A FEASIBILITY STUDY OF NATIONAL TRANSPORT MODELLING FOR THE UNITED KINGDOM

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1. PURPOSE

This paper summarises work to date on the UK Department of the Environment, Transport and the Regions' on-going Feasibility Study on National Transport Modelling.

The Department of the Environment, Transport and the Regions does not necessarily endorse the views expressed in this paper, and has not yet decided whether or not to proceed with development of a National Transport Model (NTM).

The paper does not discuss likely costs of NTM development, though these are being estimated as part of the Feasibility Study, but rather focuses on the potential role of a NTM, and on what form it would best take.

2. CONTEXT AND STRUCTURE OF STUDY

Policy Context

The Government has recently set out its key criteria for assessing transport policy options as:

- integration; ensuring decisions are taken in the context of a coherent, integrated transport policy covering all modes. There is particular emphasis on making public transport more attractive.

- accessibility; making it easy for people to reach the places they wish to get to.

- safety; making travel safer.

- economy; getting good value for money, and supporting sustainable economic activity in appropriate locations.

- environmental impact; both positive and negative, on both the built and the natural environment, and at the global, national, regional and local level.

This followed action to strengthen the co-ordination of transport policy with environment, land-use and economic development policy, by integrating the former Department of Transport into the new Department of the Environment, Transport and the Regions as from June 1997.

Potential form of and role for the NTM

Given this policy context, the form of NTM being evaluated is intended to be a flexible and wide-ranging tool:

(a) dealing with both passenger and freight travel, for all modes of transport;

(b) providing consistent analyses of scenarios and of the impacts of national transport policy options, including policies operating at a local level on a wide-spread basis, and taking account of alternative land-use scenarios; with results that can be disaggregated by key dimensions;

(c) providing a framework for setting up consistent, complete, and readily analysed national disaggregated data-bases of current travel patterns and transport supply, which would be updated from time to time to ensure their continuing relevance, and could assist in monitoring trends;

(d) integrated with a "post-processor" to estimate national transport environmental impacts, based on the NTM's transport system outputs;

(e) potentially underpinning the development of compatible Regional Transport and Environmental models (which could be useful for developing consistent Regional Transport Plans within the Regional Planning Guidance framework, particularly if the proposal to bring trunk roads planning within this process is taken forward).

Ideally the NTM would also incorporate land-use/transport interaction modelling to provide estimates of the impacts of transport system changes on land-use patterns (in addition to estimating the impacts of alternative land-use scenarios on transport patterns, as is envisaged above). However, it is clear modelling just transport on a national basis would be complex and challenging to develop. There is also a lower degree of consensus on what relationships are appropriate for estimating transport impacts on land-use patterns, than there is on the relationships within the transport sector itself. It therefore seems prudent to limit the scope of any initial NTM to modelling the transport sector (taken to include the effects of alternative land-use assumptions on travel patterns), whilst allowing for sensitivity tests of alternative assumptions about transport system effects on land-use patterns where required.

However the option should be kept open for later NTM enhancements to incorporate formal relationships estimating transport impacts on land-use patterns, within an additional land-use/transport module which would interact with the initial transport module.

NTM outputs would serve both to directly inform debate, and as input to more detailed local or theme-specific analyses. As a policy testing tool, the NTM could for the first time provide a means of systematically comparing the consequences of alternative national transport policies.

In considering wbat the role of the NTM would be, it is helpful to consider what characteristics of policy issues make national model analyses likely to be useful. A list is set out in Table 1.

Table 1. Policy characteristics which suggest NTM analyses could be nseful

Policy areas wbere significant sums may be allocated from a central pot, and a consistent analytical assessment of the impacts of alternative policy options and/or of their regional impacts may assist decision making.
Policy options wbere the debate may benefit from a widely accepted quantitative assessment of their likely overall national impacts (*a possible example might be identifying the maximum potential for reducing highway traffic by improving public transport or cycling facilities*).
Policies which are applied nationally, but bave varying impacts by broad location (*a possible example is fuel price changes and their differing effects on urban and rural areas*).
Where an overall national policy may be needed to give general direction and a framework for decisions that will be made locally (*a possible example is land-use policy*).
Policies which are locally determined but, when applied widely, are felt likely to bave impacts of national significance on overall travel patterns (*a possible example is stringent city centre parking controls*).
Locally applied policies which interact with nationally applied policies, or have "spill-over" effects, for example by diverting trips from close to distant destinations, whicb cumulatively are of national significance, or of significance for a number of Regions (*a possible example is selective but widespread urban highway restraint measures*).

Taken together, the points in Table 1 identify the core roles for a NTM as providing an internally consistent and comprehensive analytical framework for supporting the development and evaluation of overall national transport strategy; and belping inform debate on national transport policy options, including debate on the overall framework within which local transport policy decisions should be made.

Scope and division of work for the Feasibility Study

These considerations bave conditioned the aims of technical feasibility work commissioned from consultants. The aims bave also been influenced by findings from preliminary feasibility assessments carried out by the Transport Researcb Laboratory [Emmerson and Paulley, 1996]. They are broadly to identify and cost options for a multi-modal NTM covering both passengers and freight, with disaggregation by broad location, person (or freight) type, journey purpose, and broad time of travel; providing an over-arching framework for consistent comparison of a range of different policy options and their impacts; and supporting exploration of alternative future scenarios. In short, the aims could be summarised as assessing the feasibility (and cost) of a national transport policy analysis model.

This contrasts to a degree with the majority of existing large scale transport (or traffic) models in the UK, which can be characterised as network analysis models. In these, modelling effort has been focussed on providing relatively detailed estimates of the impact of proposed major new roads (or sometimes railways) on passenger travel, and on estimating link flows accurately. However, in recent years a number of UK urban models have been developed of the policy analysis type, attempting to forecast a wide range of responses and policy impacts in an integrated and consistent way.

The Department sought a sensible way to structure the potentially wide ranging scope of the Feasibility Study into manageable Projects. The thinking outlined above led to the conclusion that work should be split between two main Projects. The first was to look at the minimum core requirement, a policy analysis type model capability with simplified transport supply representation, and to design and cost this. This became "Project 1" of the Feasibility Study. The second was to look at the feasibility of developing a fuller supply side representation by means of a detailed network assignment layer, which could be combined with the policy analysis model to form an integrated NTM system. This became "Project 2" of the Feasibility Study.

An important reason for focussing Project 2 specifically on the feasibility of a sound detailed network assignment layer for the NTM was the Department's experience with the RHTM (Regional Highway Traffic Model) of the late 1970s. This failed to achieve acceptable levels of accuracy in its highway network assignments, despite substantial expenditure on model development. Thus the Department felt particularly careful assessment was needed in this area.

In addition to these two main Projects, a separate smaller study was set up to look at the feasibility of developing national transport environmental impacts modelling - a key area of interest - by "post-processing" NTM outputs. Thus three linked consultants' Projects were commissioned for the Feasibility Study:

- Project 1, with the brief of designing and costing a stand-alone National[1] Transport Policy Model (NTPM), without the complexity and implied cost of a detailed national network assignment process. This has been carried out by a consortium of The MVA Consultancy, the David Simmonds Consultancy, and the University of Leeds Institute for Transport Studies. It should be stressed that the purpose of including model design within this Project is not to commit the Department to implementing the details of this particular design if it is decided to go ahead with developing a NTM, but rather to provide a firm basis for estimating likely costs and for reaching a decision on whether or not to proceed with a NTM development of this general type.

- Project 2, focussing on assessing the practicality and likely cost of compiling the national[1] travel demand and network data needed to add a sound explicit Spatially Detailed Network Assignment "Layer" (SDNAL), to be integrated with the Policy

[1] For practical reasons, the scope of the consultants' Projects was in fact restricted to Great Britain rather than the United Kingdom, since it was considered that including Northern Ireland in the core coverage of the NTM would not raise any major additional feasibility questions. If it is decided to develop a NTM, a subsidiary decision can be taken at that point on whether to include Northern Ireland in its core area.

Model designed by Project 1. This has been carried out by the Ashresearch consortium made up of WS Atkins, Steer Davies Gleave and Hague Consulting Group.

- Project 3, on the feasibility of modelling national[1] transport environmental impacts using NTM outputs. This has been carried out by WS Atkins, with Hague Consulting Group and the Meteorological Office.

In parallel with this technical feasibility work, on-going informal consultation is being undertaken by the Department, seeking views on the potential value of a NTM, and what the priorities would be for its application.

The following Sections of this paper give a brief summary of key points from:

- consultation (to date) on the potential role for and benefits from a NTM
- the Project 1 consultants' findings
- the Project 2 consultants' findings
- the Project 3 consultants' findings

3. SUMMARY OF RESULTS TO DATE FROM CONSULTATION

Consultation carried out

The main elements of consultation to date have been:

- two articles in the transport press inviting views;
- two conference presentations in addition to the one associated with this paper at the 1997 European Transport Forum;
- a Seminar on the role and value of a NTM, with representatives of a sample of relevant organisations (including, for example, the Automobile Association, local government officers, the Freight Transport Association, the Office for Rail Passenger Franchising, Transport 2000, and the Council for Protection of Rural England); and
- a questionnaire to those attending the Seminar and to relevant Department officials on priorities for NTM applications and their potential value.

Information has also been sought from other European countries with national transport models on how and why these have been developed, costs of doing so, and uses these have been put to. Thanks should be recorded to those consulted who have given their time for this purpose, and to a number of those working with national transport models in other countries who have also been very generous in sharing their experiences.

Results from consultation

Key points to emerge are a widely based view from those consulted that a NTM is potentially a valuable tool, particularly in providing a consistent national framework for appraising a wide

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range of transport policy options, and for exploring alternative scenarios; and that results at a relatively aggregate level (say split by built-up and non-built-up areas within individual Regions) are all that is essential for this purpose. Local, specifically targeted modelling is felt to be more appropriate for assessing individual local issues or policy options. These views seem consistent with the structure decided on for the Feasibility Study Projects.

Table 2 summarises views of respondents to a questionnaire on what policy areas would be most usefully analysed by a NTM, and the value in doing so. The 20 respondents were split roughly equally between Department officials, and representatives of bodies invited to the Seminar on the role of a NTM mentioned above. Given the small sample, its results should be interpreted cautiously. For brevity, only overall average views on the value of NTM analyses for overall policy areas are shown, rather than individual's views on each policy lever within each policy area. However, there was a high degree of agreement between respondents on relative priorities. The table also shows the advice of Project 1's consultants on the capabilities of the form of NTM they propose, without and with an additional Spatially Detailed Network Assignment Layer (SDNAL), so that desired capabilities for the NTM can be compared with its likely actual capabilities.

Table 2. Summary of views on NTM priorities, and consultants' views on capabilities

	(A) Overall view	**(B) Overall view**
	NTPM only	**NTPM with addition of SDNAL**
Potential Policy Levers or Scenarios for analysis, by area		
1. More efficient use of existing capacity	++ *2*	++ *2**
2. Allocation of capacity by regulation	++ *3*	++ *3**
3. Allocation of capacity by physical measures	++ *3*	++ *3**
4. Local fiscal measures	+++ *4*	++ *4**
5. National fiscal measures	+++ *3*	++ *3*
6. Increases in capacity via infrastructure build	++ *3*	++ *3**
7. Institutional arrangements (via assumed impacts on service levels etc)	++ *3*	+ *3*
8. Non-transport measures(eg land use)	+++ *4*	++ *4*
9. Scenario testing of (largely) exogenous factors - see below		
Assess alternative travel "futures", and their acceptability	+++ *4*	++ *4*
Assess effects of specific trends, eg increasing tele-working	+++ *3*	+ *3*
Assess impacts of changes in attitude to travel	+++ *4*	++ *4*
Assess effects of international passenger and freight movements	++ *4*	++ *4*

Notes:

Median view shown on value of NTM application for the individual policies (not shown above) in each broad policy area, on the scale:

no value (-), limited value (+), valuable (++), very valuable (+++), essential (++++).

Project 1 consultants' advice on the capability of the NTPM, without or with a SDNAL, for analyses of particular policy options (in italics), medians over groups of policies:

no capability (0), limited capability (1), average capability (2), good capability (3), very good capability (4);
note that in some cases, additional analyses/research would be needed to set up appropriate inputs for the NTM for particular issues.

"" in column B where consultants consider one or more individual policies in this category would be better modelled with the addition of the SDNAL than by the NTPM alone, but average capability for policy area falls in the same band for both columns.*

Some of the respondents' views are counter-intuitive in that the value of a NTM with SDNAL (column (B)), is sometimes felt to be less than that for a NTM without a SDNAL (column (A)). Incorporating a SDNAL should never decrease the value of the NTM, since this layer could be "switched off" if so desired. These results seem to reflect a sense that for policies where the addition of a SDNAL is not felt to be useful, its additional cost and complexity count against it. Although respondents were asked to put considerations of model development costs aside when completing the questionnaire, this is obviously difficult to do.

Uses of NTMs in other European countries

A number of other European countries have developed or are in the course of developing National Transport Models. These models vary in scope and aims, so their relevance to the form of NTM being evaluated for the UK also varies. Nonetheless, it seems reassuring that these national models appear to have proved of value. Table 3 gives an indication of some of the broad areas of application for these national transport models.

Table 3. Sample broad areas of application of some European national transport models.

COUNTRY	SAMPLE BROAD AREAS OF APPLICATION (OR *INTENDED APPLICATION*)
Germany	Allocating transport infrastructure resources between regions; policy development; freight infrastructure planning[1].
France (Matisse model)	Planning of long distance road and rail infrastructure[2]
Netherlands	Underpinning national transport and environmental plans, providing consistent inputs for regional transport models, appraisals of alternative telematics investments to make the most of the existing network[3]
Norway	Assessment of CO2 targets and transport's contribution, development of consistent national multi-modal road and rail passengers and freight infrastructure investment planning[4].
Denmark	Long term forecasts, assessing major road and rail infrastructure options[5]
Sweden	Assessment of inter-urban infrastructure development plans[6]
Austria (under development)	*Assessment of inter-urban infrastructure development plans*[7]
Italy (under development)	*Assessment of inter-urban infrastructure plans, monitoring travel trends, scenario assessment*[8]

[1] Macro-Economic Evaluation of Transport Infrastructure Investments, German Federal Ministry of Transport, 1993; and information given at PTRC National Transport Models conference, The Netherlands, June 1997.

[2] Overview and evaluation of methodologies for forecasting of induced traffic on new transport infrastructure, HCG for European Commission DG XI, October 1996

[3] Dutch Ministry of Transport, personal communications and Paper given to Seminar on Role of a UK National Transport Model, November 15 1996.

[4] Norwegian Ministry of Transport (Ms A Brendemeon), personal communication

[5] Mr A Daly, Hague Consulting Group, personal communication

[6] Information given at PTRC National Transport Models Conference, The Netherlands, June 1997

[7] Professor K Axhausen, University of Innsbruck, personal communication

[8] Italian Ministry of Transport (Dr P D'Anzi), and Italian National Model Development Team, personal communications.

4. SUMMARY OF FINDINGS ON THE DESIGN OF A NATIONAL TRANSPORT POLICY MODEL (PROJECT 1)

Implications of policy testing requirements for model form

To help determine what form of National Transport Policy Model (NTPM) would be best, lists of possible policy levers of interest to the Department were compiled and considered, in addition to the broad objectives set out in Section 3. These lists drew on earlier work by TRL [Emmerson and Paulley, 1996]. The emphasis of NTPM is seen as being very much upon the consideration of policies rather than the testing of even major individual infrastructure schemes: the optional addition of a Spatially Detailed Network Assignment Layer would be intended, amongst other aims, to extend the NTM's scope to include broad brush testing of groups of major schemes or possibly of particularly large individual schemes.

Options considered for model form

The design process began by considering different ways in which the model might represent space and the demand for travel. Spatially, these included different levels or hierarchies of conventional zones; sample areas (akin to a system of case studies); disaggregate approaches involving samples of addresses; and more abstract forms such as a typology of origin areas (see for example Fowkes et al, 1995); notional (discontinuous) area-type-based zones for both origins and destinations (as in the Dutch Scenario Explorer - see Verroen and Jansen, 1993); and an archetypal region (see the archetypal town developed for land-use/transport analysis by Rickaby, 1991).

For representation of demand, the initial choice was between: using trip length distributions; a disaggregate approach using a sample of trips or tours (with associated expansion factors); and conventional matrices of trips or tours.

A key issue for the design was the degree to which many national policy questions are likely to need to concentrate on seeking to change local travel patterns, in particular persuading people not to use cars for short or medium length trips. This contrasts with the conventional concept of a national model as one in which long distance trips are modelled in detail whilst the large majority of short-to-medium distance trips are treated in very much less detail (or not at all); and with the principal goal being to evaluate options for major inter-urban transport infrastructure. This sort of national model goal is illustrated by a number of the sample areas of application of existing national transport models listed in Table 3. However, this approach is not appropriate in the current context, given the objectives for the NTPM. It was therefore necessary to seek ways of dealing explicitly with short trips in the model. The sheer number of different possible choices which then have to be considered led to a focus on sampling strategies rather than upon spatial aggregation as the means of developing a practical and manageable model.

One hybrid approach, considered but not eventually adopted, involved using a sample of origin and destination addresses within a coarse zoning system. This was felt to have potential advantages but to be complex and under-researched. Further discussion of the alternatives produced the hybrid idea which was eventually adopted: to specify a very fine zoning system (finer than originally considered possible, with around 11,000 zones), but to operate the model with only a sample of these zones as trip origins. At the same time it was argued that NTPM should have a much coarser representation of transport supply, in terms of characteristics such as traffic speeds; detailed representation of transport networks would be left to the possible Spatially Detailed Network Assignment Layer (SDNAL) being considered in Project 2.

It was agreed that it would not be the best use of Project 1's resources to develop a design for new car-ownership models, given the availability of the recent Improved Car Ownership Models (ICOM) developed for the Department [The MVA Consultancy, 1996]. This decision implied that the Project 1 design for the NTPM's car-ownership modelling would be aggregate in nature, albeit with a number of household categories considered separately. Whilst this did not logically preclude the use of sample-based disaggregate modelling for subsequent choice processes, it did mean the value added by such an approach in this particular context was felt to be low.

The essential characteristics of the proposed NTPM therefore emerged as:

(a) large notional speed-flow zones within each region for representing supply-demand interactions;
(b) a sample of very fine zones for modelling of origins;
(c) for destinations, very fine zones near to any given origin, with progressively greater aggregation further away;
(d) an aggregate representation of transport demand, i.e. quantities (trips or tonnes) in "matrices" rather than sampled movements with associated expansion factors.

<u>Relationship between the incremental model and the cross-sectional data</u>

Another major decision was that the NTPM itself should be essentially incremental in nature. The argument for this was mainly that the many non-transport factors influencing travel choice (particularly choice of destination) should be dealt with by ensuring that the resulting patterns are represented in base matrices; the transport model then deals exclusively with the transport-related <u>changes</u> in these matrices.

If a full description of <u>base</u> demand can be provided, such an incremental model can be achieved either by using that information directly as input (see for example Bates et al, 1991), or by ensuring that it is exactly reproduced in a cross-sectional model (see for example Williams and Beardwood, 1993). Mathematically, these two approaches should be identical, but we believe that the former is more efficient. The development of a full description of the base demand (which stems from the specified objective of modelling all travel and transport) is part of the implementation task (see below) rather than a function of the model itself.

<u>Scope of the model</u>

So far as passenger travel is concerned, it was readily agreed that the model could and should represent responses to changed travel conditions in terms of changes in frequency of trip-making (generation/suppression), of destination, mode, time of travel and (in broad terms and mainly for longer journeys) of route. It was also agreed that the model should represent responses in terms of changed car occupancy, though further research was felt to be needed in order to implement this. Two other responses - changes in car ownership, and in land-use, arising from changes in the transport system (rather than from demographic and economic trends) - were classified as being in the domain of a land-use/transport model rather than of NTPM itself; these have accordingly left for possible later development, though sensitivity testing of assumed relationships would be catered for in the NTPM.

In addition, it was noted that the Vehicle Market Model recently developed for the Department by the Institute of Transport Studies at Leeds University already provided some capability for modelling the effects of policies on the proportions of different types of car on the roads (for example, splits of diesel and petrol engined, or company and privately owned cars), which could complement the NTPM.

The definition of the modes to be modelled was largely determined by the requirement to represent all travel. The proposed list of modes (for modelling mode choice) emerged as air; car/rail mixed mode ("park-and-ride"); rail (including Underground and Light Rapid Transit); bus or coach (including charter/contract); car, including motorcycle and taxi; bicycle; walk. This list is in order of generally increasing (actual or potential) spatial ubiquity; where more than one mode is used in the course of a journey, the "main mode" is the earliest, most restricted one in this list.

For those modes which primarily cater for short distance trips - urban bus, walk and cycle - it is not expected to be practical or worthwhile to model specific trip origins and destinations and costs of travel in great detail. Broad brush relationships between area type, trip length and typical generalised costs per kilometre will be used instead. Thus even if it is decided to construct the SDNAL to complement the NTPM, trips on these modes would not be assigned to explicit networks.

Time of travel is proposed to be treated so as to distinguish morning and evening peaks and the off-peak hours of an average weekday, and weekends/bank holidays. Modelling of <u>choice</u> of time of travel will be between the different periods of the weekday, but not between weekdays and weekends/holidays.

For freight, the proposal is to model (constrained) distribution, mode, time-of-travel and (broad) route in very much the same way, with the "mode" alternatives being road freight; combined transport (road + truck or trailer on train); direct rail; container on road vehicle; container by road and rail; sea/inland waterway.

For completeness, the model is required to include the within-country parts of international journeys/freight movements, and within-country travel by non-residents during their visits. These would have more restricted choices modelled: for example, the mode of international movements would be exogenously forecast rather than determined by transport conditions within Britain or the United Kingdom.

<u>Treatment of travel</u>

A major issue in modelling of passenger travel is the choice between using a basic travel unit of trips or of tours. It was noted that the majority of those models which use tours find it impractical to go beyond representing a simple tour to and from the "primary destination" (for an exception, see Daly and Lindveld, 1995), and that this was likely to be the case if tours were modelled in NTPM. It was also felt that simultaneous modelling of the time of outward and return travel was likely to be over-elaborate. The view was eventually reached that a production-attraction approach to home-based trips, making the distinction between home-to-work and work-to-home, and so on, and with the facility to model mode and destination choices on the basis of the round-trip cost, would provide most of the required effects with less computational and data burdens than implied by an explicit representation of tours.

NTPM is envisaged as classifying travel by person type (child, working adult, other non-retired adult, retired) and by purpose (provisionally five home-based purposes modelled on a production-attraction basis: work, employer's business, education, shopping, other; and two non-home-based purposes modelled on a simple trip generation basis: employer's business and other). The choice process itself would consist of a hierarchical system of incremental logit models for choice (or more precisely, for change of choice) of destination, mode, time of travel and route. Note that the order of choices in the hierarchy would vary between purposes. Different sub-models linked to this are proposed for frequency (suppression/generation) and car occupancy effects.

Freight demand choices would be modelled by a more restricted version of the same design.

The incremental model would be "driven" by changes in generalised costs (appropriately specified by person type and purpose), stemming from changes in the physical supply of transport infrastructure and services, from changes in other model inputs such as fares and costs, or from changes in the supply feed-backs (see below). Before running the incremental model to deal with the effects which are "internal" to the transport system, an external forecasting process would be applied to take account of non-transport factors such as changes in the size, composition and distribution of the population. This in turn would be driven by a "Scenario Generator" to ensure the consistency of the "planning data" inputs, and in particular to facilitate testing of alternative land-use assumptions. In particular, origin and destination zones would be "tagged", for example as being in located in city centres, suburbs, town peripheries, or rural areas. This would allow changes to be made readily to input land-use assumptions at the national level, for example to explore the likely impacts on travel of trends in the types of area where shops are located. The ability to represent such alternative land-use patterns meaningfully in the model was a key factor in the choice of a fine zoning system.

Figures 1 and 2, at the end of the paper, show the relationship between the Scenario Generator, the External Forecasting Model, and the iterative process which would find the equilibrium between demand and supply changes within the NTPM.

Treatment of transport supply

The representation of transport supply is intended to provide absolute values of all the required variables, even though only the changes are strictly needed for incremental demand calculations. The required variables consist of a set of time components (eg in vehicle-time, walking time), some of which may be weighted as counting more (or less) than "standard time", and a set of money components. The latter would be divided by the appropriate value of (standard) time to obtain generalised costs in time units. Car costs would be built up per vehicle and, subject to further research findings, divided by the occupancy to give a per person value.

The provision of these supply components for journeys at the level of the very fine trip end zoning system requires a distinction between the "on-line" and "off-line" networks. The off-line network is a more detailed and explicit representation (which might be that of the Spatially Detailed Network Assignment Layer, if this is developed) of car and public transport supply, which would be used both to build up the base values of supply variables for each journey which has to be considered (bearing in mind that these would only be for a sample of the total possible origin zones), <u>and</u> to define a set of "aggregate links" (one or more for each notional speed-flow zone in each region) which would constitute the "on-line network" used to process the highly aggregated speed-flow relationships.

Other feed-back relationships would apply to represent (i) the effects of the broad relationship between car parking demand and capacity, and (ii) a degree of feedback in public transport travel whereby (for example) increasing demand may lead to improved service via assumptions on operator responses. Car occupancy effects could also potentially be treated as a feedback process, rather than as a choice in the demand model.

<u>Outline of the implementation process</u>

Project 1's proposals for implementation of the NTPM have been strongly influenced by the parallel Project 2 work on how best to create base matrices for a spatially detailed network assignment layer: the two sets of ideas have emerged as closely linked.

The key argument to emerge from this aspect of Project 2 is that the best way to create a full set of base matrices from which to pivot an incremental model is to make use of a sophisticated cross-sectional model embodying many of the incremental model's relationships. This would be used to create a wholly synthetic set of "seed" matrices. The seed matrices would then be refined to reflect (inevitably) partial survey data. The process of refinement could be very limited, drawing only upon a few major data sets, or could set out to use every possible scrap of travel interview and count data. Different levels of this process imply a range of options for the overall NTPM/NTM implementation process.

The Project 2 proposals for constructing base matrices are discussed further in Section 5. So far as the implementation of NTPM is concerned, this implies the need to develop and calibrate an initial <u>cross-sectional</u> model (the "seed model"), which in turn requires a complete set of transport supply characteristics (as absolute values, not as changes). Once the calibration of the cross-sectional model reached a certain point, its outputs, the "seed matrices" would be used as the starting point for refinement outside the model drawing on survey data, as proposed by Project 2. The results of this process would be used as "base matrices" for input to the incremental model. There might then need to be a process of adjustment to either or both of the cross-sectional model and the base matrix estimation procedures, to achieve acceptable consistency between them. The final stage of the process would be to refine the calibration of the "incremental model" (starting from the coefficient values used in the cross-sectional model) so as to reproduce known sensitivities. The "incremental model" here includes the supply feedback processes as well as the demand modelling.

The incremental model would be embedded in a wider system including ("upstream") the Scenario Generator and External Forecasting Model, and ("downstream") means of outputting the results (in tabular, graphic and map forms), of estimating national transport environmental impacts via a closely integrated "post-processor", and of carrying out economic evaluations of the transport policies tested.

Conclusion

The proposals for the NTPM's form outlined above have emerged from a extensive process of design and discussion which has focussed on a set of requirements differing in some key respects from those underlying many existing national or regional models. This has resulted in a design which is itself unconventional in some respects. The Project 1 consultants believe that the proposed design represents the best balance between the potential risks of innovation to meet new requirements and the security of established but potentially less relevant techniques.

However as noted earlier, whilst this model design work has aimed to provide a firm basis for estimating development costs and identifying likely model capabilities, if it is decided to proceed with developing a NTM, the Department may well wish to make changes to these proposals or to consider adopting modifications to the suggested design which others may put forward.

5. SUMMARY OF FINDINGS ON THE FEASIBILITY OF A SPATIALLY DETAILED NETWORK ASSIGNMENT LAYER FOR THE NTM (PROJECT 2)

Background

Construction of useable representations of the national transport networks is seen as posing relatively few feasibility problems, though likely to consume significant time and resources; and there are existing models and data sources which would form a good basis for this task. The main focus of the Project has therefore been on whether and how sufficiently accurate base matrices can be constructed to assign to these networks, in particular for road and rail travellers and freight, in order to obtain acceptable nation-wide link flow estimates.

Note that for the SDNAL, unlike the NTPM, it is not envisaged that just a sample of origins would be used in the modelling, since this would cause difficulties in an explicit network assignment process.

The role of a model in estimating passenger base matrices

Whilst many highway-only assignment models have constructed base matrices directly from survey data, for the SDNAL of the NTM the use of a model to provide underlying structure for the multi-modal base passenger matrices is seen as essential. Hence there is a close link with the model design proposals of Project 1, as noted in the preceding section.

One reason for concluding a structuring model is essential for base matrix estimation is that a fine zoning system, which implies a very large number of zones, is required to give accuracy in assignment of zone-to-zone trips to the networks. An analysis of existing models and their uses pointed to a overall target of about 4,000 zones for the SDNAL, and hence about 16 million potential zone-to-zone movements in each base matrix. Thus the sampling error in survey data at the zone-to-zone level would be far too great for "purely observed" matrices to be reliable at this level, particularly given the further splits needed by time-of-day and purpose.

Furthermore, the majority of zone-to-zone pairs are likely to be un-observed in survey data, and there will be a low average number of trips between zone pairs, leading to substantial data "lumpiness". Thus there will be many surveyed cell zeros, under-stating "true" (small) flows. There will also be large numbers of cells with very low numbers of surveyed trips which after grossing-up will often overstate "true" flows: for example, with a grossing-up factor of say 10, all "true" non-zero flows of less than 10 trips will be over-estimated, or alternatively under-estimated as zero. All this points to the need for a substantial degree of grouping of the surveyed trip data in order to achieve statistical reliability, and hence a need for a model to help give sensible allocations of the grouped survey data to the required zone-to-zone level.

However, the major factor is the role of the SDNAL in supporting incremental NTM forecasts, which need to reflect the complex interactions between travel choices such as mode, destination and time of day implicit in the base trip matrices. A model is required to give coherence and compatibility to these base estimates, in order to avoid anomalies arising in incremental forecasts from the base.

Regarding the type of model that should be used, experience points to a potential range from relatively simple gravity models (both trip-end constrained and unconstrained) as used for example in RHTM, through link-count-constrained methods (sucb as implemented in ME2 and other similar procedures), to the more statistically based approaches used in the Dutch National Model (DNM). These methods represent a progression from simple methods to more flexible ones with a more rigorous statistical basis, informed by lessons learnt from weakness found in earlier methods.

The following sections summarise some key points from the recommended approach to base matrix estimation for highway travellers, rail and inter-urban bus travellers, and road and rail freight.

As noted in the previous Section, urban bus, walk and cycle trips would not be assigned to explicit networks, and a detailed matrix estimation procedure incorporating surveyed trip data by origin and destination is not felt to be appropriate for these modes. These modes are therefore not discussed further here. In contrast air trips are expected to be assigned to an explicit network, but since air travel accounts for a small proportion of all trips, and there are existing models which could act as a basis for developing air matrices, it was not considered necessary to work up detailed proposals for development of air travel base matrices at this feasibility stage. Thus air travel is also not discussed further here.

<u>The recommended approach for passenger base matrices: highway travellers</u>

The recommended approach to developing passenger base matrices builds on that of the DNM, with initial matrix structure and size determined by a "seed" matrix estimated by a detailed multi-modal demand model together with trip end estimates. This would be combined with the available survey data (Road Side Interviews (RSIs), counts, rail and inter-urban bus ticketing data, and National data-sets such as the Census Journey to Work survey) using a matrix refinement process taking account of the variances of the various data inputs.

As discussed above, the use of survey data requires a careful balance between detail of segmentation, and grouping to give appropriate statistical accuracy. Data would typically be grouped into origin and destination sectors, trip distance bands, cordons and screenlines. The main matrix estimation would be for week-days, peak and off-peak. Week-end/holiday matrix estimates would be cruder, being derived by factoring the week-day matrices due to the limited survey data currently available for week-end and holidays travel.

A staged approach to base matrix estimation is envisaged:

- initial strategic estimation at a national level, using national and strategic data sources (listed below) at the 24 hour week-day level, maintaining purpose distinctions. Optionally, this could be extended to include time-of-day estimation if the subsequent local estimation stage is not pursued.

- a local estimation stage, applied separately for trips in say 7 broad areas covering the country, with long-distance trips being treated as a distinct category. The area matrices and long-distance trips would be extracted from the results of the strategic estimation stage. The local estimation would use local counts and RSI data, and distinguish time periods within the day but typically aggregate purposes together. This reflects the type of additional data likely to be available locally where purpose segmentation may often be limited or non-existent. The local estimation stage can be seen as an optional refinement, seeking to improve on the results of the strategic stage.

At both stages, actual or estimated variances of all contributing data would be traced through to ensure appropriate weightings were applied wherever data were combined, and to provide estimates of the statistical reliability of the final matrices. The latter would be useful in helping identify what options for any future data collection would be most cost-effective.

Key data sources for the strategic stage would be:

- the "seed" demand matrices output by the NTPM designed by Project 1 (note that as discussed towards the end of Section 4, this means there may need to be an adjustment process to ensure acceptable consistency between the NTPM model and the base matrices).

- the primary RSI data-sets, from a number of regional studies undertaken by the Department or its Highways Agency which have compatible purpose, occupancy, and geographical coding at the trip record level. It is necessary to go back to trip records rather than use the matrices processed from these, because the latter are not compatible to the same degree. These primary sources include around 2,200 RSI sites and 2 million trip records, though not all parts of the country are covered.

- screen-line count data (for which a wide variety of sources are available, though these would need careful scrutiny for quality and compatibility).

- for home based work trips, the decennial Census 10% sample "Journey to Work" estimates would be an important input, suitably factored from "normal work-place and mode" estimates to "average week-day home-based work trips by mode" for the required base year. This factoring would probably involve using trends from the Labour Force Survey; and trip rates per person and per job, suitably segmented, from National Travel Survey household travel diary data-set.

- National Travel Survey data to contribute to estimates of inter-Regional trip movement estimates.

Some areas in this suggested process have been identified which require research, though they are not felt raise any fundamental feasibility concerns. These are:

- bow best to handle any major inconsistencies that become apparent between the modelled seed matrix and the survey data.

- how best to handle multi-modal trips; for example, car/rail trips will potentially contribute to both car and rail link flows found in on-system surveys, and the statistical merging process will need to make suitable allowance for sucb issues.

- the treatment of long-distance trips, particularly if it is decided to proceed with the local estimation stage, where it is proposed these trips are treated as a distinct category.

<u>The recommended approach for passenger base matrices: rail and inter-urban bus</u>

The available data for these modes is very different from those for highway travellers, and so whilst the proposed underlying principles are common, practice would differ substantially.

For rail, a single stage estimation procedure is recommended. Main data inputs would be likely to be the Office for Passenger Rail Franchising's CAPRI rail passenger ticketing database (assuming agreement from the data owners), the Census Journey to Work (factored as described earlier) and the London Area Travel Survey/British Rail Origin Destination survey for 1991 of South East England rail passenger travel. This last survey covered about 55% of national rail week-day trips. In addition, there would be count data (probably needing to be specially collected) for use in adjusting the different data sets to a common base year.

It would be necessary to match the station-to-station level trips in CAPRI to ultimate origin and destination zones by exploiting information from network assignments and/or simpler manual assignment processes. Similar procedures have been carried through successfully in work by Hague Consulting Group for Dutcb National Railways [Cohn N, Daly A et al, 1996]. It is also necessary to estimate trip purpose and time of day splits for the CAPRI data, but this sbould be quite practicable using existing data sources.

For inter-urban bus, due to particular commercial sensitivity, it is less certain that access to ticketing information can be achieved. However, if this proves possible, the matrix estimation process would be similar to that for rail: otherwise cruder estimates will need to be made relying more heavily on the synthetic model estimates, Census Journey to Work data, time-table information, and possibly counts.

The recommended approach for freight base matrices

On the highway side, the recommended broad approach is to assemble freight tonnage matrices by commodity type at a county-to-county level from existing road freight surveys, and to distribute flows between smaller zones using Census workplace data.

The road freight surveys used would be the Continuing Survey of Roads Goods Transport (CSRGT) and its companion survey the Continuing International Road Haulage Survey (CIRHS). A first step would be to merge these into a single consistent source of road freight origins and destinations at county level by broad commodity type.

This county level matrix would be disaggregated to a finer zone structure using appropriate sub-sets of the decennial Census special workplace statistics as a rough proxy for freight trip ends, possibly after updating using Labour Force Survey trends. Research is needed here to confirm the best way to use Census data for this purpose.

The initial zonal level road freigbt matrix would be refined, and time of day information added, by a matrix adjustment process using RSI information in a similar way to that proposed for constructing the highway traveller matrix.

For rail freight, the suggested first stage would be the construction of a rail-head to rail-bead matrix from operator information. A simple allocation process drawing on information from the road freight matrix and possibly also some specially commissioned surveys would be used to allocate rail-bead trip totals to surrounding (assumed) ultimate origin and destination zones in order to complete the matrix.

Conclusions

The Project 2 consultants' conclusion is that a sound spatially detailed network assignment layer for a NTM is achievable. A staged approach is recommended, which gives the opportunity to phase development work.with break-points, to help manage risks. It is proposed to aim for around 4,000 zones for network assignment purposes for both passengers and freight, though it may prove necessary to fall back on a lower number of zones for freight wbere there is less previous experience to build on.

In a separate project, the Department has recently initiated the construction of a detailed national index of sites from strategic RSI data-sets. This is to serve other purposes, but will also potentially serve as useful ground-clearing for the recommended base highway matrix construction approacb.

6. SUMMARY OF FINDINGS ON THE FEASIBILITY OF ESTIMATING NATIONAL TRANSPORT ENVIRONMENTAL IMPACT INDICATORS FROM NTM OUTPUTS

Background

This project considered the feasibility of developing a prospective "post-processor", a National Transport Environmental Impacts Model (NTEIM), to provide a consistent and quick-to-run tool using outputs from the NTM to derive policy relevant national transport environmental impacts information.

The results sought are national patterns of transport emissions of greenhouse gases and air pollutants; and the incremental effects of transport scenarios and policies on overall annual frequencies of "exceedences" of air quality criteria (such as set out in the UK National Air Quality Strategy [Department of Environment, 1997a]), and possible noise level criteria. The main focus of the project was on developing possible outline methods for assessing road vehicle environmental impacts, as the most significant transport source of air pollutants and noise.

It seems clear that the level of sophistication appropriate for the NTEIM would be closely linked to the degree of detailed spatial accuracy sought in the NTM, and in particular whether it is decided to incorporate a spatially detailed network assignment layer in the NTM. The consultants therefore developed an outline generic and phased approach which can be adapted to reflect the level of reliable spatial detail in outputs available from the NTM. It could also be used with other more local transport models.

An initial review of the literature and of the Department's existing environmental modelling tools led the consultants to the view that existing methods could largely be adopted as they stand for making national transport emissions estimates using outputs from the NTM. It would be possible to make some minor improvements on current capabilities, reflecting the improved national transport system data available from the NTM. In addition, it was recommended that better allowance could be made for likely spatial variations in emission rates as discussed below.

In contrast, it was concluded significant new work was desirable to develop procedures for modelling overall transport-related air quality and noise exceedences, though this only seems likely to be worthwhile if a spatially detailed network assignment layer is included within the NTM. The objective here would not be to attempt accurate estimates of individual local environmental impacts, but rather to produce overall, unbiased and transport-policy-sensitive estimates of overall frequencies and distributions of exceedences, by type of location. In addition to refining the allowances made for spatial variations in emission rates as mentioned above, some allowance could also be made for likely spatial variations in pollutant dispersal rates.

Air quality impacts of transport scenarios or policies

For estimating national frequencies of air quality exceedences, there is a danger of systematic under-statement from modelling using average parameter values. The recommendation is therefore to take explicit account of the more significant distributions of parameter values likely to affect emission or dispersal rates, and hence affect the annual frequency of exceedences in particular area types. The estimated transport impacts would be added to background estimates of the concentration of pollutants from non-transport sources obtained from the Department's existing environmental impacts modelling approaches. See for example [Department of Environment, 1997b; NETCEN, 1996]

Two main factors were identified affecting vehicle emissions which are not accounted for in existing methods: frequency of vehicle acceleration and deceleration under stop/start driving conditions, and (probably less significant) time spent ascending and descending gradients. It was considered that all these deviations from driving at a steady speed on the level would typically increase emission rates for some pollutants, so their effects would not cancel out as one might assume.

For assessing likely variations in emission rates by location, it was felt useful progress could be made towards identifying types of local areas where time spent accelerating and decelerating, or ascending and descending, would be a greater or lesser proportion than on average. This would be based on information on road types and junction frequency, and on the distribution of gradients, processed from Ordnance Survey(OS) digitised maps using a Geographical Information System.

For assessing likely variations in dispersal rates by location, the degree to which there are buildings by the road-side, and their heights, are known to be important factors. Again, useful progress could be made by drawing on OS digitised maps, though the absence of building <u>height</u> information in these maps means additional assumptions would be necessary by area (say city centres, suburbs, and non-built up areas) on the proportions of road-side buildings taller than critical heights.

By combining estimated vehicle mileage and average speed changes from the NTM with local distributional information derived in these ways, the likely under-estimation of frequencies of exceedences based on average parameter values would be reduced, and a more reliable (though still only indicative) geographical distribution of transport-sector caused exceedences could be derived.

<u>Transport Noise Impacts</u>

Transport noise impacts estimates would start from base estimates of noise levels taken from the National Noise Incidence Survey (NNIS) of the early 1990s, or an update of this survey. The NNIS covered a sample of a thousand homes across the country, and incidentally showed that transport noise, and in particular road traffic noise, was the dominant source for more than 90% of the population. NNIS data, adjusted to remove major individual transport noise sources (to avoid double-counting) and updated using broad trend assumptions, would provide the base estimates of background noise levels.

Standard transport noise modelling techniques such as those set out in the UK Design Manual for Roads and Bridges [Department of Transport, 1993] would then be applied to the NTM's outputs for major transport links of vehicle flows by time period, to derive associated noise impact corridors. These would then be superimposed on the background noise distribution. The result would be the required distribution of noise levels by area reflecting NTM estimates of vehicle travel patterns.

<u>Calibration of air quality and noise impact relationships</u>

The relationships needed to convert NTM vehicle and average speed outputs to incremental air quality and noise impacts would in general be calibrated and cross-checked using detailed local models, though where adequate survey information is available this could also be used.

7. CONCLUSIONS

A significant programme of feasibility work on National Transport Modelling for the United Kingdom has been undertaken, in parallel with consultation on the likely value of a NTM and on what priorities should be for such a model.

Consultation has identified a considerable degree of support for a NTM as a potentially valuable tool to inform the development and evaluation of national transport strategy on a consistent and integrated basis.

The Feasibility Study consultants' recommendations are that a range of feasible options exist for developing a NTM which would meet many of the Department's main policy analysis aspirations, and would also be capable of supporting a potentially useful national transport environmental impacts assessment post-processor.

A key factor differentiating options for the NTM is the degree of accuracy sought in representing transport movements at a spatially detailed level. This will have implications for the model's capability (both in estimating transport patterns and in deducing environmental impacts of transport), and for the costs and potential risks of development.

Although the estimated development costs are not reported here, it is clear they would be significant, and given tight budget constraints value-for-money will need to be considered carefully in reaching a decision on whether to proceed with NTM development or not; and on what form of NTM to develop should it be decided to proceed.

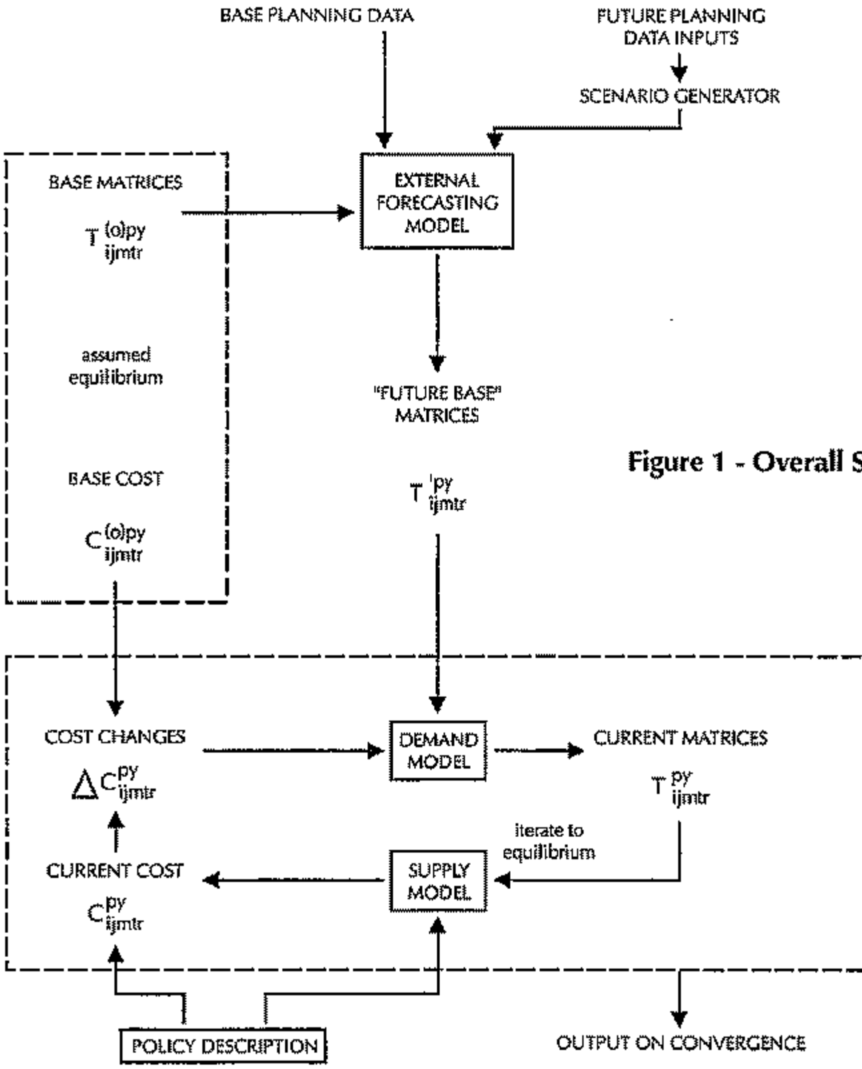
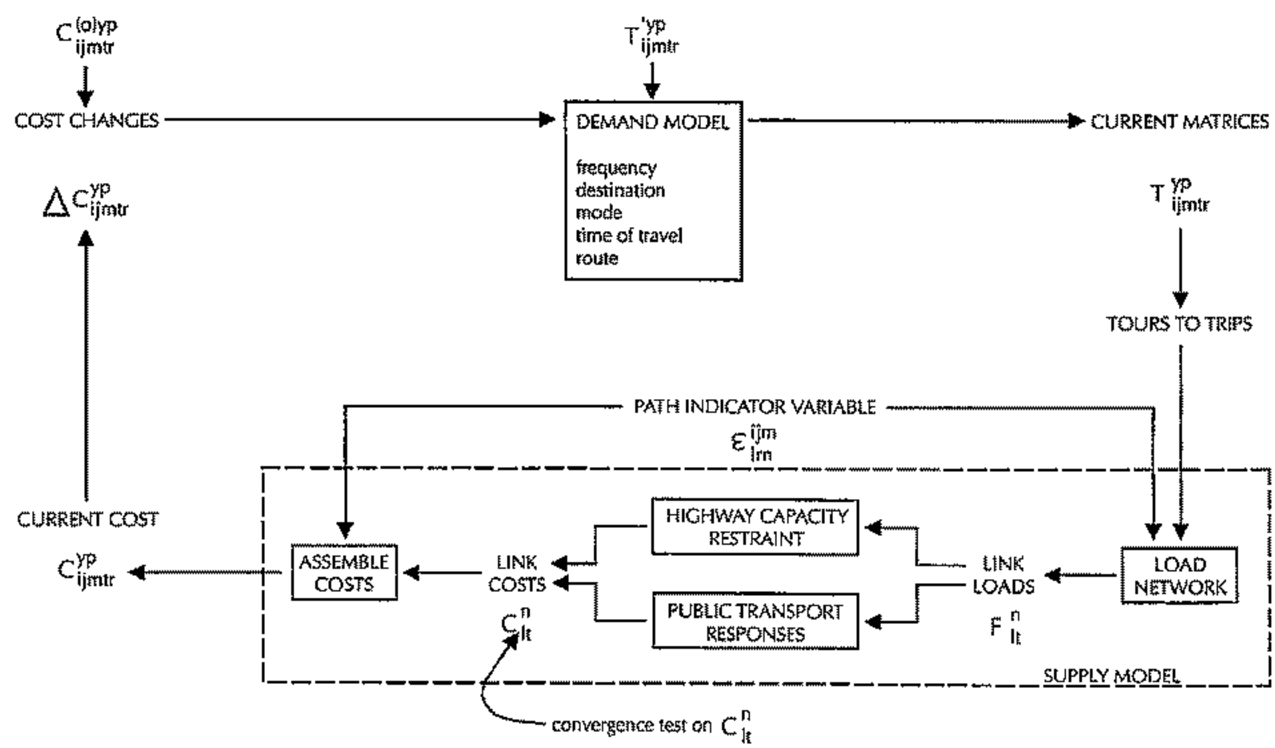


Figure 1 - Overall Structure of NTPM

Figure 2 - Internal Structure of NTPM Supply/Demand Equilibrium Module



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