---|---|---|---|
| **Transport planning suites** | | | |
| TRIPS | Transport planning suite | CITILABS/MVA | http://www.trips.co.uk/ |
| EMME/2 | Transport planning suite | INRO Consultants Inc. (Canada) | http://www.inro.ca/ |
| ptv vision | Transport planning suite | Ptv (Germany) | http://www.english.ptv.de/cgi-bin/produkte/vissim.pl |
| **Traffic assignment** | | | |
| CONTRAM | Dynamic traffic assignment | Mott Macdonald/TRL | http://www.contram.com/ |
| SATURN | Traffic assignment with demand estimation capabilitiesWS Atkins | | http://www.its.leeds.ac.uk /saturn/main.html |
| PARAMICS | Microscopic traffic simulation | SIAS | http://www.sias.co.uk /sias/paramics.html |
| VIPS | Public and private assignment and mode change | VIPS AB (Sweden) | http://www.vips.se/ |
| **Strategic** | | | |
| TPM | Strategic | TRL | http://www.trlsoftware.co.uk /productTPM.htm |
| STM | Strategic | TRL | http://www.trlsoftware.co.uk productstm.htm |
| START | Strategic | MVA | http://www.mva-group.com /projects/saopaulo.htm |
| **Land–use transport** | | | |
| MEPLAN | Land–use transport | Marcial Echenique & Partners | http://www.meap.co.uk /meap/ME&P.htm |
| MENTOR | Land use (links to transport models) | Marcial Echenique & Partners | http://www.meap.co.uk /meap/ME&P.htm |
| DELTA | Land use (links to transport models) | David Simmonds Consultancy | http://www.cix.co.uk /~davidsimmonds /models1a.htm |

Table 1: Examples of Models currently used for appraisal.

| **Lever modelled** | **Model type** | **Responses modelled** |
|---|---|---|
| **Efficient use of Existing Capacity:** | | |
| Road: | | |
| Traffic management | Detailed road network; aggregate | Route, t.o.d |
| Information | Detailed network with segmentation | Route, t.o.d., dest. |
| Public Transport: | | |
| Co–ordination (eg interchange) | Detailed network | Route, mode |
| Scheduling | Detailed network with segmentation | Route, mode, t.o.d. |
| Information | Detailed network with segmentation | Route, mode, t.o.d., dest. |
| **Allocation of Capacity:** | | |
| Regulatory: | | |
| Speed limits, parking controls, etc | Detailed networks some segmentation | Route, t.o.d., mode, dest. |
| Physical: | | |
| Barriers, lane segregation, etc | Detailed network, segmentation preferred | Route |
| Fiscal: | | |
| Fares, parking charges, road user ) | Strategic, network not always necessary, | T.o.d., mode, dest., |
| charges etc ) | segmentation preferred | suppression/generation |
| Public transport subsidies | Strategic | Mode |
| **Institutional Arrangements:** | | |
| Deregulation of public transport | Strategic, possibly with network | Mode |
| Private capital for roads | Detailed network | Route, mode, dest. |
| Non transport measures: | | |
| Land-use | Land-use/transport model | Route, mode, dest.,LU |
| General taxation | Strategic, segmented | Mode, dest. |
| Opening times, conditions of work | Strategic, segmented | T.o.d., mode, dest. |
| Changing patterns of behaviour | Strategic, segmented | All |
| **Provision of Capacity:** | | |
| Infrastructure: | | |
| Road (highway and parking) | Network | Route, t.o.d |
| Rail | Network | Route, t.o.d |
| Air | Network | Route, t.o.d |
| Public Transport: | | |
| Route density ) | Strategic, some network | T.o.d., mode |
| Frequency ) | representation (including those for | T.o.d., mode |
| Vehicle size ) | competing modes). Segmentation | Mode |
| Freight: | | |
| Vehicle size ) | Strategic, some segmenation | Mode, dest. |
| Load factors ) | | Mode |

*Key: T.o.d.: time of day; Dest: destination; LU: land–use*

Table 2: Model Structures Required for Analysis of the Impacts of Policy Measures.

## References


Cairns S, *et al* (1998) *Traffic impact of highway capacity reduction: assessment of the evidence.* Landor Publishing, London ISBN 1 899650 10 5.

Chatterjee, K, McDonald, M, Paulley, N and Taylor, N (1999). *Modelling the impacts of transport telematics: current limitations and future developments.* Transport Reviews Vol 19, No 1.

Fox, K (2000) *SMARTEST–new tools for evaluating ITS.* Traffic Engineering and Control January 2000 p20-22.

Highways Agency (1997) *Induced Traffic Appraisal Design Manual for Roads and Bridges*, Volume 12 Section 2. HMSO.