Victoria Transport Policy Institute
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Telephone: 250-360-1560 | email: Info@vtpi.org

Making the Most of Models

Using Models To Develop More Effective Transport Policies And Strategies

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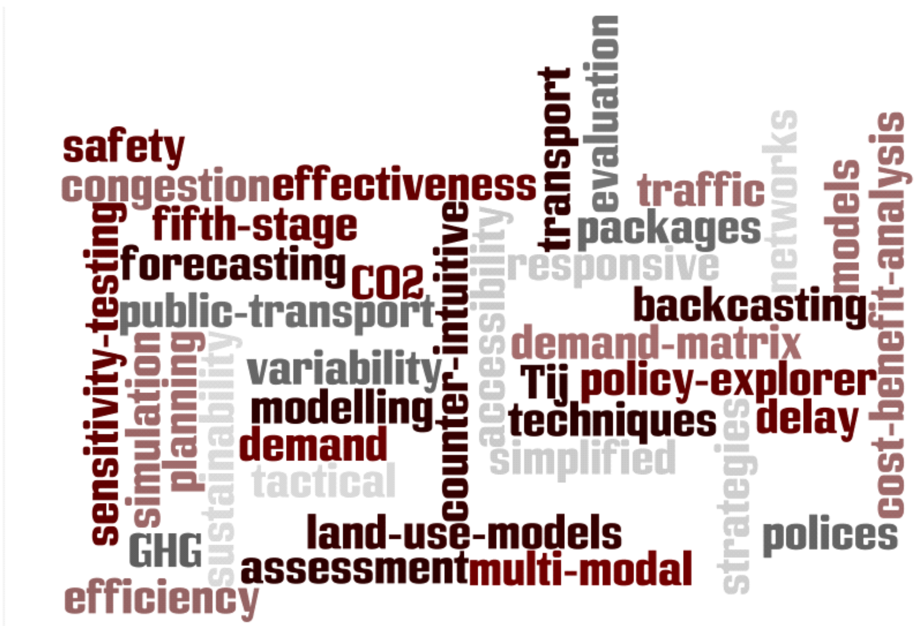
By
Peter Furnish and Don Wignall

Peer Review
Luis Willumsen (Steer Davies Gleave)



Abstract

This paper reviews the role of conventional transport models in the development of transport policies and strategies. This is followed by an exploration of the additional contribution that simplified models could make, if these were made more widely available.

An example of a simplified model, developed in New Zealand, is described to illustrate the use of this type of modelling for policy and strategy development purposes.

The paper concludes that conventional transport models and simplified models could play greater roles in supporting the development of transport policies and strategies.

Executive summary

Overview

Modelling has the potential to provide the transport sector with a quantified understanding of current and future issues. This is very important if different parts of the sector are to be better connected and if future actions are to be coordinated and integrated. Forecasts from models have the potential to provide the sector with a common overview of current and future transport conditions and also to forecast the likely effects of transport policies and strategies. This paper considers how the potential offered by modelling can be turned into reality.

Due to the variable level of understanding amongst transport professionals, modelling is often perceived to be a difficult subject. However despite this, engagement on the subject of modelling is needed to inform and support the development of more effective transport polices and strategies.

Increasingly, transport professionals need to demonstrate their appreciation of the wider economic and social context they are working in and also have to respond to the effects of environmental externalities arising from transport. This means that models also need to adapt to reflect these widened requirements.

To use models successfully, transport professionals require an appreciation of the range of modelling techniques available and also an outline understanding of the capability and suitability of models for different tasks, circumstances and challenges.

The current global economic downturn has demonstrated that models need to have the potential to deal with the risk and uncertainty associated with decision making and that conventional transport models, because of their fairly fixed nature, are unlikely to be adequate for sensitivity test purposes.

In writing this paper an attempt has been made to avoid the use of formulae and ‘jargon’ wherever possible. However, as this topic involves numerous technical terms associated with the development of methodologies, a ‘Glossary’ of modelling terms has been included at the end of the paper.

Is a model required?

Modelling often plays some part in the development of transport policies and strategies, but the precise role of modelling is rarely well developed or widely understood in these processes.

Although the whole subject of modelling is often perceived as a very complex one, it is important for transport professionals to appreciate that the output from most models can usually be produced in easily understood summary formats, and provide useful forecasts of the potential performance of policy and strategy options.

Policies direct the effort of the transport sector towards defined objectives, whatever these might be, for example to promote economic growth and to improve safety.

Strategies organise the way that policies are implemented, and ensure that actions are complementary rather than contradictory.

As a first step in developing policies and strategies, it is important to clearly define the task in hand. This starts with clarifying the purpose of the task, the scope of the issues or problems being considered and the nature of the objectives being addressed. It is only once the purpose, scope and objectives are thoroughly understood that data and analytical requirements can be determined and specific modelling requirements identified.

The development of policies and strategies (and in fact all other transport tasks, including model specification) needs to occur within the context of an overall assessment and evaluation framework.

It is of course possible to produce transport policies and strategies without recourse to modelling, but even when this is the case, may result in policies and strategies that are either ineffective, short-lived, or that have unintended or even counter-productive consequences. If suitable models are identified and appropriately used, this will inform and assist the development of effective transport policies and strategies.

Transport models

Conventional transport models replicate current levels of demand, movement patterns and system capacities, in order to form a detailed transport system representation for analysis and forecasting purposes. This detailed representation provides a potentially powerful resource for forecasting and for policy and strategy development purposes. However, conventional transport models also have substantial limitations in terms of 'suitability and responsiveness' for such purposes.

The 'classical' transport model consists of four main stages, namely: attraction/generation, distribution, mode choice and assignment. Due to their structure, conventional transport models tend to be useful for analysing current conditions, forecasting the effect of future 'business as usual' type strategies and for testing the performance of network improvement options. These models are predominantly applied as part of detailed programme investment decisions. There is significant potential for this type of model to play an increased role in policy and strategy development when more strategic characteristics are incorporated into their construction.

However, even if conventional transport models are significantly extended in capability terms, some policy and strategy options will remain difficult to fully test using a four stage approach. Conventional transport models therefore need to be supplemented by other techniques, such as simplified modelling, when assessing the effects of transport policies and strategies.

National transport models are required to provide the centre with the overall 'big picture', to estimate the effectiveness of future national transport policies and strategies, and to establish planning and investment priorities at the national scale.

Simplified models

Simplified models can be thought of as being highly aggregated representations of the transport system, with the ability to respond to changes in policies or strategies, and to forecast the resulting variations in demand. This means that a broader range of policy and strategy options testing can be undertaken, using simplified models, than is often possible using conventional transport models.

Simplified models can be constructed using a variety of source material, depending on the required purpose and the availability of data. These models have the potential to provide a rapid, flexible and cost effective testing capability, and to supplement the outputs from conventional models.

Simplified models are likely to be of most value if they provide an overview of transport issues, make model techniques more accessible and deal with pricing and behavioural issues better than alternative calculation methods.

An example from New Zealand

An example of a simplified model, the Strategy Review Model, has been constructed in New Zealand. The model illustrates a way of using outputs from conventional *'four stage'* transport models to provide a more flexible, or *'fifth stage'*, testing tool and this has been used to assist in the development of transport policies and strategies.

The model consists of a series of linked modules that have been applied at the national, regional and corridor scales.

An educational interactive version of the model has been developed, called the SRM Communications Model, and which is now available via the following web link:

http://www.transportfutures.net/CommunicationsModelV_PA_1.html

Conclusions

Models are required in order to develop effective and lasting transport policies and strategies. These models will be most effective if a wide range of transport professionals have access to modelled outputs to inform and support policy and strategy development.

Conventional transport models are a valuable resource and are very useful for network planning and project options testing. There is much potential to improve conventional transport models to make them more suitable for policy and strategy development and such improvements would be very worthwhile. However, even if all conceivable improvements were made to conventional transport models they would still be unable to address all required policy and strategy issues.

There is a need to employ supplementary and simplified modelling techniques to address the structural problems associated with conventional transport models. Simplified modelling techniques have the potential to engage a wider professional audience and to assist in 'reconnecting' the transport sector.

Making the most of models

Contents

1 Introduction

1.1 Purpose

The purpose of the paper is to explore the potential role of models in the development of transport policies and strategies.

The paper argues for the increased use of appropriate modelling to provide a common forecasting and sensitivity testing capability and to assist in connecting currently fragmented parts of the transport sector. The paper then goes on to discuss how this might be accomplished.

Modelling is often regarded as a difficult subject by many transport professionals. However, models are essential for policy and strategy development processes and discussion on the subject is needed if models are to be utilised in the most appropriate ways possible.

This is not intended to be a guide for expert modellers or academic researchers, but rather the paper is intended for transport professionals who are interested in the role that modelling currently plays within the transport sector.

The paper reviews a range of modelling approaches, the current types of available model and the factors that affect the choice of models.

The paper goes on to consider how the use of models for policy and strategy purposes could be improved and supplemented by simplified modelling, to provide an overview of transport issues and the ways in which models could be made more understandable and accessible to transport professionals.

1.2 History

The rise of transport planning as a profession was originally synonymous with the development of transport modelling. Transport planning as a profession is deeply rooted in the systems based transport modelling techniques developed in the USA in the 1950's, *'..the transportation planning process has developed using a sequential series of models to deal with individual parts of the problem..'* (Bruton, 1985, 271).

Consequently, the first transport planners relied very heavily on modelling and the concept that urban traffic is a direct and predictable function of the land use that generate them (Mitchell & Rankin, 1954). This approach was developed in several early studies, including those in Detroit (1955) and Chicago (1956) and became a standardised approach representing *''..a new science of urban transportation planning, which for the first time claimed to be able to scientifically predict future urban traffic patterns.''* (Hall, 1988, 328).

It is still true today that conventional transport modelling underpins most large transport planning projects, especially for major transportation studies and for the evaluation of major new transport investments (Litman, Nov 2008, 2).

This paper raises issues that are common to many developed western countries, including Europe, Australia and the USA, however, many of the examples quoted are drawn from recent experience in New Zealand.

Since the birth of the transport planning profession nearly half a century ago, there have been many changes in the transport sector. For example, many more transport professionals, a minority of who can now be described as transport planners, are now employed, in comparison with earlier decades. Registered transport professionals in NZ rose from around 100 in 1974 to almost 900 in 2008 (Douglass, 2007)[1]. Many of these 'new' transport professionals are engaged with a diversity of modes and associated issues and may only rarely encounter model based techniques.

Typically, national transport systems can be thought of as having been developed over a long period of time, on the basis of government investment decisions, in response to changing priorities, demand levels and economic requirements.

Policies and strategies are used to implement objectives through the management and development of the transport system, and can be described as follows:

- The use of higher level transport policies (typically developed through '*policy analysis'*) is normally undertaken as a centralised activity, although some operational policy issues are undertaken on a regional or urban area basis.
- The implementation of strategies (typically developed through *'transport planning'*) represents a large proportion of transport sector activity (in terms of effort and expenditure) and this tends to be dominated by transport planning, which is primarily undertaken at regional and project levels.

The development of modelling techniques, since the early development of systems based models has improved the ability to replicate real world conditions, especially in terms of:

- The detailed operational performance of the transport system
- Responses to changes in circumstances or network conditions.

However, it has not yet proved possible to produce fully detailed and sufficiently responsive models that can fully reflect both detailed operational aspects and also deal with a wide range of behavioural issues. This has limited the usefulness of conventional models for many policy and strategy development purposes.

Over recent decades, the transport sector as a whole has expanded in scale and complexity, changing from a sole focus on operational issues, such as the speed and reliability of the transport system, to include a range of wider social, environmental and economic objectives. This has lead to widened roles for policy analysts and transport planners and a range of other professionals. Town planners and strategic planners need to interface with transport planning as part of their wider planning considerations. Engineers also have a substantial involvement in the design, justification and implementation of policies and strategies.

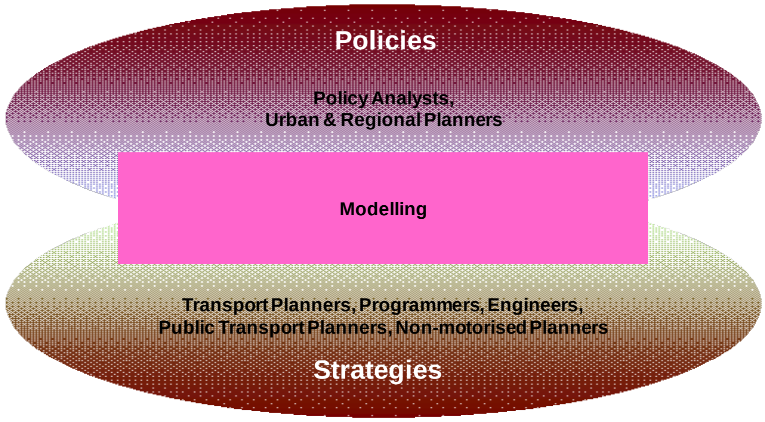
Nowadays most transport planners, analysts, planners and engineers are likely to be non-modellers. The modelled information available to these transport professionals is often partial and may not provide a balanced overview of transport conditions and associated effects.

Most transport professionals are now unlikely to have any direct access to models, despite the now widespread availability of computers, the wide computer skill base in the workforce and the large number of commercially available software products now on the market.

[1] This is in contrast to the overall employment trends in the transport sector as a whole which employed 14% of the total workforce in 1973 but only 4% by 2005 (Douglass, 2007).

All transport professionals would benefit from supportive modelling (see Figure 1)

Figure 1: Development of the transport system



1.3 Current issues

At the highest level, a transport system may not fully reflect 'top down' aspirational policies and strategies. In particular, there is a divergence between required outcomes and expected future business as usual outcomes. In recent times there has been an increasing gap between the required outcomes for transport systems and the actual achievement of progress towards these outcomes. A review of required trends for the transport sector found that: *''..in 11 out of 12 directional statements, the trends are neutral or in the wrong direction..''* (Transit, 2007, 4).

In the explanatory note for recent legislation the following comment was made: *''There is a strategic gap between the vision and broad objectives in the NZ Transport Strategy and their implementation''* (LTMAB, 2008). A prime contributory factor to this 'strategic gap', is that in practice, transport policies and strategies are implemented as a result of the accumulated efforts of many individuals, working to a diversity of detailed processes, which often include the application of conventional modelling methods and outputs.

Criticisms of the transport planning process (and by implication of conventional transport modelling) include that, at the operational level the process has historically been *..'too concerned with the technical problems associated with traffic estimation and network planning...'* and has also considered: *'.. too few (if any) alternative plans and policies for inadequately defining goals and objectives and basing the evaluation of alternative proposals solely on economic grounds..'* (Bruton, 1985, 56). Since this time there have been improvements to transport planning and modelling practice but these advances have often proved to be marginal, for example:*'... the differences between first and second generation model systems have often been overstated..'* (Otorzar and Willumsen, 2006, 20) and on the subject of initiatives to undertake more realistic 'activity based' modelling: *...' While the approach promised an improved theoretical approach, there is still no cohesive theory..'* (Hensher, 2007, 72)

These issues have lead to the wider transport sector being 'unconnected' in the sense of lacking a collective quantified view, lacking a common understanding of the specific transport system conditions and lacking a common view of associated external issues. There may also be a lack of understanding about how policies and strategies are to be achieved and a lack of consensus on the likely effects of current policies and strategies, even if they are capable of being implemented. This lack of connection and consensus in the sector has resulted in an inability to direct and refine policies and strategies effectively in order to achieve objectives.

Monitoring analysis is clearly essential to indicate the past and current effects of policies and strategies. However, by its very nature monitoring only 'looks backwards' to give an indication of the overall direction that we were moving in. Sometimes monitoring is used to establish trends that are then projected to produce indicative forward trajectories which can be useful for short term comparison purposes. However, in contrast to 'trend trajectory' analysis, models offer a superior forecasting capability and also the facility to test alternative future approaches, and so can play a key role in informing professionals of likely effects of policies and strategies. These approaches can be extended to include 'back-casting' methods (VIBAT, 2006) but this too can only be achieved through the use of models.

To summarise, since the birth of modern transport planning, the transport sector has continued to invest in and to utilise models, but at the same time, the sector has become increasingly disconnected from supportive, appropriate and comprehensive modelling techniques.

1.4 Basis of models

A very simple outline of the basis on which models are developed is discussed below:

- Models are simplified representations of reality and are: ..*''problem and viewpoint specific..''* (Ortuzar and Willumsen, 2006, 2) and therefore models only make a partial contribution to the decision making processes associated with policy and strategy development.
- Models are usually computer based programmes that represent selected factors and that allow part of the real world to be imitated. Most model users purchase and use software designed by others.
- Models facilitate data handling and manipulation through a set of assumed relationships.
- Models have the potential to replicate current transport conditions, to forecast future effects and to provide a numerate basis for informed discussion purposes (including between professionals within the transport sector).
- Models provide the forecasts needed to undertake the quantified assessment of future policy and strategy options.
- All 'conventional' transport models are made up of mathematical formulations and arose from systems based planning dating back to the 1950's. They are typically composed of a maximum of four stages, namely trip generation, distribution, mode choice and assignment (see Section 3 and Glossary)
- Essential though conventional transport models are, they have limitations and the paper reviews the need for further supplementary approaches (see Section 4).

Transport policy and strategy development is particularly suitable for model based applications because transport, unlike some other sectors, can draw on extensive source data and well established analytical and forecasting techniques.

The increased complexity and fragmentation of the transport sector over time has lead to the use of specialised modelling techniques that are often aimed at relatively narrow aspects of transport. More comprehensive model based techniques to identify overall trends and outcomes, especially at the strategic scale, are often unavailable (Wignall, Dec 2008)

1.5 Report structure

The remainder of the paper is structured as follows:

- A range of possible model forms are available and questions concerning their use and selection are discussed in Section 2.
- The potential value and limitations of conventional transport models are explored in Section 3.
- The need for simplified modelling and the contribution that this could make is described in Section 4.
- A simplified model developed in New Zealand, called the Strategy Review Model, is outlined in Section 5 to provide an example of simplified model application for policy and strategy development purposes.
- The main conclusions of the paper are contained in Section 6.

2 Is a model required?

2.1 Initial questions

Are policies and strategies really necessary?

Policies direct the effort of the transport sector towards defined objectives, whatever these might be. Without an explicit policy framework, different professionals are likely to pull in different directions depending on their individual philosophies. Policies need to be well constructed and tested before adoption if they are to be effective. It is also important to identify and resolve potential conflicts between different policy elements, to produce a consistent and co-ordinated policy framework.

Strategies are ways of organising how policies should be implemented, to ensure that actions are complementary and productive, rather than contradictory and hence unproductive. For example, individual proposals may be worthwhile when considered individually, but when considered in combination with other proposals they may not make sense (NZTA, 2008). Reasons to thoroughly test strategies in advance of implementation, and to thereby avoid unproductive combinations of proposals, include:

- Subsidise rail services and bus services to serve the same routes, when rail services are operating below capacity because travel is encouraged by cheap and slow bus services.
- Build new peak period road capacity for general traffic, whilst improving public transport services along the same corridor, when the net effect is to induce traffic growth, increased congestion and no increase in public transport patronage.
- Build a new road to accommodate general traffic growth and then toll both the old and new roads, when this has the effect of reducing demand levels to within the capacity of the old road.

All policies and strategies have positive and negative aspects, and the assessment of options is needed to allow optimum polices and strategies to be determined.

Why is modelling so important – can't we manage without models?

Where policies and strategies are developed without recourse to modelling, these are likely to be ineffective, short-lived, have unintended consequences and may even be counter-productive.

Modelling is only one component within policy and strategy development, but modeling is very important because of the need to forecast the individual effect of policy and strategy options and also to forecast the interactions between different policy and strategy components.

Modelling often plays some part in the development of transport policies and strategies, but the precise role of modelling is rarely well developed or explicitly defined. If models were more appropriate and were better applied, they would considerably enhance the formulation of policies and the development of strategies.

What do I need to know about modelling?

Although the whole subject of modelling is often perceived as a very complex one, it is important for transport professionals to appreciate that the output from most models can be produced in easily understood summary formats suitable for forecasting policy and strategy performance.

A very broad understanding of the overall modelling process, the primary inputs involved and the meaning of the main model outputs is probably needed by transport professionals. Transport professionals do not need to be programmers, but simply need to be able to ask some basic questions of models and to be able to interpret any results appropriately.

Very few people, even those who may be described as 'transport modellers,' are actually involved in the development of 'modelling theory', which is really the preserve of a select few academics and professional researchers.

What are models used for?

The predominant use of models is to analyse operational issues, such as travel speeds, network delays and the capacity for movement between areas by different modes.

However, models can also be used to estimate other important impacts, such as fuel use, emissions, air pollution and casualties.

Model outputs can be obtained that can act as useful proxies for objectives, for example: economic growth (multi-modal travel times and capacities for travel and transport between economic nodes), health (active mode use, casualties), environment (emissions, pollution)

How can you tell that a model is needed?

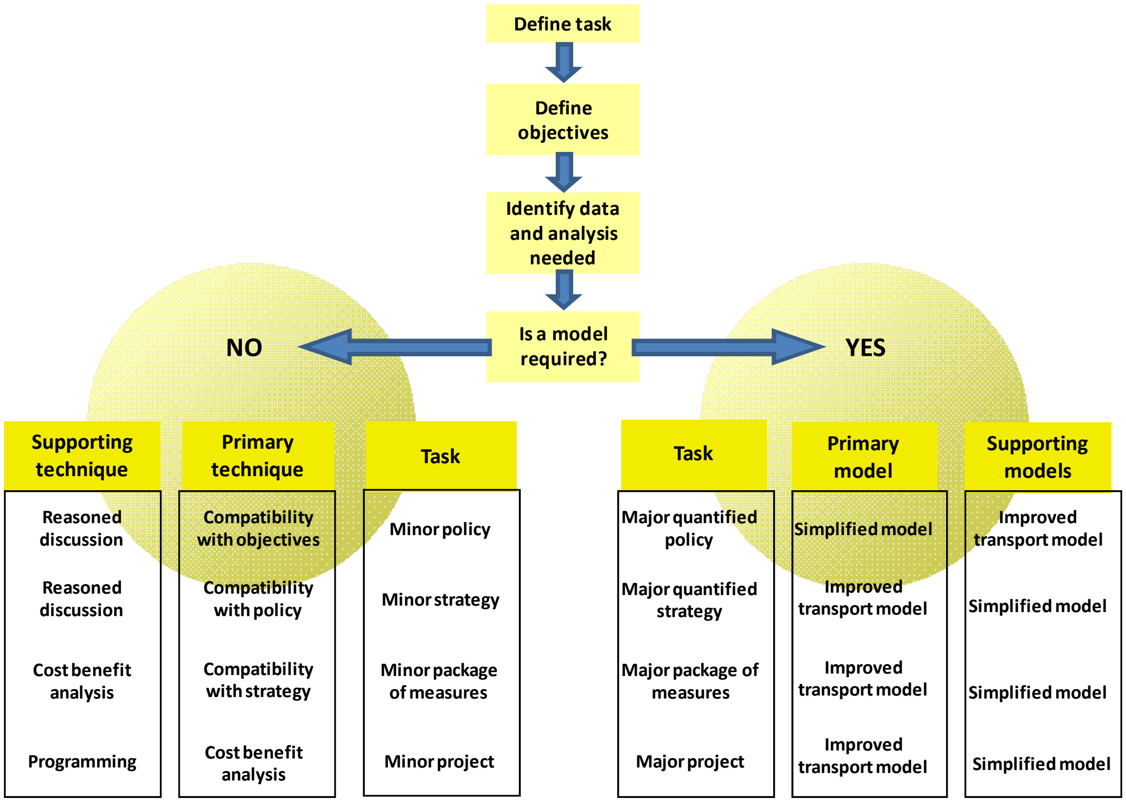
As a first step in developing policies and strategies, it is vitally important to clearly define the task in hand. This starts with clarifying the task purpose, the scope of the issues or problems being considered and the nature of the objectives being addressed. It is only once the scope and objectives are thoroughly understood that data and analytical requirements can be determined and specific modelling requirements can be identified.

The development of policies and strategies (and all other transport tasks, including model specification) needs to occur within the context of an overall assessment and evaluation framework (see Figure 2).

It may be possible to undertake some simple tasks through an examination of available trend data, a review of literature, discussion and consultation. However, without some quantified forecasting and options testing capability using a model, confidence in any conclusions drawn is likely to be limited.

Policies and strategies that are not based on quantified forecasting and options testing are likely to be inadequate and short-lived.

Figure 2: Is a model required?



<u>In what context should a model be used?</u>

It is important that model development takes place within an overall assessment and evaluation process (DfT(1), 2009, Webtag Units 1.1 and 2.1: EC, 2003, Boulter & Wignall, 2008, 3.3)

A range of other processes interact with and are affected by modelling (see item 7.1 and other aspects of an overall study process shown in Figure 3)

<u>When could it be too complex, costly, time consuming or risky to use or develop a model?</u>

It is important to use the most appropriate method to undertake a task within time and resource constraints.

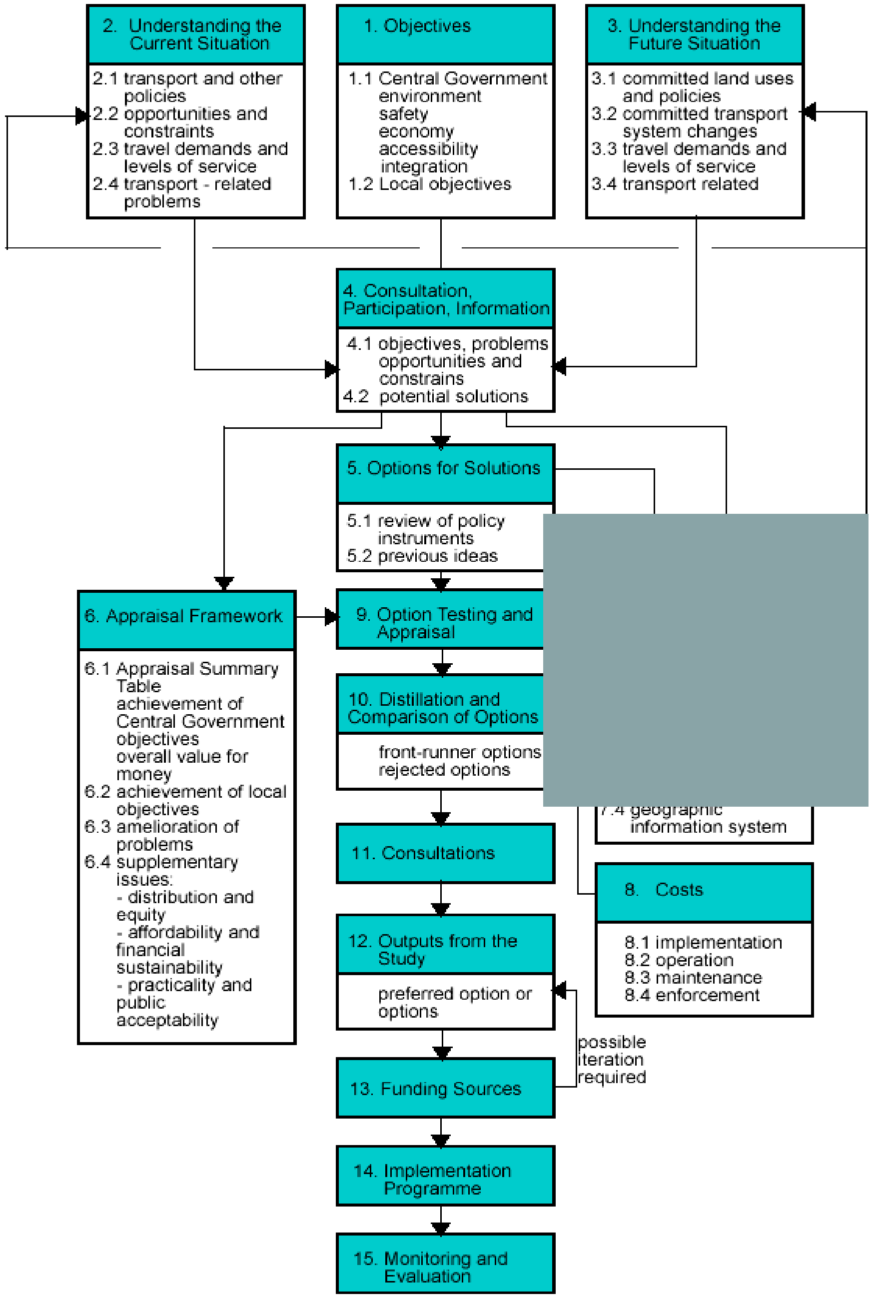
In most cases, if the task is short-term, the most practical course of action is likely to be either to use an established model or to make use of commercially available software.

<u>Should a general 'standing' model be developed for an area and maintained in perpetuity for use with all potential tasks in the future?</u>

Although a general model is useful for many tasks, and will form a good basis for further analysis, such a model is unlikely to be sufficiently comprehensive to be suitable for all tasks.

For example a conventional transport model for an area may not adequately represent all modes or may not be suitable for testing price-based or other policy measures.

Figure 3: Modelling in context



__Can models be counter-productive?__

Yes, if models are used for the wrong purpose, especially if they are over relied on for answers to questions they were never designed to answer. For example, a road traffic model may be very useful at describing operational conditions along a transport corridor and to develop road improvement proposals. However, such a model is unlikely to be able to adequately represent freight or public transport modes, either of which could materially affect the road based improvement being considered.

The task being undertaken will vary according to spatial scale and the type of options to be investigated. In turn this affects the nature of data, analytical and modelling requirements as indicated in Table 1 below:

Table 1: Establishing the nature of modelling requirements

Scale	Options to be investigated	Data, analytical and model requirements
Developing **national** transport policies and strategies (multi-modal or single mode)	Alternative investment, management and national pricing measures.	Strategic representation of networks, trends and forecasts.
Developing **regional** transport strategies and programmes (multi-modal or single mode)	Alternative investment, management and regional pricing measures.	Regional representation of networks, trends and forecasts.
Developing integrated packages for **local areas or corridors** (management and improvement)	Alternative investment and management measures.	Wide area or corridor options testing.
Developing individual proposals for a particular **route or services**	Investment and management options.	Localised area options testing.

What are the other arguments against models?

Difficulties with models could include:

- Models may be unreliable or may mislead.
- Models may be limited or silent on some important aspects.
- Models could be intended to be used only for project assessment and for the testing of relatively marginal network changes.
- Models may not make sense when compared with other data such as trend based projections.

In some circumstances, each of the above may be true, but the majority of problems associated with models are caused by their inappropriate specification, use or interpretation, rather than any inherent problems of particular models.

When is a model not a model?

Sometimes the term ‘model’ may be misapplied to refer to basic techniques, such as simple regression analysis and the projection of past trends into the future. This should not be called a ‘model’ but this terminology is sometimes used as ‘convenient shorthand’

The use of the term ‘model’ should be limited to a technique that is capable of not only forecasting future conditions, but also that is able to test the potential effects of future options.

How can models improve economic performance?

Models can identify whether or not the substantial national resources planned to be used for transport purposes are likely to be effective.

Models can tell us a lot about the effectiveness (or otherwise) of investment programmes especially in terms of gauging the investment efficiency of policies, strategies and projects: *…'better modelling…'* leads to …*'better investment decisions'…* (DFT (3), 2009)

However, even most sophisticated models have limitations and cannot be used to provide guidance on all aspects of the linkage between transport and economic growth. In particular, care should be taken when interpreting modelling results (Furnish and Wignall, 2009).

2.2 Selecting a model

It is important to follow an ordered process when considering model selection, to:

- Clearly establish the task purpose, objectives, issues and outcomes to be addressed.
- Identify data, analytical and assessment requirements.
- Review the potential for different types of model to support task requirements.

There is a world of difference between a well scoped model that is fully appropriate for policy and strategy development purposes and a model that is only suitable for very limited project type applications. With sufficient forethought and resources, highly versatile and useable models can be created to support policy and strategy development, in a variety of formats.

A number of authoritative model guides aimed at modelling professionals have been published (Hensher, 2007: Ortuzar and Willumsen, 2006: TRB, 2006: BTE, 1998: IHT, 1996) and these contain technical outlines for a range of different modelling techniques.

For transport professionals without a detailed modelling knowledge, suitable literature is more limited, but some useful modelling reviews in this area have been undertaken (Litman, July 2008: IHT, 2001: RTPI, 1998)

For policy and strategy development purposes, two main model types are commonly used, namely:

- *Conventional' three and four stage transport models*: These are the most commonly used in practice and are extensively available (see Section 3 and Glossary).
- *Simplified models*: These are sometime applied to make rapid progress in particular circumstances (Section 4).

A simple typology of models is suggested in Table 2 below, in the context of policy and strategy development.

Table 2: Simple model typology

Group Classification	*Model Sub-Type*	Examples	Purpose	Strengths	Weaknesses
Educational	*N/A*	*METS, COM, GUTS, PLUTO*	Illustration of typical effects and relationships	Clarity and simplicity	No practical application for policy and strategy development
Simplified models	***Simplified demand***	*TPM, STM, SRM, Regression based spreadsheet models,*	Simplified representation of selected aspects of the transport system	Responsiveness, flexibility, speed	High degree of aggregation.
	Structural models	*UMOT, Scenario building models*	High level relationship model	Speed and simplicity-multi-modal	Based on very broad relationships.
	Sketch models	*START, Strategic transport models*	High level simplified representation of a conventional transport model	Speed and simplicity-multi-modal	Based on conventional transport model techniques
Land use models	*N/A*	MEPLAN, DELTA, UDM	Representation of land use and associated activities	Interactive capability (with transport models)	Experimental models difficulty in accurate forecasting
Conventional transport models	***Transport models*** *(three or four stage)*	*EMME, TRACKS, VISUM, CUBE, TRANSCAD, TRANSIM*	Detailed representation of the transport system, including aggregate and disaggregate/activity based approaches	Detail of the data, network representation and analytical depth	Lack of responsiveness to changes in price or behaviour.
	Assignment models *(single stage)*	*SATURN, CONTRAM, VISSIM, AIMSUN, PARAMICS, SISTM*	Network (usually road traffic) assignment models	Precision	Reliant on estimated inputs on demand or input from higher-level models
	Operational models *(traffic engineering)*	*TRANSYT, SIDRA, LINSIG, Operational spreadsheet models*	Localised capacity analysis	Precision	Reliant on simple assumptions or input from higher-level models

Many other model 'brands' apart from those mentioned above are also available (LTT, 2009).

'Educational' type models (Ortuzar & Willumsen, 2006, 425) are very helpful for training purposes and to develop mental models (Hensher, 2007, 2: Ortuzar & Willumsen, 2006, 395) of transport behaviour. In fact it is hard to overstate the value of education and training in modeling, as reported at a recent UK workshop:

'In discussions it was suggested that education and training in modelling techniques has essentially missed a generation; for reasons which appear completely accidental. Thus the task to be accomplished is not simply to build on existing technical modelling training as this is so insufficient at the moment. The task seems to be to create that base training; and also to ensure that it is excellent.' (DfT (4), 2009)

Interactive 'land use' type models also have a very important and specialist niche role (Chan, 2005: Timmermans, 2003). However, if an interactive land use model is not used it is still important to test the effects of alternative land use patterns prior to developing transport 'solutions' to a 'given' land use pattern.

Other conventional transport modelling techniques are also available, for example:

- *Variable demand modelling, car ownership forecasting, public transport modelling and matrix estimation.* These are often either supportive or component techniques, rather than representing comprehensive models in their own right.
- *Accessibility models, travel time variability techniques, freight models, safety models, emissions models and pedestrian models.* These tend to be used as speciality models or 'one-off' study topic tools or are generally 'ancillary' to overall policy and strategy development.

Comprehensive packages offering a full range of conventional transport modelling capability, through from strategic modelling down to micro-simulation are rare, and in most cases a decision will need to be made as to which 'model component' to use.

How detailed should the model be?

The level of detail in a model depends on a number of factors, such as the number and size of zones, the level of segmentation of travellers (for example, in terms of car ownership or income), the treatment of single trips or combinations of these in 'tours', the number of attributes used to describe links (capacity, speed, lane widths, flaring of approaches, signal timings, side friction, etc). However, even setting aside the issues of costs and time, it is not always the case that the most detailed model is the most accurate for forecasting purposes. Two other factors have a strong influence on accuracy: the quantity and quality of the data and the 'forecastability' of those inputs for future years.

It is always possible to fit very complex and detailed models using sufficient data so that they represent the observed base year reasonably well. This gives confidence in the model based on the fact that the model 'validates' and the data, for example on population and income levels and distribution in each (small) zone is accurate. However, it is often the case that the forecasts for these future inputs in small zones are much less reliable than for more 'coarse' zonal representations, because of inherent uncertainties (about population, age and income distributions) of the data. The forecasts of population and income (in general those items in the dotted boxes in Figure 4 in Section 3) are likely to be more accurate for larger zones and less detailed segmentation.

The most useful model must strike a balance between realism (greater detail) and forecastability. For strategic models that forecast transport performance many years ahead, simpler models tend to be more appropriate. For tactical decisions, such as traffic management measures, a greater level of detail, for example using micro-simulation models, is likely to be required. In the ultimate analysis, the modelling effort (time and money) must be related to decision making risk (for example, that Plan A is better than Plan B) and the costs associated with making a wrong decision.

Often, more than one model will be required for policy and strategy development purposes, and when this is the case, it is very important that models are linked and complementary.

The final choice of model is also likely to be related to cost, familiarity and personal preference.

2.3 Modelling practice in New Zealand

New Zealand does not have a national transport model, although some national spreadsheet models have been developed centrally for specific purposes (see further discussion on national modelling in 3.5 below).

With the odd notable exception, for example the TRACKS[2] four stage model and associated suite of programs, there is little 'home-grown' software choice available in New Zealand and the main sources of model software are from Europe, Australia and the USA.

Multi-modal four stage models have been developed in a number of major urban areas, including: Auckland, Wellington, Christchurch, Hamilton and Dunedin.

More localised conventional transport models are available for many other urban areas, but these models are of varying types, quality and spatial coverage.

A large amount of modelling resources are devoted to single stage traffic assignment modelling, using simulation, micro-simulation, traffic engineering network and junction modelling. It is also common for local area and corridor studies to be road network based and to use traffic assignment models.

Some international modelling practice, for example, with respect to the treatment of induced traffic (Webtag, 2.9.1) and suppressed demand (MVA, 1998), can sometimes be regarded as 'not-applicable' to New Zealand conditions, and may therefore be omitted from the development of current models.

2.4 Modelling needs

In many respects modelling is a very complex field and the application and interpretation of models can be very technically difficult tasks.

There is however, a danger in over-reliance on a relatively few 'expert modellers', who often have to focus on technical issues related to the justification of new projects (Mees and Dodson, 2006, 11: Bruton, 1985, 56), rather than being asked to select the most appropriate modelling techniques in support of policy and strategy development.

Some transport models, for example micro-simulation, are subject to highly detailed representation, which appear to be very realistic. However, the assumptions used, for example with respect to future traffic demands, in this type of modelling need to be made explicit, clearly understood and the results appropriately interpreted. This modelling needs to be connected to other areas of transport practice, especially the treatment of other modes. If micro-simulation is used on the basis of poor assumptions, or in isolation from wider considerations, it will produce very precise, but inaccurate, results.

[2] Developed by New Zealand consultancy Gabites Porter

There is often an absence of comprehensive 'overview' modelling which means that many transport professionals are left without a quantified appreciation of the 'big picture' in transport (Wignall, 2008). In particular, the *'..need for changes in the relationship between modellers and transport planners. However, the greatest problem is to close the gap between public understanding and transport policy and models could help to close these gaps, but need to work much harder as tools to deliver a dialogue between transport planners and users.'* (Halden, 2002).

The difficulties of providing transport professionals with supportive modelling include:

- Increasing specialisation and fragmentation of roles within the transport sector.
- An increasing scarcity (in terms of the proportion of total professional transport work undertaken) of analytical and modelling skills within the sector.

Both of these factors have resulted from the expansion of the sector and the range of different backgrounds of the personnel now engaged as transport professionals. This makes it all the more important to provide highly accessible models to a range of different individuals for a variety of purposes. If models appear to be a 'black box' then they will be of limited use. If models appear inaccessible, then this is not the fault of the potential end user.

There are many reasons why transport professionals should seek a greater involvement in modelling. For example of useful non-expert involvement in models is the role that other professionals can play in spotting 'anomalies' in model results, especially when modellers get 'too close' to the mechanics of the modelling process.

In summary, there is a need for suitable models to be identified, and for these to be appropriately used, in order for models to play an increased role in supporting the development and implementation of more effective transport policies and strategies.

3 Transport models

3.1 What are transport models?

The term 'transport model' is commonly used to refer to the dominant form of model used in developed economies for transport planning purposes, namely the 'classical' four stage transportation model. In this paper, the term transport model is often replaced with the term 'conventional transport model' to differentiate it from other model types, such as educational, simplified or land use models, each of which also has an important role to play.

Conventional transport models describe current levels of demand, replicate current movement patterns, define system capacities and thereby provide a detailed representation of a transport system for analysis and forecasting purposes. This detailed representation of the transport system, provides a potentially powerful resource for policy and strategy development purposes. However, conventional transport models also have substantial limitations in terms of their 'suitability and responsiveness' for such purposes.

Conventional transport models have been developed for many urban areas and road corridors in New Zealand, although the scale, type, quality and age of individual models varies considerably between locations.

The term 'transport model' has become synonymous with the four stage model process and this type of modelling is integral to the training of transport planners. For this reason, to many transport planners, the consideration of alternatives or supplements, to overcome some of the inherent deficiencies of four stage modelling for policy and strategy purposes, is almost unthinkable. This attitude is reinforced by the nature of the day to day 'project based' tasks that transport planners have to undertake, which depend on results from conventional transport models. There is also likely to be little if any financial or other incentives to experiment with alternative modelling approaches.

In giving consideration to modelling options, many transport planners may also be limited by their knowledge and mathematical understanding of modelling theory. This may be one reason why few transport planners appear to become leading 'modellers' and why those from other backgrounds, for example, from mathematics or physics, are particularly attracted to modelling. This may reinforce the perception of modelling as a highly technical and academic discipline, rather than a supportive discipline that is closely linked to the practicalities of policy and strategy development.

Conventional transport modelling typically requires:

- Demand data describing travel between zones, and
- Network characteristics, describing the capacity of the linkages between zones.

The movement patterns described by the model are then checked (or validated) against actual travel flows on the network. Future changes in population, car ownership, land use patterns and networks are used to assist in the prediction of future travel volumes, movement patterns and operational conditions.

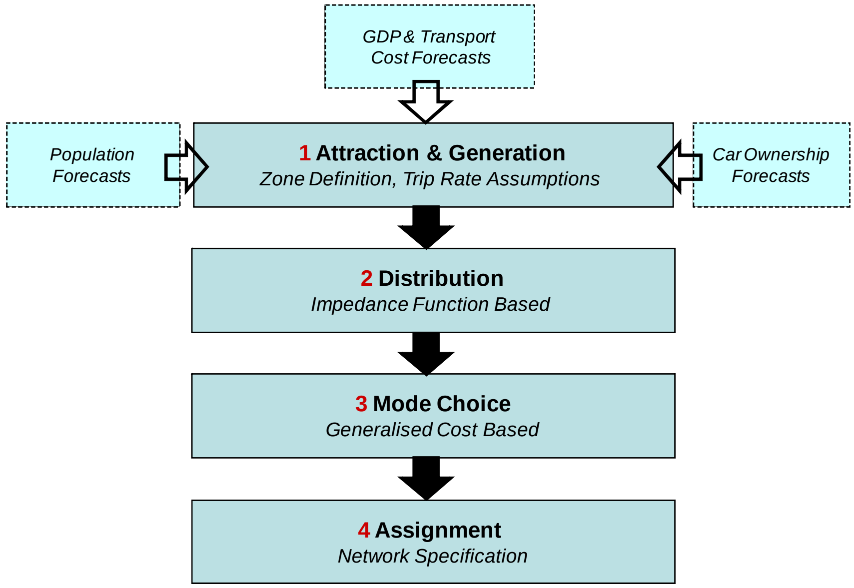
Transport models typically have up to four stages, see Figure 4, namely:

- *Stage 1 Trip generation and attraction*: The amount of travel generated by or attracted to different land use type zones. The basis for this is the observed level of current trip attraction and generation.
- *Stage 2 Trip distribution*: The amount of movement between each zone pair. This is a critical component of transport models is the function used for the trip distribution stage. The traditional approach to this has been to assume that the amount of travel between two zones is represented by a 'gravity' function incorporating the scale of the activity in each zone and the difficulty (or 'impedance') in travelling between them.
- *Stage 3 Mode choice*: The use of modes for movement between zones (not undertaken for 3 stage models)
- *Stage 4 Trip assignment*: The exact routes or services within the network used for inter-zonal movement.

Another stage is sometimes added to this list, namely the choice of time to travel. This is useful in representing more accurately 'peak spreading and also to account for larger time shifts, such as shopping at off peak times to avoid delays. However, following convention, we retain the 'four stage' terminology in this paper.

It is not uncommon for several models at different scales to co-exist within major urban areas. For example, there could be a strategic four stage model, a more detailed traffic assignment model, a public transport model and a local area micro simulation model, all within a particular area. However, these are simply applying the same basic 'conventional transport model' methodology at different levels of detail and/or spatial coverage.

Figure 4: Conventional four-stage transport model



3.2 Building a transport model

The theory behind the basic four stage model is well established, but in fact there is a wide range of choice available as to the exact way that conventional transport models are developed. Many alternative techniques are available to model builders for application within a four stage framework. This discretion on the choice of detailed techniques can have a large effect on model outcomes. So much so, that there is really no such thing as a 'standard' conventional transport model.

Figure 5 illustrates some of the key choices to be made when constructing a conventional transport model.

Figure 5: Conventional transport model choices

Strategic	Intermediate	Tactical
Disaggregate	Partly disaggregate (segmentation)	Aggregate
Variable demand	Partly variable	Fixed demand
Multi-modal	Limited mode representation	Simple mode
Macroscopic network representation	Mesoscopic network representation	Microscopic network representation
Dynamic	Limited dynamic aspects	Equilibrium
Interactive land use	Limited interactivity	Fixed land use
Policy responsive	Partly responsive	Policy non-responsive

It would be possible to employ several 'state of the art' techniques, in the development of a conventional 'strategic' transport mode. The selected techniques could include: a high degree of disaggregation, variable demand techniques, dynamic functions, interactive land use capabilities, comprehensive multi-modal representation and pricing responsiveness. The result of such a combination could create a highly sensitive and powerful tool that would be useful for many aspects of policy and strategy development.

Such a flexible and responsive tool could however, be extremely difficult and resource hungry to build and maintain. A fully comprehensive conventional 'strategic' transport model, unless developed as a 'simplified' strategic model (see Section 4), is likely to be very costly, potentially cumbersome to use and therefore many of its capabilities may never actually be required in practice.

Conversely, if a purely 'tactical' conventional transport model was constructed, this might result in an aggregate, fixed demand, single mode, equilibrium type model. Such a model would be much easier to build and maintain than a more strategic model and could be used to evaluate simple project options in certain circumstances, but this model would be of very little use for comprehensive policy and strategy development purposes due to its narrow focus (ITS, 2005).

Given that budgets and timeframes are always limited, in practice, most conventional transport models represent a compromise between what could be undertaken and what is possible in practice.

Most conventional transport models lie somewhere in-between the strategic and tactical model extremes described above and could be termed 'intermediate' in terms of these characteristics. As a result, the full potential of conventional transport models is rarely realised in practice.

Furthermore, even though the methods and principles of four stage modelling are well established, there remains considerable scope to vary the detailed specification and the governing principles to be applied. For example, supposing a decision has been taken to incorporate a gravity model type approach for trip distribution, there remains a range of choice as to how to apply this gravity model. This could extend to approaches based on least cost, entropy, utility, efficiency or several other options (Erlander & Stewart, 1990, 100-104). There are many similar decisions at many points throughout the specification and detailed construction of a model, the type of car ownership forecasting method, the specification of the mode choice function, land use representation and so on, each of which could materially affect model performance and the potential responsiveness of the model to changes circumstances, policies or strategies.

It should also be emphasised that there is a large potential difference between the theoretical strength of a particular technique adopted and its applicability to behavioural responses in the real world. It cannot be assumed that by replicating the current transport network conditions that this will necessarily be a suitable basis for forecasting the effects of policies and strategies.

3.3 Strengths and weaknesses of transport models

The best current approaches to transport planning in New Zealand are represented by multi-modal (four stage) strategic models in the main metropolitan areas

Transport models are typically good at:

- Representing personal travel by private car modes.
- Collating and organising survey data.
- Analysing 'operational transport' aspects, including: traffic volumes, road capacities and resultant travel system mobility as expressed in terms of road travel times and delays.

- Producing forecasts of future operational road network conditions under future *'business as usual'* ('expected future conditions based on current policy settings, expected land use change and anticipated expenditure)
- Testing the potential effect of potential road network improvement options or public transport service changes, especially in comparing the relative effect of different 'do-something' options under 'business as usual conditions'

Conventional transport models represent a substantial and indispensable resource to the sector in terms of the capture and analysis of detailed information regarding current trip movement patterns and traffic volumes.

In New Zealand, the recently completed Auckland Region strategic model is probably the most advanced, with major public transport and interactive land use model components. Strategic transport models in Wellington and similar models being developed in Christchurch and Hamilton, also represent good current New Zealand practice in the field of conventional transport modelling.

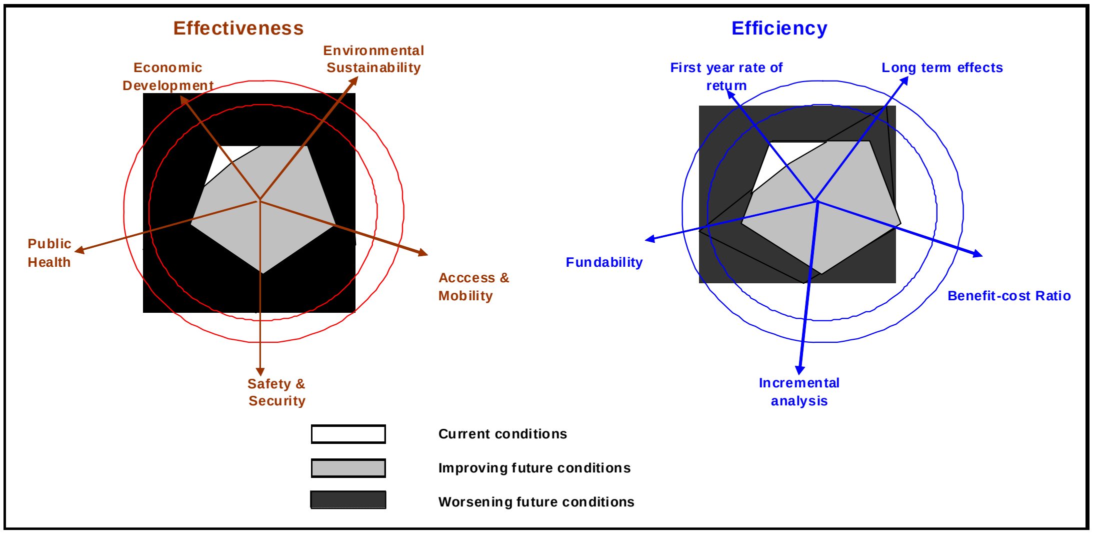
However, conventional transport models commonly have a number of shortcomings:

- Interactive land use models are rare and land use is normally treated as an input only.
- Very few transport models fully allow for induced traffic effects (completely new trips arising from increased network capacity)
- Some are not suitable (without substantial modification) for testing pricing and policy options and none can handle travel behaviour change initiatives correctly.
- Four stage models are not good at representing: non-car modes, especially non-motorised modes, localised (intra-zonal) movements, freight modes or long distance modes.
- Four stage models are limited in terms of forecasting public transport use (MVA, 2007) due to their heavy reliance on forecasts and assumptions that are external to the modelling process (for example, population, car ownership, land-use and economic conditions)
- Three stage models are used in some major urban areas and major corridor studies, but these models can be fatally flawed for policy, strategy and 'integrated package' development purposes, as they cannot deal with multi-modal or inter-modal issues.
- Reviews have confirmed that models are neither precise nor accurate (Flyvbjerg and Buhl, 2006: National Audit Office, 1998) and are only intended to forecast the general level of future demand, associated transport system performance and related outcomes.

The main use of conventional transport modelling is in the evaluation of transport network improvement options, especially road projects. *''the four stage model...was primarily designed for the analysis of urban highway investment. This remains its most likely function...,''* (Hensher, 2007, 20).

However, transport objectives now extend far beyond operational transport considerations for private car traffic, and include requirements to contribute to economic growth, better health, safety, accessibility and environmental and economic conditions (Figure 6). For these and other purposes, such as testing non-motorised mode initiatives, alternative freight strategies, demand management options or price-based measures, conventional transport models are limited and other approaches are needed (ARC, 2009)

Figure 6: Forecasting the future performance of policies and strategies



The limitations of four stage models are largely are due to their inherent structure and the assumptions used in their construction. Four stage models are primarily concerned with private car travel and use external forecasts (such as income, car ownership, population and land use). In combination, these factors tend to make models unresponsive to options testing techniques. This means that (without substantial modification) most conventional transport models are unable to be used for a variety of important purposes, such as testing the effects of potential variation in fuel price, changes in vehicle operating costs, parking price changes, road toll charging, public transport fare changes, changes in parking supply or public transport service changes.

Many models are still based on fixed (or virtually fixed) demand matrices (Goodwin, 2004). This has several implications, especially in terms of a lack of realism in operational terms with implications for economic appraisal.

Further problems with models can occur if they do not contain ‘dynamic’ aspects (Goodwin, 2005). This is because conventional transport models usually represent a sequence of ‘equilibrium network conditions,’ for each future forecast year. However, responses to changes in travel conditions, in terms of choice of time, route, destination or mode are not instant and delayed responses of different types are likely to occur. Some changes in behaviour may not be reversible and the order in which measures are implemented is also likely to affect outcomes, even if the same final conditions (policy variables) prevail in a particular target year. Truly dynamic models would be able to incorporate these effects and should therefore produce more realistic and useful results.

A significant proportion of current modelling in New Zealand is single stage (assignment) and single mode (road traffic). Considerable resources are also expended in the related field of micro-simulation, which is (in most applications) a graphical extension of traffic engineering. Other operational models are also used for network, link and intersection traffic engineering type analysis. Useful though these assignment and operational models are for certain purposes, these precise techniques can tell us little about the overall performance of the transport system and the opportunities available for policies and strategies to meet wider objectives. Great care is needed to avoid assignment and operational modelling being undertaken as part of a traffic engineering centered approach to policy and strategy development.

Conventional transport models are therefore useful, but if used as the sole or primary tool for strategy and policy development, will tend to reinforce traditional transport 'predict and provide' type planning. If policy and strategy is dominated by conventional transport modelling, then this is likely to act as a limiting factor in addressing and achieving objectives (Litman, 2009). Conventional transport models often need to be supplemented when forecasting the effects of transport policies and strategies.

Conventional transport models also need to be more transparent, for example, Nock, 2008, has called for the modelling fraternity: *'..to change by making more of an effort to include the end-users at a far earlier stage of model development. Why should people listen to modellers?...at present, clients often have only the haziest idea of what transport models can actually do for them.'*

It is important that models are as balanced and appropriate as possible, whatever the purpose, and many of the points made in support of better policy and strategy modelling in this paper, can also be applied to project based modelling.

3.4 Future improvement potential

In an ideal world, all existing transport models would be improved and appropriate models would be comprehensively and be seamlessly co-ordinated at the local, regional and national scales.

In fact, improvements in conventional transport model theory <u>are</u> continuously occurring (Hensher, 2007) but in practice, progress in developing advanced conventional transport models has been slow.

The following improvements to conventional transport models would assist policy and strategy development:

- Model scope to include reference to overall objectives in addition to operational and technical criteria.
- More extensive survey and stated preference data
- Better data verification methods, to ensure model results are plausible, especially when compared with results from other geographic and topic areas.
- Consistent definitions (e.g., level of service criteria) and analytical techniques (e.g. network and service representation) to reflect good practice in the sector.
- All significant models to be four stages (unless clearly inappropriate)
- Variable (not fixed) demand matrices, fully allowing for induced traffic where network capacity is increased.
- Improved intra-zonal and localised travel representation.
- Allow for the interaction of land-use planning with transport supply.
- Include convenient policy and strategy option testing capabilities during model development.
- Incorporate longer distance representation of travel and transport issues, including external movements, beyond the detailed modelled area, where possible.
- Allow convenient and affordable access to models for all potential users.
- Provide suitable information for public communication and education purposes (especially in terms of graphical presentation format)

Finally, no matter how good the model is, it is very important that the specification of tests and the interpretation of results are also appropriate. For example, the questions asked of the model need to be balanced and the reasoning applied to the interpretation of results needs to go beyond a simple (often traffic engineering based) 'predict and provide' approach.

3.5 National scale transport modelling

Most of applications of conventional transport models are at the regional, urban or project scales. However, for policy and strategy development purposes it is also very important to have multi-region or national scale option testing capabilities that can forecast effects and review policies and strategies for longer distance movements.

New Zealand does not currently have a national transport model, although some spreadsheet models have been developed centrally for specific purposes. These include, a national vehicle fleet emissions model (VFEM), a national land transport fund (NLTF) forecasting model and a national tourist demand model. These models are very useful for their intended purpose, but do not address the full range of policy and strategy issues and are not widely available.

Various other national scale models have been developed in the past, including a national safety model, a national freight model, a rail emissions model and a state highways model, but none of these are currently operational.

The development of a national transport model requires careful consideration, especially in terms of purpose, scope, type, modal representation and level of zonal and network aggregation (Lundqvist, 2002: Land Transport NZ, 2007).

For example, a national 'network' model could take the form of a conventional transport model and represent trips between zones. If so it is likely to be helpful in terms of representing longer distance movements, but such a model would have difficulty in adequately representing local trips, which make up the overwhelming majority of journeys. The coarse nature of such a model would mean that, it could not be used for network capacity assessment purposes. In classification terms, a national network model is likely to lie somewhere between a conventional transport model and a simplified (strategic) model.

Other approaches for multi-region or national scale modelling include:

- An operational 'traffic' based model (for each mode) can represent all movements on a selected network (HA, 2003). Such a model could be validated and used for capacity analysis purposes although it would be very limited in terms of forecasting and future options testing capability
- A conceptual national model, similar to the approach in the UK (DfT (2), 2009) or through a summary type technique, such as used by the SRM National Compiler (TFL, 2009)
- At the national level, and for illustrative purposes only, an interactive educational model has been developed, to demonstrate a range of policy and strategy options, called the SRM Communications Model (see section 5)

4 Simplified models

4.1 What is a simplified model?

Simplified models represent the transport system with a high degree of network and zonal aggregation.

Simplified models can be thought of as *''emphasising the use of readily available data and the communicability of simpler model features and results in order to supplement the information and capability of existing models''* (Ortuzar and Willumsen, 2006, 395).

Simplified models produce mainly 'indicative' or 'approximate' forecasts, rather than conventional transport models which attempt to provide 'precise' or 'accurate' results.

Simplified models also tend to be supplementary models and are unlikely to replace the need for conventional transport models (PTRC, 1992).

Simplified models have the following characteristics:

- The use of summarised data to represent the transport system.
- Application of behavioural relationships and assumptions.
- Provision of a rapid, flexible and cost effective resource.
- Facilitation of tests beyond those possible using conventional transport models.
- Responses to price, supply or other changes affecting behaviour and demand.
- Suitability for a broad range of policy and strategy option test purposes.

4.2 Simplified model types

Three types of simplified model types discussed below:

(i) Simplified demand models:

- *Mode choice models:* Stand alone method, using a variety of alternative mode choice model formats, that can be used to ask 'what if' type questions by varying: service, time, cost and other utility functions.
- *Elasticity based models:* This is a particularly useful approach because conventional models do not normally incorporate elasticities and so an approach based on them offers a useful comparative method. These have the potential to be used in peer reviews of conventional transport models and in some circumstances may represent an alternative method to conventional transport modelling. Elasticity based models are responsive to a range of factors and are able to draw on extensive literature, empirical studies and research, representing a valuable resource for model construction. However, elasticity techniques can be difficult to integrate fully into conventional transport models (Mott McDonald, 2006) and so free standing simplified models are likely to be needed to apply elasticity techniques successfully.

(ii) Structural models:

- *Generalised relationship models:* These are very limited in terms of calibration for localised conditions (Khisty & Sriraj, 1997, Zahavi, 1981)
- *Regression based models:* These are useful for testing future forecasts under different conditions and can involve the development of a purpose designed spreadsheet model incorporating supporting multi-regression formulae. Care is needed in ensuring the independence of the variables being analysed. The quality of associated forecasts (such as income and fuel price forecasts) may also require sensitivity testing. One of the difficulties with this technique involves being able to differentiate between correlation and causation. The availability of a high quality series of past trend data and good forecasts of associated variables are also required to undertake this type of technique successfully.

(ii) Sketch models:

- *Highly simplified conventional transport models:* These have a very restricted numbers of large zones and links. A modified conventional model, together with other strategic assessment techniques were used for strategy test purposes by Fowkes et al, 1998 and Bristow et al, 2002. Another example of simplified modelling testing the effect of different policies on passenger transport and environmental effects was undertaken by Hensher, 2002.

Simplified models can be constructed in different ways, including:

- *Using the outputs from conventional models:* This is good in the sense that it can build on the detailed work and 'business as usual' forecasts of conventional transport models, which tend to be relatively reliable forecasts. This approach is clearly reliant on transport models being available.
- *Incorporating a full forecasting capability:* This has the advantage of removing reliance on external forecasts, but is likely to represent a relatively crude method, requiring extensive checking against current and trend data.

There are many different types of simplified models, but they have some things in common, especially a high degree of aggregation in terms of spatial coverage and network representation.

A number of simplified models have been developed internationally, for example, the Strategic Transport Model, developed and applied in the UK (TRL, 2009).

Simplified models have also been applied in developing countries (Khisty & Sriraj, 1997: PTRC, 1992)

There are also many other techniques that represent elements of simplified modelling, for example: car ownership forecasting and matrix estimation, but these tend to be contributory techniques rather than 'comprehensive models' of the transport system, and so are not described in this paper.

4.3 Strengths and weaknesses of simplified models

Simplified models have a number of strengths, including:

- Potential for greater segmentation of demand type, behaviour and dynamic aspects than is normally possible in conventional transport models
- Speed and low cost of use
- Transparency, ease of understanding and use
- Testing flexibility and accessibility

Simplified models enable policy and strategy option testing to be undertaken when other means are not available.

A particular strength of an elasticity based approach is the range of literature on the subject that can be incorporated without extensive data collection.

Simplified models provide an overview of transport issues, make model techniques more accessible and provide a check on alternative calculation and modelling methods.

However, simplified models have a number of weaknesses, for example they:

- Cannot represent detailed networks and spatial areas.
- Often rely on the transfer of assumed relationships from one context to another.
- Are not normally suitable for detailed project appraisal.

4.4 Applications of simplified models

Simplified demand models, like all models, need to be used and interpreted appropriately and can only ever provide indicative, comparative and approximate answers.

It is important that simplified models do not produce misleading results, order of magnitude type errors or incorrect relationships, any of which would be unhelpful or potentially counter-productive.

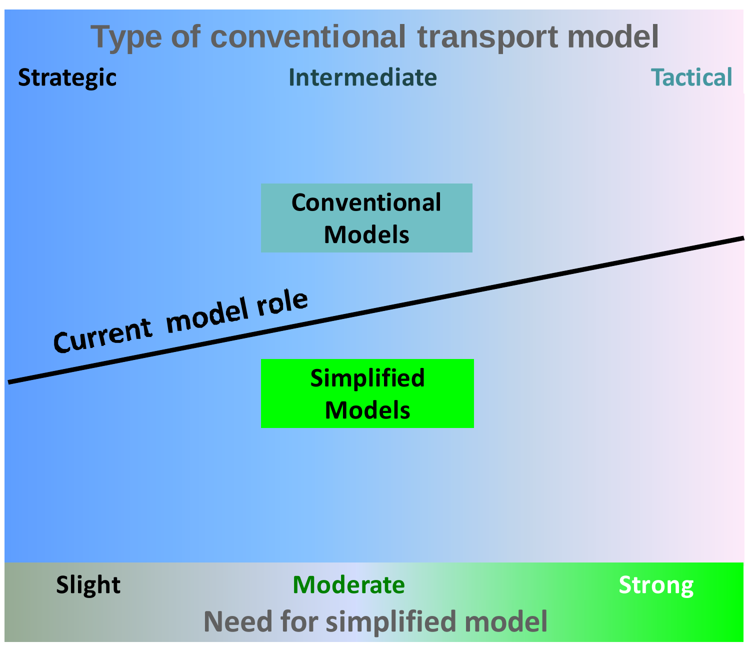
Simplified models may be needed in the absence of other forms of modelling and also when existing models have limitations in terms of sensitivity, flexibility, speed or cost.

Simplified models are required in three main circumstances, namely when:

- Conventional transport models have been constructed in ways unsuitable for broadly based policy and strategy option testing purposes. These could include limited mode representation, a lack of responsiveness to changes in pricing, capacity or other aspects likely to influence behavior.
- For review and calibration purposes, when comparison with conventional models is required.
- Where models do not exist, are unavailable or inaccessible.

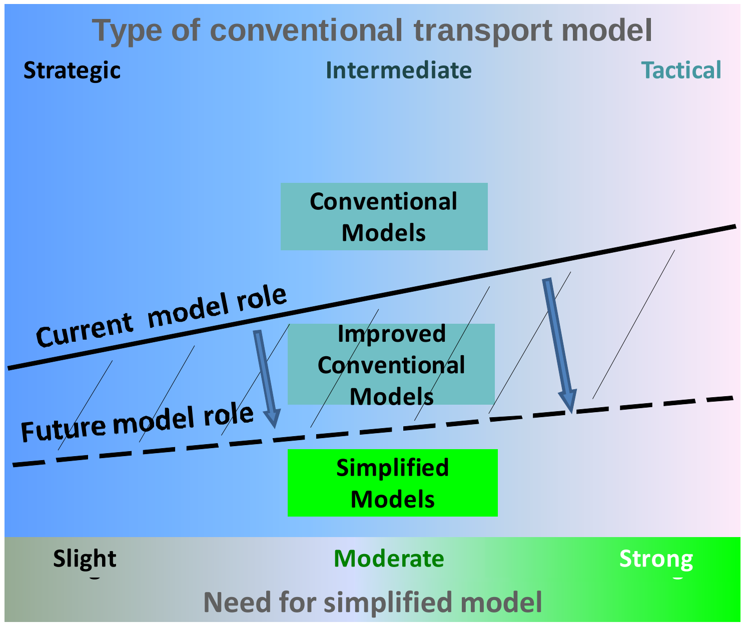
Figure 7 below, illustrates the role of conventional transport modelling in policy and strategy development. This suggests that the greater the strategic nature of the model, the greater potential role for conventional transport models in supporting policy and strategy development. The figure also illustrates the diminished role of simplified models when a conventional strategic transport model exists.

Figure 7: Role of models in policy and strategy development.



The comprehensive improvement of existing transport models, as described in Section 3, is recommended. However, this will inevitably be problematic because of the time, cost and difficulty in doing so. Such improvements to conventional models would be very worthwhile, however even once these are completed, there is still likely to be a need for simplified modelling to supplement existing conventional transport models (see Figure 8)

Figure 8: Role of improved conventional models



It is important that the modelling is widely available, rather than being restricted to a limited number of expert modellers, and that all professionals are able to access and utilise the outputs of supportive models. Not everyone needs to become a hands-on model user, although more transport professionals than ever before have some degree of computer literacy and are therefore fully capable of interrogating simplified models.

5 An example from New Zealand

5.1 Development of a simplified model

In New Zealand, relatively few modelling techniques are available to support the development of:

- National scale policies and strategies.
- Regional policies and strategies (with the exception of network improvement strategies)
- Sub-regional strategies (packages of integrated multi-modal measures in localised areas or corridors)

For these reasons, a simplified model was developed in 2008 to provide a policy and strategy options testing capability. The model is called the Strategy Review Model[3] (SRM) and where possible, this builds on outputs produced by conventional transport models.

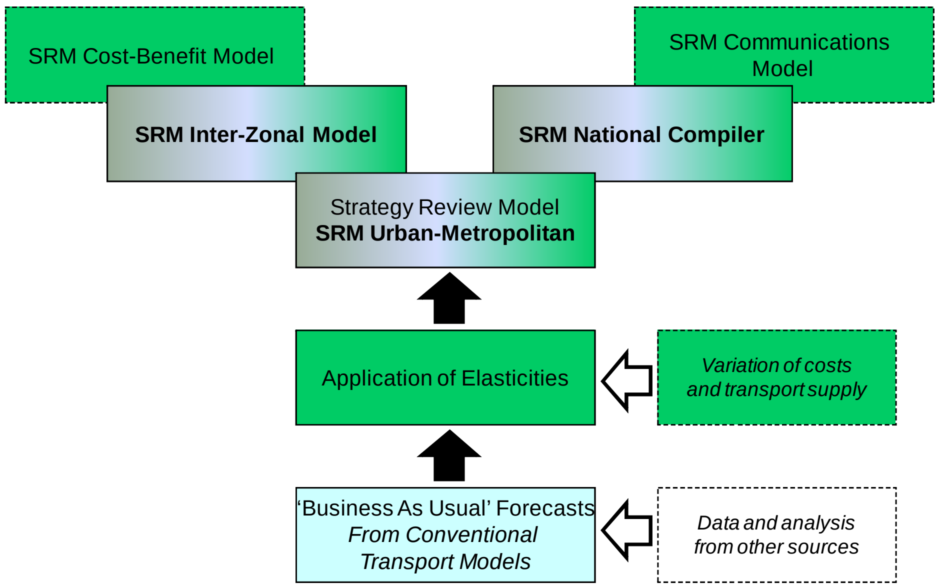
The SRM model is available in three principal forms (see Figure 9):

- A single zone macro-scale model (SRM Urban-Metropolitan Model). This also has a companion facility called the ‘national compiler’ to produce national forecasts when required.

[3] Further details available from www.transportfutures.net

- An educational interactive version has been developed (SRM Communications Model) and is now available via the internet to represent the effects of national policy and strategy options over the period 2007-2015.
- A multi-zone model intended for corridor based studies (SRM Inter-zonal Model). This has a companion cost-benefit analysis facility that can be used to evaluate infrastructure improvements and public transport service options.

Figure 9: Strategy Review Model Components



The initiative to develop SRM arose from the need for a tool to test policy and strategy options and no suitable and immediately available commercial software could be identified.

SRM is 'elasticity based' and incorporates the results from empirical studies and research literature. The model also makes the most of available data and relationships, such as network speed-flow curves, identified from conventional transport models.

The model provides a sensitivity testing tool for the review of potential price changes and supply based measures, such as changes to public transport services, road capacity or other modal investments.

The approach selected was to build on the outputs from conventional transport models, mainly because these outputs were readily available and yet required additional analysis to be of real use for policy and strategy test purposes.

By building on the capability of existing four stage transport models, the approach can be offers a 'fifth stage', for policy and strategy development purposes.

In the short term, it is difficult to see how transport policy and strategy development can be adequately informed and tested without making use of simplified models.

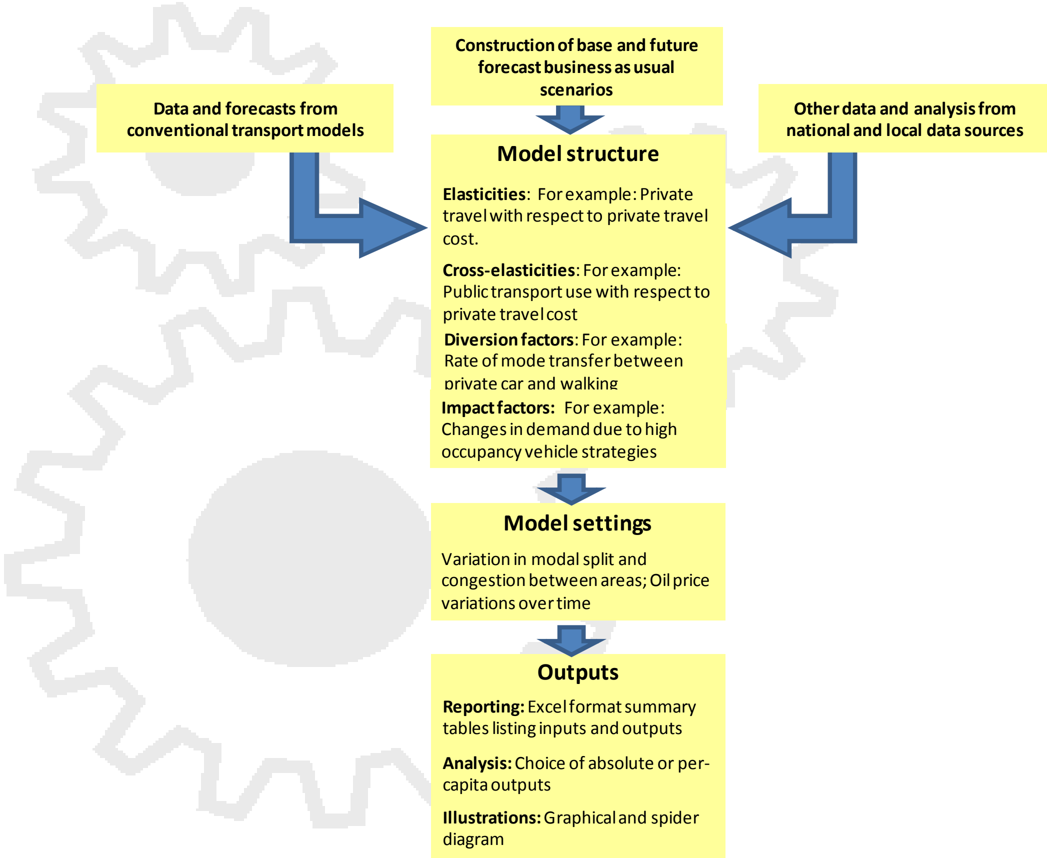
5.2 Model structure

SRM is based on the application of elasticities, cross-elasticities, diversion rates and impact factors. The structure of the model was designed to encompass the primary factors likely to influence changes in modal demand (see Figure 10)

The elasticities have been derived from published studies and research and have been expressed within the model as a plausible conservative range of values with actual elasticity value established within the range by the conditions within each modelled area.

The SRM model is currently set up to forecast demand and to describe conditions and associated effects in defined locations, for a base year (2007) and for selected future years, particularly 2010, 2015, 2025 and 2040.

Figure 10: SRM model structure



The model is designed to test the likely impact of different combinations of changes to various factors (see Figure 11 below), including:

- Public transport service levels and fares
- Private vehicle costs (including those related to road pricing and road building)
- Fuel costs
- Local strategies, such as: travel demand management, network management, intelligent transport systems and high occupancy vehicle strategies.

Following an initial peer review (Willumsen, 2008) the model remains in active development mode, and a number of improvements are planned, including better time period representation. Other improvements to the model are also under active consideration, including the inclusion of freight and safety indicators.

Compromise and approximation has been needed in order to develop the simplified model and these have been documented (TFL, 2009) to allow the results from SRM to be appropriately qualified.

All SRM software is available for trial purposes, on request to www.transportfutures.net

Figure 11: SRM Communications Model - Capability

User Settings	PT Patronage	Distance Travelled	Walking and Cycling	Congestion	Travel Time	Vehicle Occupancy
HOV Investment						X
NMS Investment					X	
ITS Investment				X		
Walking and Cycling Investment	X	X	X			
Public Transport Service	X	X	X	X	X	X
Public Transport Fare	X	X	X	X	X	X
Road Investment	X	X	X	X	X	X
Private Travel Cost	X	X	X	X	X	X

Model outputs

5.3 Applications to date

For any particular application of the model, aggregated base year and future 'business as usual' data are required. The relevant parameters for each location, for example in terms of mode split and congestion, also need to be established as inputs to the model.

SRM has been applied on a number of recent studies, for the public and private sectors, including:

- *Background assessment for New Zealand Transport Strategy (NZTS) 2008 development purposes:* Analysis of outcomes, including, walking and cycling, public transport, single occupancy vehicles, speed, reliability and CO2 for the year 2040.
- *Regionalisation of the 2008 NZTS targets:* Walking and cycling, public transport and single occupancy vehicle targets for 12 regions and 4 unitary authorities for the year 2015.
- *Auckland regional target forecasting:* Review of walking and cycling, public transport, single occupancy vehicles, speed, reliability and CO2 targets for 2015, 2025 and 2040.
- *Integrated corridor transport package assessments:* Corridor based travel planning, road capacity changes and public transport assessments. Including modal demand forecasting, service frequency analysis, private vehicle travel cost changes, fares policy testing and comprehensive cost benefit analysis. Proposals in the Wellington and Waikato regions.

5.4 Model accessibility

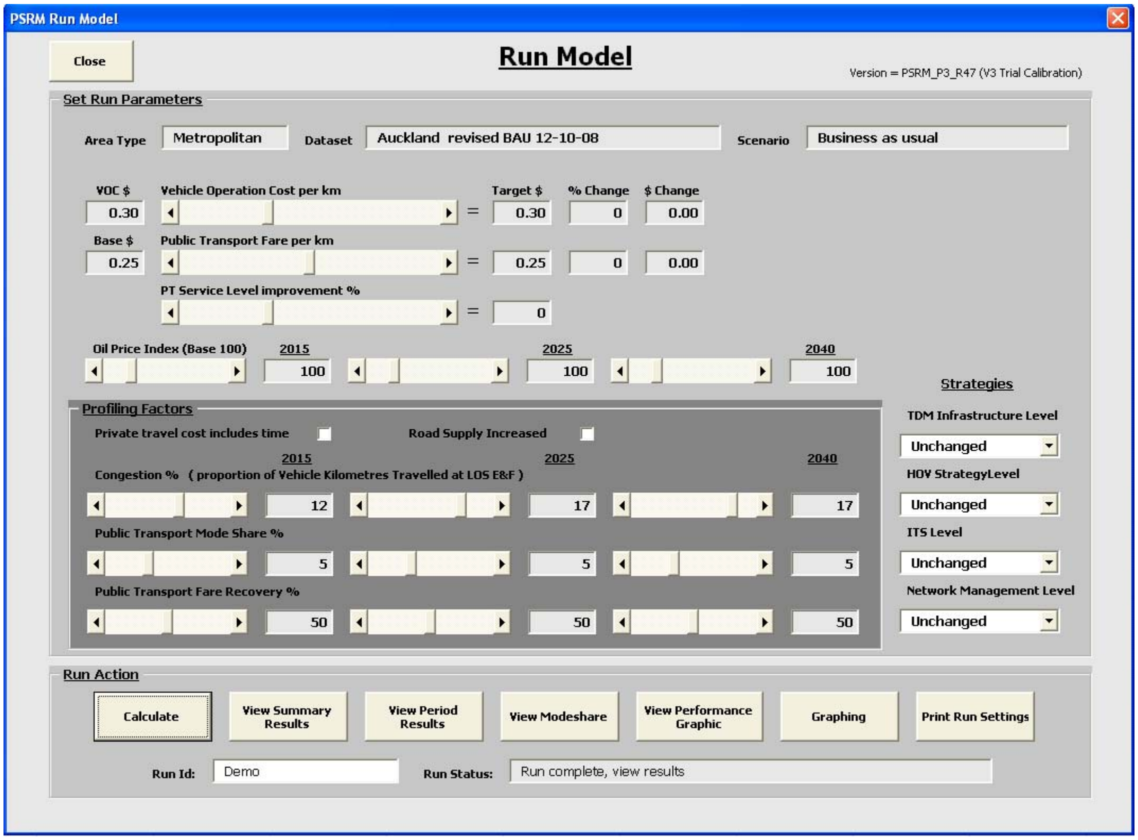
Modelling is often perceived to be a highly complex subject and there are often difficulties in encouraging non-modellers to engage in the subject. Our recent experience of this is provided below:

During the development of SRM, test versions of the software were issued to a range of professionals working in the field of transport policy and strategy development in New Zealand. This experience indicated the following:

- Mental models (Hensher, 2007, 2: Ortuzar & Willumsen, 2006, 395) are currently dominant in the field of policy and strategy development.
- Most professionals have limited confidence in modelling applications, mainly because of unfamiliarity with modelling techniques, a lack of access to models and a lack of user-friendliness of many models.
- Models that appear complex, or that require significant amounts of training, are of very limited interest to most professionals.
- Attractive models that can be instantly accessed and that also produce intuitively plausible results, are well received.
- Models that are highly accessible to a diversity of individuals, for example, via the internet, or intranet of larger organisations, appear to provide the most suitable communications medium.
- Policy analysts do not generally perceive a role for modelling in their work.
- Conventional transport modellers and 'traditional' transport planners are often reluctant to acknowledge the potential added-value offered by simplified models.
- Those professionals involved with the practical implementation and monitoring of strategies aimed at significant changes in behaviour and outcomes, are most likely to value simplified modelling support.

The SRM model has been developed using standard software (Excel and Visual Basic), to enable it to be operated on all personal computers with these programmes. Some additional security features have been included in order to establish version control. A screen shot of the SRM model input control screen is shown in Figure 12.

Figure 12: SRM Urban-Metropolitan Model – Settings



Recent developments in the SRM Communications Model have included the production of versions in PDF and HTML formats, using the more versatile Flash language.

The SRM Communications Model is an educational model, rather than a simplified model, and is therefore not suitable for policy and strategy development purposes. The model controls are represented by simple sliders which are moved by the cursor, and the results for each indicator are displayed interactively on the single viewable screen.

The screen is fitted with information buttons that display when the cursor hovers over them and some further details can be activated by the ‘more’ button.

An automated tutorial slideshow is also provided for ‘first time’ users and more detailed automated tutorials for individual indicators can also be accessed when required.

A screen shot of the SRM Communications Model control screen for public transport, is shown below in Figure 13.

Figure 13: SRM communications Model – Public Transport

The model is currently calibrated to produce national (New Zealand) results and can be accessed available via the NZ Transport Agency SmartMovez web site which contains the following statement:

''*During preparation of the GPS, a computer model was used to look at the impacts of possible interventions. A simplified version of the model, called the transport strategy communication model, has subsequently been constructed. While too general to be used for making specific decisions, we think you will find it very useful for understanding possible interventions and their impact on land transport…*'' (NZTA, 2009)

Alternatively the model can be accessed directly via the following link:

http://www.transportfutures.net/CommunicationsModelV_PA_1.html

6 Conclusions

6.1 Key modelling needs

Models are required in order to develop effective and lasting transport policies and strategies. Models are potentially helpful at all scales, including local areas, transport corridors, regions and at the national scale. Models can establish the current and future operational performance of the transport system and test the effectiveness and efficiency of policy and strategy options.

A national perspective is particularly important for considering overall performance criteria, especially as the standard of local and regional modelling is highly variable, and to inform central planning and investment priorities.

However, models (whatever the scale) are only of real help if they are suitable for purpose and appropriately used. Models can provide approximate forecasts of future conditions and can also be used to estimate the effects of policy and strategy options.

Computer based models are required to provide transport professionals with quantified supportive techniques to assist in the development of effective policies and strategies.

An outline knowledge of modelling should also be regarded as a core skill for all transport professionals.

6.2 Conventional models

Conventional transport models represent a very considerable and indispensable resource to the sector, in terms of the capture and analysis of detailed information regarding current trip movement patterns and traffic volumes. Conventional models are also needed to test future road traffic network improvement options.

Conventional transport models cannot meet all the needs of the transport sector and it would be unreasonable to expect them to do so. This is because the purpose of conventional transport models is (mainly) to predict demand, estimate capacity and to select between significant network improvement options.

Consequently, conventional models are often unsuitable for many policy and strategy development purposes. This is because transport objectives now extend far beyond operational transport network considerations for private car traffic, and include requirements to contribute to economic growth, better health, safety, accessibility and improved environmental conditions. This means that conventional models are often of limited use for testing non-motorised mode initiatives, alternative freight strategies, demand management options or price-based measures. The inappropriate use of conventional models for such purposes has the potential to produce irrelevant or even misleading results.

The support currently provided by conventional models to the development of policies and strategies is therefore limited.

It is important to make the most of conventional transport models to maximize their usefulness for policy and strategy test purposes. There is also considerable potential to improve conventional transport models and to make them more suitable for policy and strategy development purposes. However, the applicability of available models and the quality of assessment they are likely to provide, will vary considerably between areas.

6.3 Additional modelling needs

Even if all conceivable improvements were made to conventional transport models they would still be unable to address all required policy and strategy issues

This is due to the inherent structure of the four stage model, which concentrates on private car travel and their use of external forecasts (such as income, car ownership, population and land use). In combination, these factors tend to make conventional transport models unresponsive to some policy and strategy options testing techniques.

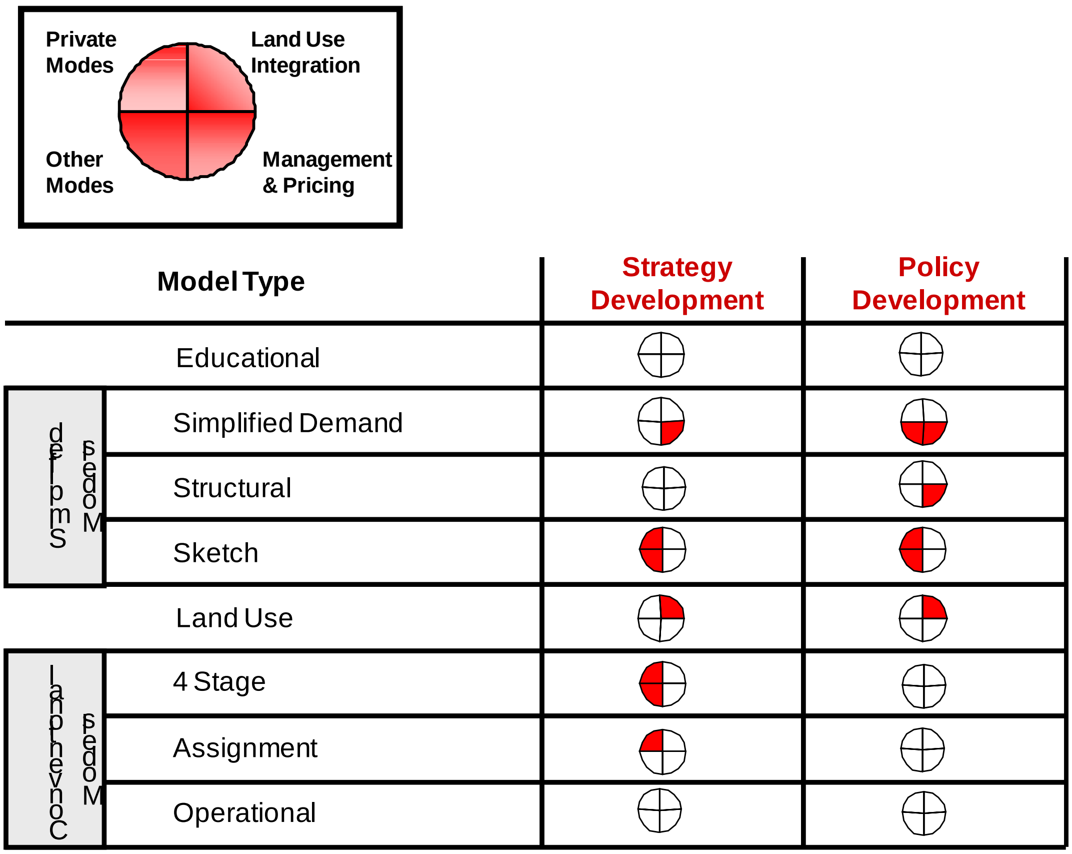
The current global economic downturn has also demonstrated that models need to have the potential to deal with the risk and uncertainty associated with decision making and that conventional transport models, because of their fairly fixed nature, may require supplementary and simplified modelling for sensitivity testing purposes.

6.4 Role of simplified models

There is a need to employ supplementary and simplified modelling techniques to address the structural problems associated with conventional transport models.

Simplified models can be used to test land-use, pricing and management options, which are needed for the development of policies and strategies (see Figure 14).

Figure 14: Role of modelling in policy and strategy development



6.5 Models to engage transport professionals

Modelling has the potential to provide the transport sector with a quantified understanding of current and future issues. This is very important if different parts of the sector are to be better connected and if future actions are to be coordinated and integrated. Forecasts from models have the potential to provide the sector with a common overview of current and future transport conditions and also to provide forecasts of the likely effects of transport policies and strategies.

Simplified modelling has the potential to engage a wider professional audience and to therefore assist in 'reconnecting' the transport sector. Not everyone needs to become a hands-on model user, although more transport professionals than ever before have some degree of computer literacy and are therefore capable of interrogating simple models.

The value of modelling is likely to be maximised if it is more widely understood and available, rather than being restricted to a limited number of expert modelers, and this means providing a wider range of range of transport professionals with access to modelled outputs.

There is a real need to 'reconnect' the transport sector with models that are appropriate for the current needs of the sector and of the professionals working within it. Improved conventional models, simplified models and educational models are all required to achieve this aim.

Correspondence: don.wignall@xtra.co.nz

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Glossary

Modelling is mathematically based, although techniques used in modelling have also been borrowed from many other scientific disciplines. This is one of the reasons that modelling, especially conventional transport modelling is a subject that is full of jargon has the potential to alienate those who are not familiar with it. Jargon has therefore been deliberately kept out of the paper as far as possible, but lay-descriptions of some common terms, either used in this paper or commonly found in the associated literature, are provided below:

- *Activity based model:* The detailed simulation of individual behaviour which is sometimes developed into a disaggregate, four stage, conventional transport model.
- *Aggregate model:* Models constructed using zonal average data (sometimes called 'first generation models' as they originated in the 1950s).
- *Assignment model*: A way of allocating trips from one location to another via specific routes.
- *Attraction/generation:* A method of estimating the number of trips 'generated from' or 'attracted to' each zone, household or land use type.
- *'Business as usual' scenario:* Expected future conditions based on current policy settings, expected land use changes and anticipated transport expenditure.
- *Calibration:* The calculation of factors within mathematical functions used in four stage modelling (for example in the distribution stage to create origin destination matrices)
- *Constrained model:* *Singly constrained models*: where an origin–destination zonal demand matrix is factored by a single growth rate applied to both zonal generations and attractions. *Doubly constrained models*: where a demand matrix has individual growth rates for zonal generations and attractions.
- *Cross elasticity:* Demand for a good or service on the basis of a change in price or a change in the supply of another good or service.
- *Conventional transport model:* The dominant form of model used for transport planning purposes, namely the 'classical' four stage transportation model, often simply referred to as a 'transport model'.
- *Deterministic approach:* An approach based on certain fixed consequences arising from changes in explanatory variables.
- *Direct demand model*: Where mode choice calculations are applied specifically to identified trips between particular origin destination pairs
- *Disaggregate model*: A model based on individual behaviour patterns, usually grouped into segments (and sometimes called second generation models as they were derived in the 1970s and 1980s)
- *Discrete choice:* Where a single choice between two modal options is calculated.
- *Distribution model:* A way of estimating the locations that generated trips will be attracted to, through the use of techniques (commonly using an impedance function based on the time or cost of travel) to create an origin-destination demand matrix.
- *Diversion rate:* Rate at which mode change occurs between particular modes when the level of demand in one of the modes varies.
- *Do-minimum scenario:* A future scenario that (usually) anticipates that only fully committed network improvements, essential maintenance and ongoing operational support occurs.

- *Do-something scenario:* A future scenario that assumes additional changes, over and above the do-minimum scenario, will occur on transport networks.
- *Dynamic model:* Models that acknowledge the changing nature of the transportation system and the variation in responses to changed conditions over time.
- *Education model:* Very elementary conceptual models aimed at training or informing mental models of the transport system.
- *Elasticity:* Changes in the demand for a good or service on the basis of a change in the price or supply of that good or service.
- *Entropy model:* A method that quantifies the level of activity within the transport system and uses probability theory to maximise this activity within a given overall (usually cost) constraint.
- *Equilibrium model:* A model that relies on delays being equalised between users across a network or system to achieve a steady state or 'equilibrium' (see also Wardrop assignment - below)
- *Fixed trip matrix:* An origin-destination demand trip demand matrix that does not allow for induced traffic effects and which is fixed in the future, no matter what changes occur or what option tests are undertaken. This means the do-minimum and do-something demand matrices are identical. Many conventional transport models are fixed or effectively fixed (where demand varies slightly between future scenarios, due to trip retiming and other generated effects)
- *Four stage model:* The 'classical' or 'conventional' transport model, consisting of attraction/generation, distribution, mode choice and assignment stages. The stages are not always undertaken in this order as the treatment of distribution and mode split can vary.
- *Furnessing:* An iterative analytical factoring technique used to apply constraints to origin-destination demand matrices.
- *Generalised cost:* A key input to transport models, describing the total cost of a journey, including nominal time costs and actual financial costs incurred.
- *Generated traffic:* Increased travel, due to rerouted trips, retimed trips or trips that change modes (but excluding induced traffic effects).
- *Gravity model:* A common type of model used in the distribution stage, based on an impedance function which estimates the difficulty (typically in terms of time, distance or cost) of travel between two locations.
- *Heuristic approaches:* Variable, relative and subjective valuations based on survey data.
- *Hierarchical demand model:* Linked to the nested logit mode choice model.
- *Hysteresis:* A property of behaviour that means that if conditions return to the state before a change (say in price) the old trip pattern is not returned. This is another way of saying that some changes in behaviour are not reversible.
- *Impact factors:* Broad effect on indicators considered likely (based on literature and studies) to occur as a result of particular actions.
- *Incremental demand modelling:* Methods of variable demand model construction intended to improve realism within the modeling process.
- *Induced traffic:* Completely new trip making as a result of additional capacity, service levels or reduced prices (excluding generated traffic effects). Induced traffic

- *Impedance function:* A measure of the difficulty involved in travelling from one location to another, as measured in terms of time, distance or cost. This function is used in the distribution stage especially for gravity modelling.
- can occur in any mode and at any point within the four stage modelling process, depending on the 'trigger' involved.
- *Land use model:* Interactive models that include a two-way relationship between transport and land use, both of which can influence the other.
- *Logit models:* A probability based technique, producing an 'S' shaped curve to explain behaviour, such as a mode choice between two modes (multinomial logit is between more than two modes)
- *Matrix capping:* A technique used, mainly in fixed trip modelling, to prevent excess demand occurring in a transport network, for example, to prevent unrealistically high delays or low speeds occurring. This can affect economic benefits, especially if it leads to an underestimation of induced traffic effects.
- *Mental model:* The understanding and views of individuals concerning the operation and effects of the transport system and the likely effects of future changes to the system.
- *Micro simulation:* Representation of the movement of individual trips, vehicles or pedestrians, most commonly applied to road traffic and often used for visual presentation purposes.
- *Mode choice model:* A way of deciding the likely use of different modes under defined circumstances, commonly based on the cost, time, utility and quality of each mode.
- *Modelling:* Any form of computer based representation of the transport system that includes a forecasting and future options testing capability.
- *Nested models:* Where a series of choices between two modal options is undertaken in an defined and ordered hierarchical sequence.
- *Non-linearity:* Where a trend or forecast relationship does not occur in a simply linear and incremental way but varies depending on one or more factors.
- *Policy analysis:* High level reasoned analysis of problems and issues to review and adjust policies, such as those relating to charges and regulations.
- *Probit model*: Similar to the logit model but incorporating normal distribution assumptions.
- *Simplified demand model:* Coarse spatial representation of the transport system, but with sensitivity to changes in behavioural or price based measures.
- *Simplified model:* Non-conventional transport model approaches, including simplified demand models, strategic models and sketch models
- *Simulation:* The replication of actual network conditions, for example, allowing for more realistic junction representation, and estimating delays, queuing, and blocking back within modelled traffic networks.
- *Single stage modelling:* A term usually usually applied to an 'assignment only' model.
- *Sketch model:* Basic representation of a transport system on the basis of highly simplified ratios and relationships.
- *Stochastic assignment:* A variable assignment that allows a certain variation in route choice to occur.

- *Strategic model:* A highly simplified or 'stripped down' version of a four stage conventional transport model.
- *Three stage model:* A conventional transport model consisting of attraction/generation, distribution, and assignment, (i.e., with no mode split stage) usually dealing only with road traffic.
- *Transport model:* The 'classical' or 'conventional' transport model consisting of up to 4 stages, attraction/generation, distribution, mode choice and assignment, together with supportive techniques (such as car ownership modeling)
- *Transport planning:* The study of movement and associated requirements, often involving the siting of new facilities. Transport planning allows for changes in future movement demand patterns, land use changes and future transport system capacity changes.
- *Validation:* A check on how well model outputs replicate and are consistent with surveyed movements on existing networks.
- *Variable demand model:* Models that allow the overall level of demand to fluctuate between the future do-minimum and do-something scenarios, rather than being fixed (as in fixed trip demand matrix models)
- *Wardrop:* Early assignment principles that say: delay will be equalised in terms of all alternative routes through a network and that overall delay will be minimised on the network so that equilibrium will be reached (Wardrop, 1952)

Footnote on how jargon is invented:

''My greatest concern was what to call it. I thought of calling it 'information', but the word was overly used, so I decided to call it 'uncertainty'. When I discussed it with John von Neumann, he had a better idea. Von Neumann told me, 'You should call it entropy, for two reasons. In the first place your uncertainty function has been used in statistical mechanics under that name, so it already has a name. In the second place, and more important, nobody knows what entropy really is, so in a debate you will always have the advantage."

Conversation between Claude Shannon and John von Neumann regarding what name to give to the *''measure of uncertainty"* or attenuation in phone-line signals (1949)