

## Is Sketch Modelling of Any Practical Value in Transport Development?

**David Kilsby**

*Manager*

*Sinclair Knight Buchanan*

**Peter Prince**

*Managing Director*

*Travers Morgan Pty Ltd*

**David Stewart**

*General Manager, Network Efficiency Strategy Branch*

*Roads and Traffic Authority of NSW*

---

### Abstract:

The use of sketch modelling in network strategy development is viewed with scepticism in some quarters. This paper reviews the development and application of such techniques in a recent major study in NSW, with particular emphasis on metropolitan Sydney. The paper describes the purpose and nature of the models used. It then assesses their effectiveness both as reflections of the real world and in relation to the strategy options under investigation. A number of lessons for strategic transport planning are identified.

---

### Contact Author:

David Kilsby

Sinclair Knight Buchanan

1 Chandos Street

ST LEONARDS NSW 2065

Telephone: (02) 436 7273 Fax (02) 438 4794

## **Introduction**

"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.

This paper attempts to put sketch modelling in perspective by reviewing its application in a recent strategic planning exercise in New South Wales, the "Road Transport - Future Directions" Study conducted in 1990-91. The general methods and findings are extensively documented elsewhere (e.g. Travers Morgan et al 1991a-f).

## **The Future Directions Study**

The NSW Roads and Traffic Authority (RTA) commissioned the Future Directions Study in June 1990 as the first stage in a strategy development process for the NSW road network. The Future Directions Study findings resulted from the efforts of many people and were put together by the project management team from consultants Travers Morgan and Sinclair Knight. The Future Directions Study was given two objectives:

- (a) to provide guidance for transport policy formulation (achieved by the identification and assessment of the options); and
- (b) to develop a strategic planning process (achieved by the framework, approach and models produced by the Future Directions Study).

### **Study timetable**

The initial timetable allowed a month for the design of the exercise; two months for the conduct of a large number of necessary sub-studies, for obtaining the views and knowledge of many experts through consultation and for the development of a strategic

modelling system ; two months for the application of the models and assessment of their results ; and a short period for writing the report. This was an ambitious but feasible programme, implying a report by December 1990.

#### Study scope

As the Future Directions Study progressed through its second stage, it became apparent that the scope for the RTA to control its future independently of other agencies was limited. To examine RTA options fully, it would be necessary to look at the combined effects of those things over which, in general, government has some degree of control :

- (a) land use : a range of possible NSW-wide population and employment distributions, in some detail for the main urban areas ;
- (b) price : different transport pricing regimes ; and
- (c) networks : road and public transport network infrastructure and management

The RTA thus found itself engaged, not in a limited roads exercise, but in a review of road policies and strategies within a major land use and transport study covering the whole of NSW.

The extension of the model system development, application and interpretation resulting from this broadening of scope was limited to a few weeks. Following a draft in March 1991, Travers Morgan et al (1991a) reported on options in June 1991. The main report was complemented by a shorter summary, Travers Morgan et al (1991b), and twelve volumes of Supporting Reports of which four, Travers Morgan et al (1991c,d,e,f), relate particularly to the material in this paper. The findings of the Future Directions Study were widely discussed within the NSW government and finally became publicly available at the end of February 1992.

#### Choice of travel models

The Future Directions Study was clearly much more than a modelling exercise, but equally clearly it could not achieve its aims without substantial modelling effort of a nature consistent with both the timetable and the scope of study.

NSW encompasses a wide variety of transport systems :

- (a) Sydney : dense road networks, extensive public transport systems (bus and rail), heavy congestion at peak times, the major proportion of industrial activity in the State ;
- (b) Newcastle and Wollongong : cities with a large but declining industrial base, low public transport use and extensive road networks ;
- (c) other cities of smaller size, where the strategic issues relate more to regional access than to the urban roads themselves ;
- (d) interstate road corridors with concentrated volumes of truck and private traffic, of which the Pacific and Hume Highways are foremost followed by the Newell

- Highway as a truck route ; and  
(e) roads in the rural hinterland used to move primary produce to markets, ports and for local access.

No single model could encompass the variety presented by the above. A system of compatible travel models was developed to capture the different effects. The main subject of this paper is the model used to explore futures for Sydney.

For Newcastle and Wollongong, TRANPLAN highway models were extended (Newcastle) or developed (Wollongong). Absence of public transport data for the regions, and the dominance of private travel relative to public transport, led to the TRANPLAN approaches being deemed acceptable although the level of detail was greater than that really required. Modal effects were dealt with, in the modelling, by sensitivity testing.

A model for rural travel in NSW, dealing with "catchment areas" for rural travel and interurban movement, was also developed as a separate exercise.

### Modelling travel in Sydney

The Future Directions Study did not have the luxury of much time to consider its choice. In view of the timetable, the first question asked was not "what sort of model do we need for Sydney ?" but "what working models can be used ?". However there was only one possible candidate at the time. This was the Sydney "grand model", an updated professional heirloom from the 70's under the custodianship of the State Transport Study Group then at the Department of Transport. Under different circumstances this might have been the preferred choice of the Future Directions Study, despite its voracious resource requirements, complex structure and over-specification for the task in hand. Fears, subsequently confirmed, as to its continuing availability during the Future Directions Study led to its rejection as an option.

This was perhaps a blessing in disguise, as it gave the Future Directions Study not just the opportunity but also the requirement to build its own multi-modal sketch planning model from scratch, with full control over the content of the model. The pragmatic question then changed to "what sort of data can we get ?". The paucity of choice quickly became evident, although the 1991 Travel Surveys and associated model development at the RTA now in progress will alleviate this problem for future studies. *The nature of the data we collect and maintain over time is much more critical in the long run to our planning capability than the nature of the models we may, at any particular point in time, be using.*

### Sketch model development

The sketch planning for metropolitan Sydney was developed using the EMME/2 software shell as a basis. EMME/2 is perhaps misleadingly described as a transport

model : it is more like a transport modeller's toolbox. Booz Allen and Hamilton undertook much of the model development for Sydney.

The Future Directions Study used 1981 travel survey data for model calibration ; road speed/flow relationships from the RTA's TRANPLAN model for Sydney ; the State Rail Authority's EMME/2 representation of its rail network ; and otherwise derived its own network descriptions, model relationships, land use scenarios and trip tables for Sydney.

#### Features of model

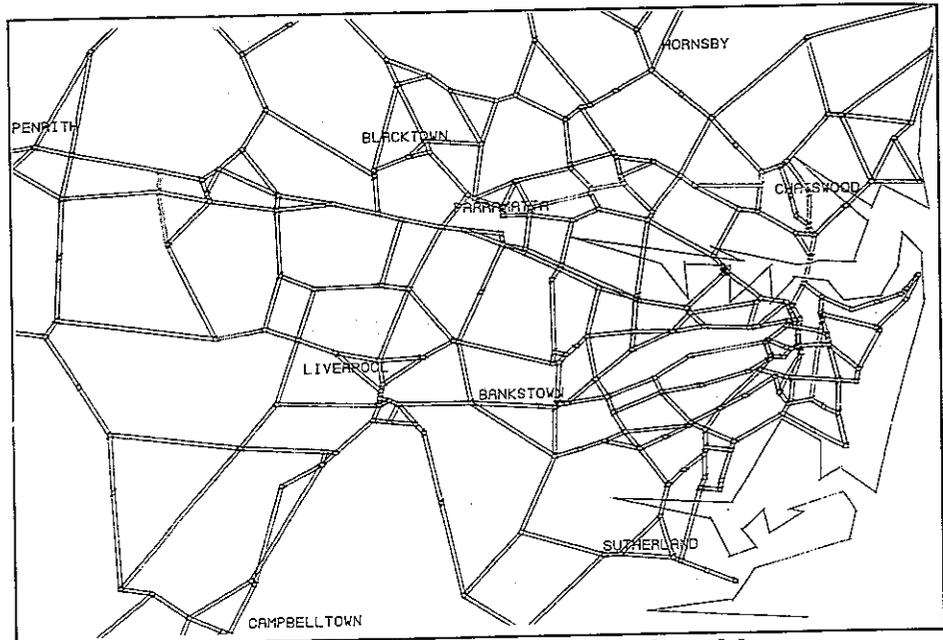
The model was, at heart, a conventional type of four-step multi-modal peak personal travel model consisting of :

- (a) work trip generation and attraction based on workforce and employment ;
- (b) work trip distribution based on function of highway travel time ;
- (c) non-work trip distribution based on population-to-population gravity model ;
- (d) mode split based on relative time and cost deterrents - time based on modelled network impedances (including congestion delay), and cost based on fare and out-of-pocket car costs including road pricing where appropriate ;
- (e) highway assignment based on equilibrium algorithms and public transport assignment based on optimal route-finding strategy.

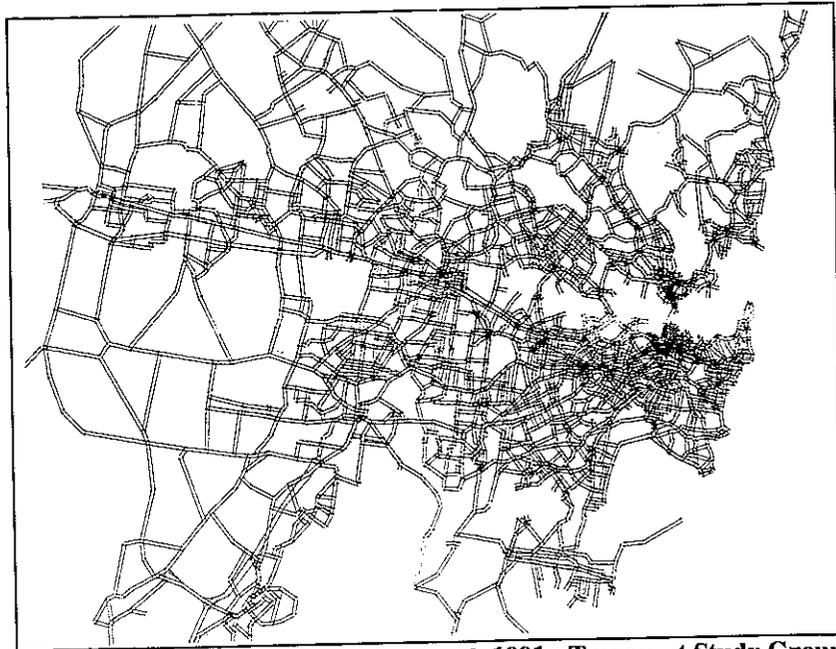
The zoning system treated Sydney by division into 77 zones. This compares to the Transport Study Group model system of 700. Even the 77 were more than ideally wished, but were necessary to design out modelling problems due to the underlying networks. The additional zones required for this had the bonus of slightly deeper examination of network effects than would have been possible with fewer. The level of network detail may be assessed from **Figure 1**, which shows the 1991 metropolitan highway network used, and for comparison **Figure 2**, which shows the 1991 highway network used in the finer model of the Transport Study Group.

This peak travel model was embedded within a broader process which incorporated further potential policy variation and enabled the derivation of a wide range of performance measures. The modelling process is fully described in Travers Morgan et al (1991f). Features of the model system included :

- (a) collapsing of the road network into a relatively small number of links each of which represented interzonal connection rather than physically distinct roads ;
- (b) validation taking the form mainly of adjustments in local road capacity on interzonal links, to give broadly today's observed conditions ;
- (c) derivation of a composite public transport network with bus and rail complementary (sub-modal split was implicit in the assignment) ;
- (d) modal expansion factors to relate morning peak travel to annual performance ;
- (e) road pricing reflected by a cents-per-kilometre mechanism having its main effect within the modal split component of the model ;
- (f) a considerable amount of iteration between mode split and assignment, between mode split/assignment and distribution, and between network specification/price setting and the four-step process ;



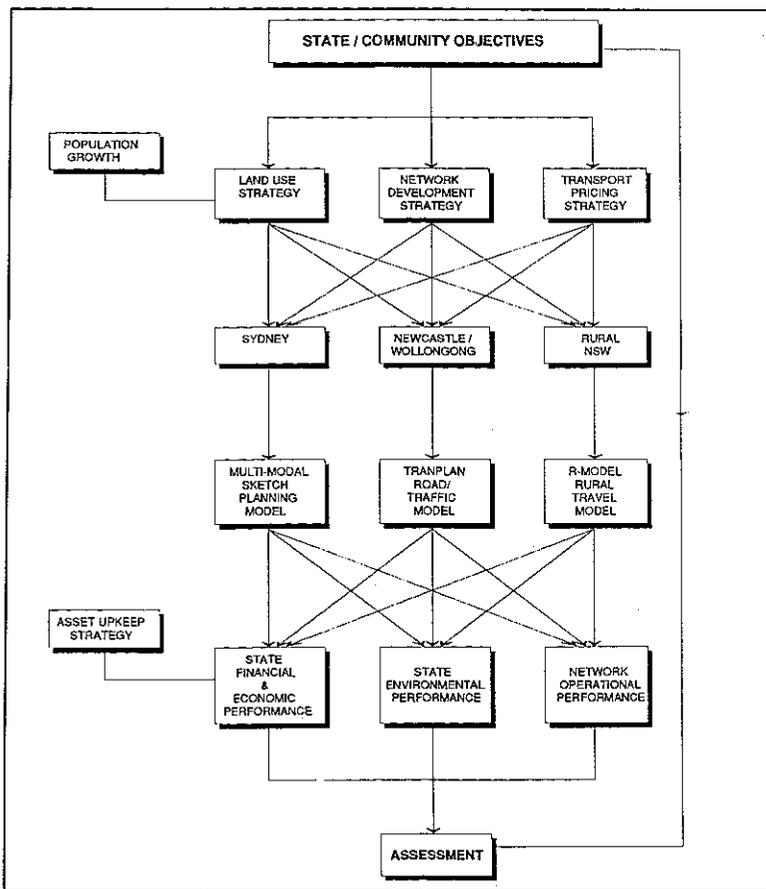
**Figure 1 Modelled Sydney road network 1991 - sketch model**



**Figure 2 Modelled Sydney road network 1991 - Transport Study Group**

*Transport Sketch Modelling for Sydney*

- (g) representation of further effects by sensitivity testing, proxies or procedures supplementary to the process, e.g. traffic on local roads, operational rail constraints, public transport fare structure, infrastructure costing, operational costing for public transport, changes in car occupancy, parking policy, peak spreading, engine technology and vehicle emissions, accidents and more ;
- (h) definition of 13 regional areas of Sydney for presentation of some results : an emerging single "Pacific Coast" conurbation consisting of these regions plus the two regions centred on Newcastle and Wollongong was identified ; and
- (i) explorative use in examining a number of different possible futures rather than progressive refinement of one future, done in a highly interactive manner with heavy utilisation of the graphical facilities of EMME/2.



**Figure 3 Analytical framework of Future Directions Study**

### **The Future Directions modelling framework**

The four travel models (Sydney, Newcastle, Wollongong, rural NSW) were integrated within the general framework of the Future Directions Study, to produce performance measures which could be combined to give, where appropriate, performance measures for the whole of NSW.

The analytical framework established by the Future Directions Study is shown in **Figure 3**.

#### Planning objectives

The process was driven by the objectives of State government and the community. A feature of the early stages of the Future Directions Study was extensive consultation to establish government and stakeholder expectations and concerns, from which the transport objectives were derived. Strategy development is essentially the selection of actions and tactics to overcome barriers to better achievement of those objectives.

#### Population growth

Population growth is expected to continue into the future in NSW. Rather than assess the effects of different net immigration rates, a common population level for the State of 8.5 million people was adopted for all futures modelled. On current trends, this will be reached in 20 to 30 years' time.

#### The three levers

Different land use distributions (three) for this population level, transport pricing regimes (three) and contrasting network philosophies (two) were established. These are summarised in **Table 1**. Further variations are of course possible.

18 composite scenarios are possible from combinations of the elements in **Table 1**.

1. Seven were selected for processing and assessment :

- (a) current trends/current pricing/demand management ;
- (b) current trends/real pricing/demand satisfaction ;
- (c) planned/current pricing/demand satisfaction ;
- (d) planned/road pricing/demand management ;
- (e) planned/real pricing/demand satisfaction ;
- (f) intervention/current pricing/demand management ; and
- (g) intervention/road pricing/demand management.

The findings of the Future Directions Study were based in large part on the differences between the performance of these future scenarios.

Table 1 Components of future scenarios

<u>LAND USE</u>	"Current Trends"	"Planned"	"Intervention"
Sydney - population - form	5.5 million urban sprawl	5.0 million Metro Strategy - sector development, some consolidation, high growth	4.5 million restricted growth in West, more consolidation
Newcastle & Wollongong	low growth	high growth	very high growth
Other NSW	low growth	high growth	selective decentralisation
<u>PRICING</u>	"Current Pricing"	"Road Pricing"	"Real Pricing"
	today's prices and charges	increase in road user charges for demand management	prices set for each mode to recover full economic cost
<u>NETWORKS</u>	"Demand Satisfaction"	"Demand Management"	
	Road building/improvement and public transport enhancements to accommodate demand	Emphasis on public transport enhancement to cater for peak demands, road system improved where necessary to complement or reinforce desirable land use patterns	

Note : "Low" and "High" growth refer to range of NSW Department of Planning official forecasts.

### Models

The different types of travel models adopted have already been described. A separate strategic model relating the quantity and quality of roads to owner and user costs was also developed and enabled strategic options for road upkeep to be identified. This, unlike the other models in the system, relates to aspects mainly internal to the RTA, although expected travel volumes are of course a factor.

### Performance measures

Performance of the land use/transport system was measured in terms of environmental, operational, social, economic and financial effects, relating to the original objectives. Table 2 itemises the most comprehensive set of performance measures, produced from the analysis of possible futures for Sydney. Some of these measures did not emerge from the complementary models for other areas and hence not all finally appeared in the form of State-wide totals or ratios.

### Results

All future scenarios assumed a 37 percent increase in population within NSW compared to 1991. Increase in travel (person-km, all modes) was in the range 50 to 67 percent.



Performance was found to be broadly bounded by two strategy choices. At one end of the spectrum was what could be considered the "current trends" strategy. Among other indications relative to 1991, this involved a 600 percent increase in time lost to congestion in Sydney, a 55 percent increase in harmful air emittants from road transport in Sydney, and a \$1.3 billion increase in annual State government transport shortfall (road, rail and bus). At the other end was what the Future Directions Study dubbed the "integrated demand management" strategy, leading to a 25 percent increase in time lost, a 16 percent drop in harmful emittants and a \$0.3 billion increase in annual shortfall.

The relevance of sketch modelling to policy making surely needs no clearer demonstration than this.

The Future Directions Study was able to formulate possible strategy components to assist movement to the more desirable end of the spectrum, based on common themes identifiable from scenario comparison. These deliberately did not include physical infrastructure projects ("lines on maps").

#### Strategic modelling in perspective

*Strategic modelling is not a detailed exercise, does not attempt to predict the future and does not in itself result in anything being built.* It incorporates broad relationships, assesses the implications of a broad range of futures and gives the basis for strategy directions. Specific infrastructure projects or other actions to implement strategies are then initiated. These are still subject to the usual procedures of planning, design, operational assessment, economic evaluation, environmental impact and so on. The models required for strategy development are broad.

The most notable features of the Future Directions modelling exercise were :

- (a) the speed with which the techniques were developed and applied ;
- (b) the relation of land use, transport price, roads and public transport in a single framework ;
- (c) the co-ordination of analysis for the three major urban areas of the State, and for country areas of NSW as well ; and
- (d) the unusually wide range of performance measures produced

#### Lessons from the Sydney sketch modelling

##### Data and knowledge gaps

The Sydney metropolitan model was designed for sketch planning and developed in a short intensive exercise. Consequently, it omitted some aspects of travel relationships.

One of these was felt particularly important but no data was available on which to base a model, namely commercial travel patterns : trucks, light vehicles, and cars used for business purposes. This was therefore addressed mainly qualitatively.

*Kilsby, Prince, Stewart*

Analysis of equity impacts by socio-economic group also remained an unfulfilled wish, as no means of producing indications as to how socio-economic status might change over time could be found. The framework for assessment now exists if a suitable method can ever be devised.

#### Selection and omission

The relationships selected for inclusion in the model were described earlier. Further aspects were regarded as not essential at this level of modelling, and not pursued. These include car ownership and availability, differences in trip generation by purpose and time of day, off-peak travel patterns in detail, income effects, cross-elasticities, junction delay, Park and Ride behaviour, taxis, school transport including escort trips, very localised travel by road and bus, mode split within public transport (where bus and rail offer competing alternatives), the special characteristics of the Sydney ferry system, and cycling as an additional transport mode. Had these been pursued, further gaps in data and/or knowledge would certainly have been encountered in some cases. Modelling is a very effective way of establishing how much you do not know.

Cycling as a mode has been incorporated as a sensitivity item in strategic models developed by one of the authors for sketch planning applications in Queensland and Western Australia subsequent to the Future Directions Study, and with hindsight could at least have been treated the same way in this exercise.

#### Scope for development

The Sydney model was assessed to be a coherent package of broad relationships, and to seek greater detail in one of these subsidiary aspects would have been of little benefit without treating all the others in the same way. This would change the nature of the model, and, more practically, the resource requirements for the exercise. However there are two aspects in which the model may be amenable to extension while retaining its character as a sketch planning tool, namely :

- (a) incorporation of Newcastle and Wollongong in sketch model directly, at same level of resolution, rather than by the separate, more detailed and road-oriented approach adopted (this would be in keeping with the strong view of the Future Directions Study that Sydney, Newcastle and Wollongong have to be treated as one conurbation in future) ; and
- (b) specific treatment of impact of transport development on land use over time (this aspect is returned to later).

#### Accuracy

The broad relationships built in to the model mean that any figure, in isolation, can be challenged for accuracy by more specific data and analysis. The orders of magnitude

### *Transport Sketch Modelling for Sydney*

appear to be correct. For instance, the unit rate for CO<sub>2</sub> emissions in 1991 derivable from the model results is about 3200 kg/vehicle/year, which can be compared with a recent independent estimate from the Friends of the Earth of 3500 kg/vehicle/year. They do not match, but are in the same ballpark.

Further, while any individual statistic may be open to query, the methodology has been applied in a consistent way to all scenarios and the conclusions of the Future Directions Study are based, in the main, on the differences between scenarios. For this reason, comparisons with 1991 are based on the 1991 modelled position rather than, where known, the 1991 actual. Furthermore, the scenarios were chosen to be significantly different from one another so that strategy implications could emerge free of doubts about estimating error within the model.

Future use of selected model results as inputs to more detailed analysis of specific issues, however tempting, would be a misuse of the process. Isolated results are as useful as a single link out of a chain.

#### Practicality

If used for the purposes for which it was designed, the modelling system for Sydney is an extremely practical one. This is because :

- (a) it is easy to understand but comprehensive ;
- (b) it requires few personnel, and can be handled by a single person ;
- (c) it runs on standard micro-computer equipment (386 PC or better) ; and
- (d) it can produce results very rapidly - network variations took in this case a few hours to test, and a thorough exploration of a future scenario required in the order of a week

#### User interaction

The interactive nature of sketch modelling and consequent learning opportunities should not be underestimated. All too often in modelling exercises the majority of attention is at a clerical level, checking highly detailed inputs and outputs for errors and anomalies, with the checked results then enjoying a perhaps unjustified air of authority. In sketch modelling there are many futures, and none of them is accepted as "the" future. The sketch modelling exercise for RTA was conducted without clerical support, and a considerable amount of insight was derived from things that did not achieve the expected results and did not appear in the finally reported networks. Three specific examples may illustrate this point :

- (a) persistent attempts with the model to raise public transport share at South Creek (SW Sydney), in scenarios with major development there and a demand management approach to networks, failed. This led to the conclusion that there is little of significance to be done with development of public transport systems when the travel attractors are spread fairly evenly around an arc of at least 180 degrees from the trip generating area (i.e. from Penrith through Parramatta and

- Liverpool to Campbelltown and even Camden)
- (b) major modelled public transport developments in the North West corridor (Richmond, Rouse Hill, Epping, North Sydney, City) failed against expectation - given the land use - to achieve respectable usage estimates, to the point where conventional transport planning would abandon the idea and revert to road improvements. However in the pursuit of a demand management strategy, the scale of public transport system development was escalated. Once this was done the usage did materialise (in the model). An unreported conclusion was that limited study areas and patchy development are unlikely to lead to significant relief of car dependency, although they could still lead to significant public expenditure.
  - (c) when changes in pricing were applied in a uniform way, the effects varied both within and between scenarios. This highlighted the equity implications of applying pricing policy when land use or transport networks or both do not allow any significant travel choice. This important point might have been lost in more detailed analysis or with fewer scenarios.

#### Transport-led development

The effect of transport on land use was not explicitly modelled, although likely transport feasibility was an implicit factor in the development of the land use scenarios. A prevalent view given to the Future Directions Study was that the present relationship between land use and transport planning was unsatisfactory, with the implication that transport plans should be more pro-active relative to land use plans. The technical tools to explore concepts of transport-led development are not available in Sydney.

However the structure of the sketch model is amenable to development in this direction, if only as an experiment. EMME/2 is a network and matrix manipulation tool of great flexibility. If, instead of making one temporal leap 25 years into the future, it were run on a more incremental basis, the effect of changing transport networks on incremental activity could be incorporated. Thus the location of employment growth could be partly dependent on accessibility to inputs (labour and freight) and to markets (population, employment, regional, interstate and international transport links), and similarly for housing growth and density changes. This perhaps points towards a Lowry-type approach with some re-thinking of what, in the 1990's, constitutes primary and secondary employment. Part-time work, flexitime, telecommuting and other social trends would also have to be taken into account.

This would enable longer-term urban development dynamics to be explored. A fixed-time-horizon model tends to impose a demand-warrant approach to infrastructure planning (when demand reaches X, build Y) and is unlikely to throw favourable light on schemes which could change urban structure over time - for instance, new rail access to Parramatta.

At the sketch planning level, the value of this type of approach could be explored relatively quickly and would illuminate land use as well as transport strategy options.

### Price

The Future Directions Study model defines future scenarios in three dimensions - land use, transport networks and transport price. The preceding thoughts indicate the desirability of land use change as well as travel change by way of model output.

It would be logical then to incorporate land pricing, to the extent that it is under Government control (taxes, infrastructure and service charges), as a policy input in addition to transport pricing. In fact it would be illogical to exclude it. A challenge.

### Demand management

The importance of demand management within urban transport policy in future is well recognised. The Future Directions Study model addressed this in three ways :

- (a) through specification of public transport systems in some detail, including application of bus priority on the road system ;
- (b) through specific modelling of the effects of this, of pricing, of managed congestion and other measures, especially in mode split and assignment ; and
- (c) through hypothesis and sensitivity (e g by assuming a change in car occupancy to certain destinations, without specifying the measures which would bring this about).

In the context of Future Directions, this was sufficient. For a more detailed assessment of possible future demand management measures in Sydney, it will not be. These measures will affect generation and distribution of trips as well as modal split and assignment, and will take the form of sticks (e g parking supply constraint, price increases) as well as carrots (e g bus priorities, Park and Ride, car pooling schemes).

### The future of strategic sketch modelling as a technique

This paper has described the wants of a particular exercise and the modelling response, as modified by pragmatic constraints of time, resources, data and knowledge. The products of the Future Directions Study demonstrate the utility of sketch modelling.

Clearly it also has limitations as a technique, but many of the issues raised in this paper also carry over into other types of modelling, for instance into broad-acre planning, project development for specific transport infrastructure schemes, or environmental corridor management.

In what our models should be doing, the pointers are towards models that

- include pricing of both transport and land as policy variables ;
- incorporate a dynamic time element, provided we also can generate better knowledge about how land use change over time is affected by the transport system ;
- can reflect the wide range of travel demand management approaches now under consideration ;

*Kilsby, Prince, Stewart*

- recognise the needs of commerce and industry as well as private individuals ;
- can identify incidence of impacts, for equity assessment ; and
- address environmental and financial sustainability over time in their scope.

And in the way in which they are used, the pointers are towards models that are

- directly related to decision-making needs and responsibilities ;
- driven from a common, comprehensive, accepted and accessible database, whatever their particular purpose ;

- based on exploration rather than prediction, with the concept of risk given more prominence in strategic decision-making ;
- amenable to promotion of interaction between professions and disciplines ; and
- used and maintained on a regular basis - "use it or lose it" is a real fear without a significant user base.

These comments are made looking to the future, and do not belittle the worth of what has been done and described here.

### **The future of strategic sketch modelling in practice**

This paper opened with the question "Is sketch planning of any practical value in transport development ?". There is no doubt that on technical grounds the answer is a positive one. On practical grounds there is a significant qualification, when we pose the follow-up question "Of value to whom ?"

By its nature, strategic sketch planning has a comprehensive scope. In the real world, institutional frameworks may inhibit the addressing of such scope. The relevance of the technique thus depends to a high degree either on the goodwill of a number of different agencies in working towards a common end, or on the more formal adoption of such responsibility somewhere within the planning process.

### **Acknowledgement**

The authors acknowledge the agreement of the Chief Executive of the NSW Roads and Traffic Authority to the preparation of this paper, which is based on research work undertaken by the authors as reported in the RTA's Road Transport - Future Directions Report published in June 1991. The views expressed are those of the authors alone.

**References**

Travers Morgan, Sinclair Knight, Booz Allen and Hamilton (1991a) *Road Transport - Future Directions : Report on Options* Sydney : NSW Roads and Traffic Authority.

Travers Morgan, Sinclair Knight, Booz Allen and Hamilton (1991b) *Road Transport - Future Directions : Summary Report on Options* Sydney : NSW Roads and Traffic Authority.

Travers Morgan, Sinclair Knight, Booz Allen and Hamilton (1991c) *Road Transport - Future Directions Supporting Reports Volume A : Study Structure* Sydney : NSW Roads and Traffic Authority.

Travers Morgan, Sinclair Knight, Booz Allen and Hamilton (1991d) *Road Transport - Future Directions Supporting Reports Volume C : Futures* Sydney : NSW Roads and Traffic Authority.

Travers Morgan, Sinclair Knight, Booz Allen and Hamilton (1991e) *Road Transport - Future Directions Supporting Reports Volume E : Urban Travel - Sydney* Sydney : NSW Roads and Traffic Authority (in two parts, E1 and E2).

Travers Morgan, Sinclair Knight, Booz Allen and Hamilton (1991f) *Road Transport - Future Directions Supporting Reports Volume L : The Modelling Process* Sydney : NSW Roads and Traffic Authority (in two parts, L1 and L2).