25th Australasian Transport Research Forum
Incorporating the BTRE Transport Policy Colloquium
Canberra 2-4 October 2002

Scenario modelling In Sydney

David Kilsby and Frank Milthorpe
Kilsby Australia Pty Ltd

Abstract

In Sydney the current Strategic Travel Model (STM) is a travel forecasting tool of world class. The Scenario Modelling Project was the first step in using the power of this model to explore alternative futures for Sydney, as distinct from the more conventional modelling task of assessing specific infrastructure projects.

The paper describes how four different futures for Sydney in the year 2021 were painted, in terms of distributions of population and employment and the transport networks serving them, and the strategic indications that emerged after applying the STM to them. The outcomes point decision-makers towards the primary issues facing Australia's largest city. The issues tend to be beyond the scope of any single government institution. The SMP has proved both the technical capability to undertake this type of project and the strategic value in so doing. It is expected to lead on to further work of this nature, to gain greater insight into the many complex relationships in the urban land use and transport system, and hence provide material to evaluate urban futures different from “the same only more”.

Contact author

Kilsby Australia Pty Ltd
Suite 46
Chatswood Village
47 Neridah Street
Chatswood Nsw 2067
Tel: (02) 9415 4544
David@Kilsby.com.au

GO BACK TO START SCREEN **GO BACK TO INDEX**

Introduction

The enhanced Sydney Strategic Travel Model (STM) which is being developed and operated by the Transport Data Centre (TDC) at the NSW Department of Transport is a powerful tool for multi-modal travel demand forecasting.

It is the best of its kind in Australia and compares well with best practice internationally. Recent development work has enhanced its capability. Milthorpe et al (2000) describe the structure of the model and the recent enhancements.

The Scenario Modelling Project (SMP) was an exercise conducted in the second half of 2001. It was the first major study that has utilised this enhanced modelling power for Sydney's strategic planning.

Scenario modelling is a methodology for exploring future uncertainty and should not be confused with conventional forecasting. It is not attempting to predict the likely future, but is looking at a range of possible futures and seeking to understand the differences between them. The process is similar to that dubbed "sketch modelling" by Kilsby et al (1992):

> *"Sketch modelling" is viewed in some quarters with scepticism. The phrase itself implies something incomplete, unprofessional, inaccurate, less than serious. The sometimes-used alternative description of "cartoon strategies" is no improvement. That a sketch must have been the basis at some stage for the ceiling of the Sistine Chapel indicates the other side of the story – at the right time, and for the right purpose, sketching is an invaluable, even indispensable, technique.*
>
> *It is essentially a modelling approach for exploring alternatives rather than for forecasting. It largely dispenses with the traditional resource-hungry network-modelling approach but it does address a wide range of policy issues and future possibilities. It is only useful in a strategic context, where broad decisions on how to proceed into the future are needed. It will take a long time for futures recognisably different from today or from each other to emerge, and so the time horizon for sketch modelling must also be long – twenty years or more.*
>
> *Once these broad decisions are in place, the more conventional planning techniques and their associated models come into play. Conversely, in the absence of strategic planning, conventional methods will continue to deliver more of the same.*

Computational power has advanced enormously since 1992 and it is no longer necessary to resort to simplified models for such applications.

The SMP has been carried out under the auspices of the NSW Department of Transport, with support from the Rail Infrastructure Corporation (RIC), the Roads and Traffic Authority (RTA), the State Rail Authority (SRA) and Planning NSW.

Objective and scope

The objective of the SMP is to better understand the travel demand outcomes of land use and transport decisions, through analysis of a series of transport infrastructure and urban development options.

Currently we are in a period of radical change and we know less about the future than previous generations did (Topp 2002). In recent years there has been a change in transport planning from “predict and provide” to demand management and planning to reduce the future levels of travel demand (Lyons et al 2002). Therefore the aim was not to derive accurate travel forecasts on individual items of infrastructure; rather it was to increase the understanding of the likely demand relativities for transport for a range of urban development and transport infrastructure scenarios.

Four such packages of options of urban development were assessed, for the years 2011 and 2021. They represented variants of land use futures broadly described as:

- “business as usual” (assumes the expected rate of fringe/established area development)
- more greenfield development at fringe
- less greenfield development at fringe
- more concentration of employment in the “business as usual” case

The transport systems for the future years were in general common to all scenarios at that year (with minor variation where appropriate).

The Strategic Travel Model

The STM was redesigned and re-estimated in a process that began in 1996. It is described by Milthorpe et al (2000). The operational model used for SMP had incorporated the highest priority changes (“Stage 1”). Implementation of additional design changes (“Stage 2”) were occurring whilst this project was being undertaken. The design process for the STM ensured that an operational model was available to be used at the completion of each stage before all parts of the model had been implemented (Hague Consulting Group and Institute of Transport Studies 1997).

Some of the key features of the Stage 1 improvements that have been implemented in the STM are:

- estimation of a joint home to work mode and destination choice model
- inclusion of a number of additional modes
- estimation of a home to work travel frequency model
- forecasting of licence holding
- forecasting of car ownership levels
- extension of the model to four time periods
- consistent linkage of the various models

- incorporation of an accessibility variable in a number of the models
- inclusion of a number of person and household segments within the model system
- use of prototypical sampling techniques to incorporate person and household variables at the zonal level
- operation of the model as a pivot point system (for home to work travel).

Stage 2 involves the inclusion of a number of additional home based travel and some work based travel purposes.

Further development or enhancement of this model was beyond the scope of the study, which was asked to use the STM “Stage 1” “as is”.

Perhaps the most productive model development, over and above those which were already being developed for “Stage 2”, would be the specific inclusion of car as an access mode to public transport. However its omission did not seriously detract from the available power of the model.

STM is a travel demand model and can thus directly illuminate the travel demand consequences of population growth, the distribution of new housing and jobs, and transport network improvements. It can also complement data from other sources and its outputs can be further manipulated to illuminate issues such as air quality, greenhouse emissions, equity, accessibility, public health and public budgets. The latter set of issues was beyond the scope of the study.

Future scenarios

Land use

The aggregate population was a common factor between the scenario packages, namely 4.45 million people in 2011 and 4.84 million in 2021. These population levels are slightly higher than the provisional forecasts made in DUAP (1999) of 4.41 million and 4.74 million respectively. If multiple population projections had been adopted for forecast years this would have made the task of separating scenario related differences and population related differences very difficult.

The principal distinguishing factor between scenarios A, B and C was the location of new dwellings to cater for the effects of immigration and declining household sizes.

Scenario A represented “business as usual”, with 30% of new dwellings in UDP areas (greenfield urban fringe). This proportion was increased to 45% in Scenario B (40% by 2011 and 50% by 2021, following advice from DUAP about the infeasibility of 45% by 2011) and decreased to 15% in Scenario C. The distribution of population between the inner, middle and outer rings of Sydney for these three scenarios is summarised in Table 1. Change in the outer ring is due to new development in established areas as well as UDP growth. In all established areas there is a decline in household size over time.

Table 1 Modelled population scenarios by ring (in thousands of people)

	1996	2001	A 2011	A 2021	B 2011	B 2021	C 2011	C 2021
Inner	677	726	804	873	785	819	833	928
Middle	1,076	1,115	1,186	1,266	1,153	1,198	1,219	1,334
Outer	2,061	2,212	2,459	2,699	2,501	2,822	2,397	2,576
Total	3,814	4,053	4,449	4,838	4,449	4,838	4,449	4,838

The employment scenarios to complement the population scenarios differed because some employment location reflects population location. However a fourth scenario, D, was developed in which the population distribution was the same as the "business as usual" (A) but the employment location was more concentrated in centres and around rail stations. The distribution of employment between the inner middle and outer rings of Sydney, and in major centres, for scenarios A and D (with the same population distribution) is shown in Table 2.

Table 2 Modelled employment scenarios by ring (in thousands of jobs), given the "Business as Usual" population scenario

	1996	2001	A 2011	A 2021	D 2011	D 2021
Inner	649	676	740	803	743	809
Middle	507	526	568	608	574	618
Outer	629	662	738	813	729	798
Total	1,784	1,863	2,046	2,225	2,046	2,225
(centres)	(503)	(530)	(594)	(654)	(618)	(705)

Transport

The road networks for 2001, 2011 and 2021 were developed following advice from RTA, and consisted of the existing road network plus both possible major and minor changes. No attempt was made at this stage to fine-tune this network for the different scenarios.

For the period 2001-2011, enhancements to the road network included the following major projects and a number of lesser ones:

- M5 East
- Western Sydney Orbital

- Lane Cove Tunnel
- Cross-City Tunnel

For the period 2011-2021, enhancements to the road network are inevitably speculative. They included the following major projects and a number of lesser ones:

- M2 to F3 Link
- F6 Tempe to Loftus

Public transport enhancements for 2011 were taken from the strategic plan documented in Department of Transport (1998)**,** even though it is now probable that not all will be implemented by then. The major modelled rail infrastructure additions (with corresponding changes to train itineraries) were:

- the full Parramatta Rail Link (Parramatta to Chatswood)
- the first stage of the North West Rail Link (Cheltenham to Castle Hill)
- the Liverpool Y-Link
- the enhancement of services to Newcastle and the Central Coast
- the Bondi turn-back (replacing the Bondi Beach extension)

Not included in the model was the proposed Thirroul Tunnel (because it affected an area external to the model).

The planned network of Transitways was also included in the 2011 network. The proposed Hurstville to Strathfield railway was also modelled as a transitway following professional consensus on this course.

For 2021 the modelled rail network corresponded closely to the 20-year enhancements proposed in Office of the Co-ordinator General (OCG) of Rail (2001). Network infrastructure additions were:

- the rest of the proposed North West Rail Link (Castle Hill to Vineyard)
- a new line from Glenfield to Bringelly (extended from Leppington as shown in the OCG plan)

The existing structure of bus networks was retained in future scenarios, but frequencies were increased in line with population growth. Because of the modelling methodology, this was deemed sufficient even in new housing areas on the fringe where provision of bus services was very basic in 2001.

Model results

General

The model was used to assess each scenario in 2011 and 2021. The model was also used to estimate 2001 performance for validation purposes and to provide a base reference case from which to calculate the change in the demand for transport. There were therefore nine distinct sets of model results.

Assumptions

As well as the many specific assumptions involved in the construction of the STM methodology, there are perhaps three rather more general assumptions which the SMP adopted.

The first was that ***the STM is fit for the purpose of scenario modelling***. This was not taken for granted but verified through a rigorous validation process. The conclusion was that the STM reproduced observable patterns of travel behaviour in the morning peak for 2001 with sufficient accuracy for it to be used with confidence for modelling of future scenarios.

The second was that ***work trips (modelled by the "Stage 1" STM) could be expanded to represent all other purposes as well (not modelled by the Stage 1 STM***). The conclusion was that, because of the higher expansion factors, travel estimates for a 24-hour period were less reliable than those for a 2-hour morning peak, and the project should concentrate on the latter. Many of the issues highlighted during the validation exercise were attributable to the interim status of the STM. When STM Stage 2 is implemented, they will cease to be relevant and 24-hour estimates should become as reliable as those for the peak period.

The third was that ***land use determines travel behaviour***. There is no feedback within the STM between transport investment and land use change. This issue has to be handled externally, in the design of the land use scenarios.

The scenarios

The STM produced a large amount of information for each scenario. This information was presented in Kilsby Australia and Computing in Transportation (2002) and a separate Appendix with collected plots was compiled.

Table 3 presents a summary of the performance of the four scenarios in 2021. The performance for 2011 is broadly between this and current (2001) performance.

Table 3 Summary of modelled performance (2 hour AM peak)

	2001	2021 Business As Usual	2021 More Fringe Devel't	2021 Less Fringe Devel't	2021 More Employ't Concent'n
Trips (m)	2.62	3.14	3.14	3.16	3.12
VKT (m)	13.95	16.32	16.55	16.14	16.28
PKT (m) – Rail	4.76	6.19	6.57	5.98	6.36
PT share of commuter trips	24.1%	25.8%	25.7%	26.2%	26.5%
PT share of all trips	13.1%	14.0%	13.8%	14.1%	14.4%
Av Car driver trip length (km) – all purposes	11.81	11.70	11.90	11.57	11.77
Av road speed (kph)	30.2	30.2	30.2	30.2	30.2

Messages

The process produced a wealth of material for each scenario. The nature of the process is such that it generates many questions and invites more detailed exploration of this material in pursuit of insight (if not always answers). With limited time and resources the modelling team were conscious that they had only been able to examine the tip of the iceberg, and also that others undertaking the same process might find their thoughts moving down different paths. Nevertheless the following were messages that emerged fairly strongly from inspection of results.

Limited change at aggregate level

The scenarios were defined by varying the location of 15% of the growth in housing stock and/or 15% of the growth in employment, and hence had much more in common with each other than they have differences.

This was a realistic approach, given the maximum degree of change probably achievable in practice, but it meant that scenario performance tended to be dominated by the common elements rather than the differences. The variance in aggregate performance between scenarios was small. The differences started to appear when performance was disaggregated.

Need for infrastructure in developing areas

Transport infrastructure in North West Sydney, South West Sydney and the Central Coast is inadequate for the population growth envisaged. The issues for road and rail differ.

For road, the growth in demand affects the areas of origin most, indicating the need for expansion of the road networks in the growth areas. For rail, the growth in demand of course requires local access but perhaps the bigger problem occurs at the destination end of the trip, in central areas (near the CBD) where the network is already operating close to, or at, capacity. Whether this problem can be significantly mitigated by a change in employment location policy could be tested by further scenarios.

Impacts of growth on the CBD

The employment scenarios analysed all assume that the main focus of the rail system remains the CBD. The STM process is unconstrained in its public transport assignments. However, in reality the rail system could not accommodate the additional patronage growth and network expansions as modelled in these scenarios without additional capacity to move trains through the CBD.

Table 4 shows that Inbound peak rail patronage to the CBD is expected to grow by 22-25% by 2021. This varies by line, and for trains coming from the North Shore the growth rate is over 100% in all scenarios. This is mostly due to the combined effect of the Parramatta Rail Link and the North West Rail Link being added to the network.

Table 4 CBD-related growth rates 2001-2021

Scenario:	A	B	C	D
City Centre Population	103%	79%	129%	103%
City Centre Employment	22%	22%	23%	27%
Inbound Peak Rail Trips	22%	25%	22%	25%
Inbound Peak Bus Trips	14%	7%	13%	16%

Effects of intervention at the fringe

The “less fringe development” Scenario C cut the growth in new dwellings in UDP areas from 30% of total net dwelling increase to 15%, and the “more fringe development” Scenario B increased it to 45%.

The expected differences in traffic emerged from the model, with “more fringe” producing more traffic in fringe growth areas and less in established areas, and vice versa. For public transport, the “more fringe” Scenario B produced more long distance rail trips than Scenario C.

The differences in key indicators between the population scenarios were shown in Table 3. At the metropolitan level, there is little difference. However there is considerable variation for specific areas within the metropolis.

Effects of greater concentration of jobs in centres and around railway stations

The “concentrated employment” Scenario D increased the growth in centres employment from 30% of the total growth to 45%, and additionally ensured that 20% of the growth (not in the main centres) was concentrated in areas with rail stations.

Comparison of Scenarios A and D shows that the greater concentration of employment produces a small shift from car to public transport. The net result in 2021 is an increase over the “Business as Usual” scenario of 2.7% in rail travel (a 2.6% increase in trips and a 0.3% increase in trip length), and a decrease of 0.3% in car travel (a 0.9% decrease in trips but a 0.6% increase in average trip length). The average length of car trips increases because some local employment has been transferred to centres or to near stations.

The greater concentration of employment in centres brings an increase in road traffic near centres as well as an increase in rail use. This suggests that the role of parking policy would be particularly significant for Scenario D.

Another observation was that the modelled local public transport failed to take a bigger share of trips to smaller centres, suggesting that an integrated approach with better local bus services as well as appropriate parking control would be called for under this scenario.

The total peak boardings on Transitway services were virtually the same in the “Concentrated Employment” Scenario compared to the “Business As Usual”, but the proportion of peak users of Transitway buses who were travelling onward by train increased from 49% to 52%.

Distributional issues

There is great variation in transport provision and choice between different parts of the metropolitan area. The transport systems were nearly identical between scenarios in any given year, so the variation did not change significantly between scenarios. However the “more fringe development” scenario produced longer average commuter trips, both by road and by rail, than other scenarios in almost all areas.

Table 5 selects some of the “Statistical Sub-Divisions” (SSD’s) within Sydney (of which there are 14) to illustrate this variation in 2021 for the “Business as Usual” scenario.

Table 5 Extracts from SSD analysis for 2021 AM peak commuters

SSD (selected)	PT mode split	Av Car Trip Length (km)	Av Rail Trip Length (km)
Eastern Suburbs	31%	10.2	10.2
Fairfield-Liverpool	26%	15.4	28.5
Outer Western Sydney	22%	21.5	46.2
Gosford-Wyong	12%	39.8	64.6

Further issues

The degree of change contemplated to date has been modest. Such modesty is not necessary in scenario modelling, the purpose of which is to increase understanding of relationships and the extent of uncertainty. It may be that relationships would emerge more clearly from more extreme scenarios.

A major aim implicit in the scenarios has been the containment of VKT, as per the State Government target. From the results to date it seems that major transport investment tends to reduce the V (by mode share change) but increase the K (through facilitating a less compact urban form). Land use policy has the potential to reduce the K without necessarily affecting the V (by making trips shorter).

The effects of putting jobs closer to where people live, using further employment scenarios created exogenously, has not yet been explored.

Pricing change also remains unexplored. Lyons et al (2002) suggest several different approaches which government in the future could adopt with regard to pricing mechanisms and levels of government contributions to the transport system.

Transport investment – or the lack of it – impacts on land use change via market responses to accessibility changes. To explore this would require an iterative process between scenario design and model runs, since this is not incorporated into the model directly.

The process (ie methodology)

Scenario modelling is a tool to aid in the development of strategy, through enhanced understanding of complex relationships and uncertainties. It should not be confused with conventional forecasting, which is a tool to aid the implementation of strategy via project assessment and refinement.

The more scenarios addressed, the greater the insight generated.
To produce its results, SMP necessarily built considerable modelling infrastructure (software tools). The marginal effort of addressing further variations in the scenarios or completely new scenarios is small.

A vast amount of material was produced and in the time available only the more obvious facets were explored.

Material that is now available for each scenario includes:

Traffic volumes	Trip length distributions
Road speeds	VKT, PKT
Volume/capacity analysis	Mode splits
Slow roads, slow travel	Demand by commuters and non-commuters
Rail patronage by line	Spider diagrams
Rail patronage by link	Time/space diagrams for PT
Station ins/outs	Car travel time contours from any chosen spot
Trains per segment	Shortest paths
(And similarly for bus)	Interchange volumes
Origins/destinations of demand using any selected link (highway or PT) or combinations of links	And more …

Conclusions

The results and findings from SMP illustrate the potential of this approach. The tools now exist. However they do not have an indefinite shelf life. A well-worn truth in modelling is "Use it or lose it".

Many messages have emerged from this exercise. These include:

- There is little scope for an "order of magnitude" change of performance in Sydney because of the huge inertia of existing activity
- Releasing land for development at the urban fringe without addressing the transport infrastructure needs have the potential to cause great problems in the future, which differ for road and rail
- All the scenarios tested showed a large increase in peak period rail trips to the CBD, many of them utilising new infrastructure
- Urban consolidation results in lower VKT overall than urban expansion
- Concentrating more employment in centres improves the public transport share of peak travel, but also results in additional traffic congestion in the areas immediately surrounding the centres and produces longer trip lengths than a more dispersed pattern of employment
- Whilst at the aggregate level there are limited differences between the scenarios, there are significant distributional issues within Sydney which raise equity questions.

References

Department of Transport (1998) Action for Transport 2010

Department of Urban Affairs and Planning (1999) Population projections for NSW (preliminary), DUAP Report 99/54

Hague Consulting Group and Institute of Transport Studies (1997) Design of new Sydney travel model. Report to Transport NSW

Kilsby Australia and Computing in Transportation (2002) Scenario Modelling Project 2001: Modelling Report. Report to Transport NSW.

Kilsby D, Prince P and Stewart D (1992) Is sketch modelling of any practical value in transport development? *Papers of the 16th Australasian Transport Research Forum*, Canberra: ATRF

Lyons G, Chatterjee K, Beecroft M and Marsden G (2002) Determinants of travel demand-exploring the future of society and lifestyles in the UK *Transportation Policy* 9 (1), 17-27

Milthorpe F, Daly A and Rohr C (2000) Re-estimation of the Sydney Strategic Travel Model, *Papers of the 9th International Travel Behaviour Research Conference*, Gold Coast: IATBR

Office of the Co-Ordinator General of Rail (2001) Long Term Strategic Plan for Rail

Topp H (2002) Traffic 2042-mosaic of a vision *Transportation Policy* 9 (1), 1-7