A Comparison of Long Term Sydney Travel Forecasts with Actual Outcomes

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1 Introduction

Travel forecasts are routinely produced for many purposes. There is a large scientific body of literature to help practitioners undertake transport modelling with Ortuzar and Willumsen (2001), and Hensher and Button (2000) being just two examples. Many transport models produce forecasts, often with a time horizon of twenty to thirty years. Therefore a considerable period must elapse before these predictions can be compared with what actually happened. The Sydney Area Transportation Study (SATS) was undertaken in the early 1970s with a forecast year of 2000. This paper examines the forecasts that were produced by SATS and compares them with what actually happened.

The Sydney Area Transportation Study was a NSW Government organisation established in the early 1970s to determine the transport needs of Sydney.

> The major objective of the Sydney Area Transportation Study is to determine the transportation needs of the Sydney Area through to the year 2000, propose a series of alternatives to meet these needs, evaluate the costs and benefits of each and recommend transportation systems that will effectively serve the Sydney Area. SATS 1974(c).

To meet these objectives a considerable amount of effort and resources were devoted to developing a strategic travel model, a predecessor of the Sydney Strategic Travel Model currently operated by the Transport and Population Data Centre (TPDC). To support the development of the model the first large scale travel survey in Sydney was undertaken. The current Household Travel Survey (HTS) undertaken by the TPDC has a number of similarities with the SATS travel survey.

In the early 1970s computing facilities were vastly different to those available to practitioners today, with the project undertaken utilising punch cards and out of hours operations on external computing facilities. The model system that was developed included the traditional four transportation steps. The model inputs are documented extensively in SATS 1974(a) and the results in SATS 1974(b). Within this paper references to these two sources have generally not been included in the text, as often every second sentence would require these references. The reader is therefore asked to assume that details about SATS have been derived from these two volumes unless indicated otherwise.

2 SATS Population and Land Use Assumptions for 2000

SATS prepared a number of population and land use inputs for the modelling. In this section of the paper some of these forecast inputs are reported and compared with the actual values. This comparison allows an evaluation to be made of the accuracy of these inputs.

2.1 Population

Three years prior to the commencement of SATS, the Sydney Region Outline Plan (SROP) had prepared population forecasts. These forecasts were the initial basis for the production of the SATS inputs. SROP forecasts were prepared for the Sydney Region, an area now referred to as the Sydney Statistical Division (SD) by the Australian Bureau of Statistics

(ABS). The SATS Study Area was a subset of this region. The major differences between Sydney SD and the SATS Study Area is the exclusion of the Central Coast and the Blue Mountains. These differences are shown in Figure 1 which also shows the six sectors which SATS used for some of their reporting.

Figure 1 Sydney Statistical Division, County of Cumberland and SATS Sectors

Table 1 summarises the population forecasts for Sydney Statistical Division, split by inside and outside the Study Area. SATS used forecast years of 1980, 1990, 2000. The most detailed data on actual outcomes is available for ABS Census of Population and Housing years, the most relevant of which is 2001. From Table 1 it can be seen that the actual population for Sydney in 2001 was close to population which SATS expected would be reached in 1990.

Table 1 Population Forecasts for Sydney Statistical Division

	Sydney Area Transport Study			Actual
	1971	1990	2000	2001
Study Area	2,773	3,824	4,286	3,755
Rest of Sydney SD	142	319	656	373
Total Sydney SD	2,915	4,143	4,942	4,128

Note: Units are Thousands

Within the Study Area, population forecasts were prepared for each of the 41 Local Government Areas. These forecasts were further broken down to the traffic zone level. These forecasts are summarised for the six regional sectors (which SATS adopted for strategic reporting) in Table 2. From Table 2 it can be seen that the distribution of the population growth is reasonably consistent with the growth that occurred until 2001.

Table 2 Population Forecasts by Sector

	Sydney Area Transport Study					Actual	
	1971	Growth to 1990		Growth to 2000		Growth to 2001	
Northern	569	89	8%	162	11%	117	12%
Central	660	0	0%	-5	0%	-19	-2%
Inner Western	492	105	10%	114	8%	149	15%
Southern	479	77	7%	83	5%	92	9%
Outer Western	286	448	43%	654	43%	365	37%
South Western	284	335	32%	508	34%	281	29%
Study Area	2,770	1,054	100%	1,516	100%	985	100%

Notes: (1) The unit of population is thousands.

(2) The percentages are for the distribution of the growth within the Study Area.

2.2 Households

One of the key inputs in determining the population distribution is the availability of sites to accommodate additional dwellings. Within a city such as Sydney these sites will generally comprise a mixture of green-field, in-fill and conversion from other uses (eg old industrial "brown-field") developments. Once the availability of potential sites has been determined, the number that will be required depends on assumptions on the number of people living in a dwelling (household size). In Sydney there is nearly exactly one household per occupied private dwelling. Table 3 shows the number of additional households that SATS expected in the Study Area and the actual number.

Table 3 Household Growth Forecasts by Sector

	Sydney Area Transport Study		Actual
	1971	Growth to 2000	Growth to 2001
Northern	182	77	74
Central	203	78	73
Inner Western	139	71	79
Southern	148	58	58
Outer Western	72	187	139
South Western	93	127	90
Total Study Area	836	598	513

Note: Units are Thousands

From Table 3 it can be that the number of additional households that SATS expected in 2000 approximates the actual increases. For the Outer Western and South Western sectors SATS had higher forecasts than have eventuated. Whilst the SATS forecast increase in the number of households in Table 3 may appear to be within acceptable bounds of forecasts, from Table 2 it can be seen that SATS had envisaged a much higher population for Sydney. The reason for this difference is the household size assumptions. The SATS team documented that there would be a dramatic reduction in household size with it falling to 3.1 by 1980 and then to 3.0 by 2000 (SATS 1974b). Table 4 shows that the actual reduction was much greater than they anticipated.

Table 4 Household Size Forecasts

Year	SATS	Actual
1971	3.31	

1980	3.09	
1986		2.85
1990	3.03	2.84
2000	2.99	2.75

Notes: (1) The Actual household size calculations have been undertaken for the whole of Sydney SD.

(2) Actual household size calculations for 1990 and 2000 are from census years 1991 and 2001 respectively.

(3) The calculation of household size is normally undertaken excluding people whose usual place of residence is not a private dwelling. It is not clear whether this distinction was made by SATS, therefore the Actual calculations have been undertaken using the estimated resident population irrespective of the category of dwelling they normally reside in.

2.3 Workforce

In 1971 approximately 47% of the population in the Study Area was in the workforce although they later concluded that the true rate was 44.5%. SATS assumed that the participation rate would remain constant until 2000. Table 5 compares the SATS workforce assumptions with the actual workforce size and participation rates.

Table 5 Workforce Assumptions

	Sydney Area Transport Study		Actual
	1971	2000	2001
Population	2,770,000	4,286,000	3,673,000
Workforce	1,301,000	1,910,000	1,820,000
Participation Rate	47.0%	44.6%	49.6%

Notes: (1) Subsequent analysis by the SATS team lead them to conclude that their 1971 employment (and hence workforce) estimates were too high (1974a).

(2) The 2001 actual values have been obtained for the whole of Sydney SD and then scaled to match the SATS region.

2.4 Employment

The workforce was allocated to six major industry employment groups. Table 6 shows the SATS employment estimates by industry group for 1971 and 2000 and the actual numbers and percentages. It can be seen from Table 6 that manufacturing employment levels decreased in absolute numbers rather than just in percentage share. Conversely the services sector has experienced more rapid growth than anticipated.

Table 6 Employment Forecasts by Industry (thousands)

	Sydney Area Transport Study				Actual	
	1971		2000		2001	
Manufacturing	416	32%	550	29%	208	11%
Commerce / Finance / Property	299	23%	458	24%	470	26%
Services / Public Authority	351	27%	615	32%	843	46%
Transportation / Communication	104	8%	134	7%	145	8%
Building / Construction	104	8%	115	6%	139	8%
Other	26	2%	38	2%	15	1%
Total Study Area	1,301	100%	1,910	100%	1,820	100%

Notes: (1) The Actual industry estimates have been obtained for the whole of Sydney SD and then scaled to match SATS region population.

(2) The industry categories have changed between 1971 and 2001 and there is some imprecision in the definitions used for the two sources.

The workforce was also categorised by five occupation groups. Table 7 shows the SATS employment estimates by occupation group for 1971 and 2000 and the actual numbers and percentages. What is not obvious from Table 7 is that the standard occupation categories that are now used by the ABS are very different to those used in 1971. The categories now used by the ABS relate to job functions rather than the industry that a person is employed in.

Table 7 Employment Forecasts by Occupation (thousands)

	Sydney Area Transport Study				Actual	
	1971		2000		2001	
Office	495	38%	892	47%	735	40%
Industrial	482	37%	580	30%	342	19%
Transportation & Communication	78	6%	95	5%	301	17%
Sales and Service	208	16%	305	16%	348	19%
Other	39	3%	38	2%	94	5%
Total Study Area	1,301	100%	1,910	100%	1,820	100%

Notes: (1) The Actual occupation estimates have been obtained for the whole of Sydney SD and then scaled to match SATS region population.

(2) The industry categories have changed between 1971 and 2001 and there is some imprecision in the definitions used for the two sources.

SATS prepared two employment distributions. The first assumed that the central Sydney area (CSA) would continue to grow and reach an employment total of 260,000 in 2000. Under this scenario the SROP target figures for sub-centres such as Parramatta, Chatswood and Campbelltown would be achieved by 2000. The second employment distribution assumed that the employment dispersal trend apparent in 1971 would decline and that the CSA would maintain its share of regional employment and reach 374,000 by 2000. Under both scenarios, the distribution of manufacturing employment was unaltered. Table 8 shows the non-manufacturing employment assumptions for the Local Government Areas where the 2000 employment varied between the two scenarios.

Table 8 Non-Manufacturing Employment Forecasts for Local Government Areas which Varied between Dispersed and Concentrated Scenarios

	Sydney Area Transport Study				Actual
Local Government Area	1971	2000 Dispersed	2000 Concentrated	2000 Difference	2001
Sydney	257,200	305,000	413,000	108,000	281,400
Parramatta	35,100	120,000	70,000	-50,000	88,000
Campbelltown	7,400	84,700	61,700	-23,000	34,400
North Sydney	37,300	66,000	54,000	-12,000	68,700
Willoughby	20,900	50,000	39,000	-11,000	55,300
Other LGAs	37,240	129,000	117,000	-12,000	137,300
Total Selected LGAs	395,140	754,700	754,700	0	665,100

Notes: (1) The employment is for the whole of the LGA and not just for the key centre.

(2) The 2001 estimates are from TPDC September 2004 employment forecasts. These are for the residents of the whole of the GMA and not just the SATS study area.

Table 9 shows the employment growth for the two scenario distributions for 2000 and the actual employment growth until 2001. From Table 9 it can be seen that aggregate growth in employment was close to the forecast amount. This is in contrast to Table 2 where the actual population growth was closer the 1990 levels rather the 2000 level. The employment growth

for outer regions, especially in the south west has been much lower than anticipated. Meanwhile, the growth in the northern sector has been much higher than anticipated.

Table 9 Employment Forecasts by Sector

		Sydney Area Transport Study				Actual	
	1971	Dispersed scenario growth to 2000		Concentrated scenario growth to 2000		Growth to 2001	
Northern	187	76	12%	53	9%	158	25%
Central	582	58	9%	166	27%	55	9%
Inner Western	222	131	21%	81	13%	124	20%
Southern	119	22	4%	22	4%	42	7%
Outer Western	75	128	21%	123	20%	154	25%
South Western	107	195	32%	165	27%	89	14%
Study Area	1,301	609	100%	609	100%	622	100%

Notes: (1) The unit of employment is thousands.

(2) The percentages are for the distribution of the growth within the Study Area.

3 SATS Travel Forecasts for 2000

The SATS model system included the traditional four transportation steps; trip generation, trip distribution, modal choice and assignment. The model system operated with five travel purposes; home based work, home based shopping, home based school, home based other and non home based. The 24 hour assignments were undertaken using stochastic assignment with capacity restraint. For the am peak assignments an incremental loading procedure was adopted. There was a vehicle ownership forecasting model which provided inputs to the trip generation and modal choice models. The am peak public transport network contained 542 bus lines whilst the off-peak network contained 377 bus lines. These are in addition to the rail and ferry lines. In addition to the usual outputs, Vehicle Miles Travelled, average speed, cold starts, emissions and noise were calculated for 2 mile by 2 mile grid squares.

3.1 Vehicle Ownership

One of the key forecast variables within the SATS model system was vehicle ownership. The Study Team recognised that vehicle ownership levels had been increasing and were expected to continue to increase in the future. Table 10 shows the SATS vehicle forecasts and the HTS results. From Table 10 it can be that the SATS forecast number of vehicles per person is close the actual number. As the household size in 2001 is lower than SATS anticipated the number of vehicles per household is lower than forecast. Conversely, the number of households with zero vehicles is higher than anticipated, 14% compared with 9%.

Table 10 Vehicle Forecasts

	SATS		HTS
	1971	2000	2001
Vehicles	850,000	2,114,000	1,895,000
Households (Families)	868,000	1,434,000	1,356,000
Population	2,773,000	4,286,000	3,698,000
Vehicles / Household	0.98	1.47	1.40
Vehicle / Person	0.31	0.49	0.51

Households with zero cars	27%	9%	14%
Households with one cars	50%	43%	39%
Households with two or more cars	23%	48%	48%

Source: HTS – Pooled Household Travel Survey 1997-2003

3.2 Commercial Vehicle Trips

In addition to the personal travel demands, SATS recognised the role the impact that commercial vehicles have on the transport system. Table 11 summaries the base year commercial vehicle travel data. One difficulty with the analysis and reporting of commercial vehicle travel is the definition of a trip. Unlike personal travel, some commercial vehicle trips can comprise a very large number of stops involving multiple pick-ups and/or drop-offs. From the median trip lengths in Table 11 it would appear that the definition used in SATS was between successive stops.

Table 11 1971 Commercial Vehicle Trips

Vehicle Type	Number of Trips	Median Trip Length (kms)	Median Trip Duration (mins)
Light Trucks	708,000	4.2	10
Heavy	223,000	5.3	17
Taxi	195,000		

Source: SATS 1974(a) Table 6.20 & SATS 1974(b) Table 6.20

Note: Metric conversion undertaken by author.

SATS also prepared estimates of commercial vehicle travel for future years. These estimates and actual commercial vehicle travel for 2002 are reported in Table 12. SATS predicted that from 1971 to 2000 the number of commercial vehicle trips would increase between 60% and 68% depending on the vehicle type, marginally higher than the 55% increase in population. The current (2002) estimates of commercial vehicle travel from the TPDC Commercial Vehicle Transport Study have a lower estimates of trips compared to 1971. From Table 11 it would appear that very different definitions of trips have been adopted.

Table 12 Commercial Vehicle Travel Forecasts

	Sydney Area Transport Study		Actual
Vehicle Type	1971	2000	2002
Light Truck	708,000	1,142,000	631,700
Heavy Truck	223,000	356,000	239,900
Taxi	195,000	328,000	
Total	1,126,000	1,826,000	

Source: SATS 1974(b) Table 3.26 and TPDC 2002 Commercial Transport Study Estimates

Note: The 2002 estimates are for the whole of Sydney SD

3.3 Personal Travel

The major demand on the transport system is from the travel undertaken by individuals (personal travel). Table 13 provides a summary of travel patterns in 1971. The travel unit of analysis in Table 13 is a journey.

> *A journey is a one-way movement from place to place for a specific purpose, by one or modes of travel.* SATS 1974(a) page VI – 1.

In Table 13 other modes of travel were excluded from the SATS analysis as a major emphasis of the analysis was on the demands for the road and public transport systems.

Table 13 1971 Summary of Personal Travel (Linked Trips)

Journey Purpose	Number	Mode Share		Median Length (kms)	
		Public Transport	Private Vehicle	Public Transport	Private Vehicle
Home based work	1,786,000	35%	65%	10.9	9.9
Home based school	575,000	69%	31%	7.5	5.3
Home-based Shopping	537,000	24%	76%	4.5	3.2
Home based Social/Recreation	761,000	10%	90%	6.6	3.4
Home based Personal business	597,000	12%	88%	nss	nss
Non Home-Based	651,000	14%	86%	6.3	4.7
Total	4,907,000	28%	72%	7.1	5.8
Trips / Person	1.77				

Source: SATS 1974(a) Tables 6.9 & 6.7

nss Not statistically significant.

Note: Metric conversion undertaken by author.

The SATS travel model was used to produce estimates of travel in the future. Table 14 shows the daily travel for 1971 and the forecast travel for 2000. The travel unit of analysis in Table 14 is a trip (which equivalent to a journey (SATS 1974(a) Table 6.1). Unlike Table 13, Table 14 includes intra-zonal travel.

Table 14 SATS Travel Forecasts (Linked Trips)

Trip Purpose	1971		2000	
	Number	% of Total	Number	% of Total
Manufacturing work	679,000	11.5%	944,000	8.5%
Other work	1,370,000	23.1%	2,335,000	20.9%
School	1,058,000	17.9%	1,607,000	14.4%
Social/Recreation	602,000	10.2%	1,569,000	14.1%
Shopping	819,000	13.8%	1,933,000	17.3%
Other	638,000	10.8%	1,490,000	13.4%
Non Home-Based	754,000	12.7%	1,273,000	11.4%
Total	5,920,000	100.0%	11,151,000	100.0%
Trips / Person	2.15		2.60	

Source: SATS 1974(b) Table 3.25

Note: Our analysis suggests that the trips / person calculation has been based on the total population, rather than being restricted to the population five years of age and older.

To compare the 2000 forecasts in Table 14 with the actual travel for 2001 from the HTS would seem to be a relatively simple task. In practice, there are a number of complications. Despite the methodology of the 1971 travel survey being similar to the HTS there are number of important differences. Some of the information not collected in the 1971 survey was travel data for persons under 5 years of age, and walk trip information, unless this was the main mode of travel (TSG 1993). Whist we have access to the original SATS travel survey data this has not been used for the analysis that we have undertaken, rather we have relied on the reporting of the analysis undertaken by SATS. One of the difficulties in analysing travel survey data is the linking together of individual travel legs to form journeys. Two separate

analyses were undertaken using the HTS data, each using different trip linking approaches. The first approach combined individual trips legs where there is a change in mode. For example someone who drives to their local railway station and then catches a train would have these two trips combined to form a single linked trip. In the second approach, from when a person leaves home until they return home, a primary purpose was assigned according to a hierarchy of travel purposes. This form of combining individual trips is often referred to as a tour. In the first approach a person can have a multiple linked trips, especially if they undertake multiple activities. Consider the example of someone who leaves home, drops a child at school and then continues onto work. With the first approach this will result in a home-based serve passenger trip and a non-home based work trip, whilst with the second approach this will result in a single home-based work tour. Table 15 shows HTS data for a number of travel purposes using the linked trip and tour definitions compared with the forecast travel from SATS.

Table 15 SATS Forecast and HTS (Linked Trips)

	SATS 2000		HTS 2001 Linked Trips		HTS 2001 Tours	
Trip Purpose	**Number**	**% of HB**	**Number**	**% of HB**	**Number**	**% of HB**
Work	3,279,000	33%	2,227,000	25%	2,801,000	31%
School	1,607,000	16%	870,000	10%	1,004,000	11%
Social/Recreation	1,569,000	16%	1,534,000	17%	1,339,000	15%
Shopping	1,933,000	20%	1,450,000	16%	1,492,000	17%
Other	1,490,000	15%	2,918,000	32%	2,359,000	26%
Total Home Based	**9,878,000**	**100%**	**9,000,000**	**100%**	**8,996,000**	**100%**
Non Home-Based	1,273,000		4,154,000			
Total Trips	11,151,000		13,154,000			

Source: SATS 1974(b) Table 3.25

Notes: (1) HB is Home based.

(2) HTS Linked Trips combines trips with change of mode purpose.

(3) HTS Tours is defined using a hierarchy of purpose.

(4) HTS Work purpose includes work related business for assumed compatibility with SATS.

From Table 15 it can be seen that the number of work trips from the HTS can vary depending on the definition and approach used to undertaken the analysis. The linked trip approach will have a lower number of home based work trips if a person makes an intermediate stop whilst travelling between home and work and visa versa. The SATS travel survey was undertaken during the period June to October with surveys not undertaken during school holidays or on public holidays, whereas the HTS is undertaken during the whole year. Consequently the HTS results are for an average weekday which includes a significant number of school holidays. Overall the number of trips and distribution by purpose forecast by SATS are comparable to the HTS results (especially the tour based analysis).

3.4 The Options

Rather than obtaining a single estimate of travel in 2000 the SATS model was run a number of times with varying levels of highway and public transport improvements, land use distributions, parking costs and fares policies. Summarised key indications from these model runs and corresponding 2001 indicators from the HTS are presented in Table 16.

Table 16 SATS Model Runs Key Indications and HTS Indicators

	SATS Projections for 2000										HTS 2001	
Label	**A**	**B1**	**B2**	**C1**	**C2**	**D1**	**D2**	**E**	**F**	**G**	**AM Peak**	**All Day**
Highway Investment	Medium	Relatively low	Relatively low	High	High	Very High	Very High	Very High	High	Very High		
Public Transport Investment	Minimum	High	High	High	High	Very High	Very High	Very High	Very High	Very High		
Land use	Dispersed	Dispersed	Dispersed	Dispersed	Dispersed	Dispersed	Concentrated	Dispersed	Dispersed	Dispersed		
Parking Cost	Unrestricted	Moderate	High	High	High	High	High	High	High	High		
Fares				Medium	Zero	Moderate	Moderate	Low	Low	Low		
Average Trip Length (Inter-zonal travel)												
Industrial Areas (kms)	15.2	15.9		16.8		15.4	15.4	15.6	15.6	15.9	17.2	17.2
Non Industrial area (kms)	16.4	17.0		18.0		16.4	17.3	16.7	16.7	17.0	15.6	15.0
AM Peak Work Trips												
High density employment areas	350,000	349,000	349,000	380,000	379,200	435,000	451,000	454,000	452,000	454,000	253,000	373,800
Other employment areas	735,000	736,000	736,000	702,000	700,000	529,000	616,000	627,000	628,000	627,000	378,000	729,900
Study Area	1,085,000	1,085,000	1,085,000	1,082,000	1,080,100	1,082,000	1,067,000	1,081,000	1,080,000	1,081,000	631,000	1,103,700
Overall Mode Share												
Public Transport	29.9	32.6	35.8	34.2	39.8	40.0	46.0	41.3	37.3	36.5	30.8	24.9
Car Diver	48.2	44.4	42.4	47.8	39.1	40.0	35.6	41.3	42.7	43.3	58.5	62.3
Other	16.4	19.0	21.8	18.0	21.1	20.0	18.4	19.4	20.0	20.2	10.8	12.8
Total	94.5	96	100	100	100	100	100	102	100	100	100	100
Mode Share - Public Transport												
High Density employment	56.0	60.4	70.1	65.8	74.0	67.2	76.1	66.3	64.2	62.3	54.3	47.8
Other employment areas	17.4	19.4	19.4	17.1	21.3	20.3	23.9	19.8	18.0	17.7	15.0	13.2
Detailed Centres Analysis												
Trips												
Sydney CBD		171,500	169,300	173,100	172,800	174,000	241,000	174,000	173,600	174,400	126,000	172,400
North Sydney		17,800	17,600	17,900	17,800	18,000	12,900	18,000	18,000	18,000	21,100	28,000
Parramatta		62,500	63,500	62,000	62,000	61,900	29,100	61,700	62,100	61,800	20,400	28,400
Campbelltown				30,000	30,000	29,300	17,200	29,300	29,400	29,300	2,700	6,400
South Sydney Industrial				17,100	17,000	17,200	17,100	17,200	17,100	17,200	22,000	45,700
Total		251,800	250,400	300,100	299,600	300,400	317,300	300,200	300,200	300,700	192,200	280,900
PT Mode Share												
Sydney CBD		70.7	79.0	81.0	84.0	82.1	80.0	82.2	82.1	80.8	80.5	75.9
North Sydney		60.0	71.8	73.7	79.1	76.5	76.0	76.2	74.4	73.8	59.5	55.5
Parramatta		49.0	58.6	62.9	71.9	66.3	66.0	64.4	59.5	59.6	31.8	27.3
Campbelltown				31.7	47.4	51.7	20.9	51.9	42.1	42.1	7.3	8.5
South Sydney Industrial				23.0	29.5	47.2	46.8	43.6	41.5	39.0	17.2	13.3
Car Driver Mode Share												
Sydney CBD		17.4	11.9	13.2	8.7	11.0	12.4	11.2	11.3	12.1	11.7	15.1
North Sydney		23.0	14.8	16.8	10.3	13.2	14.0	13.7	14.9	15.6	28.0	30.8
Parramatta		31.5	25.0	25.3	15.4	19.6	19.2	20.8	25.5	25.2	61.0	59.5
Campbelltown				41.0	25.3	23.0	44.8	22.8	29.4	29.3	89.8	81.9
South Sydney Industrial				57.7	46.5	33.2	33.9	37.3	38.4	40.8	72.7	74.9
Other Mode Share												
Sydney CBD		11.9	9.1	5.8	7.7	6.9	6.8	6.6	6.6	7.1	7.8	9.0
North Sydney		17.0	23.4	9.5	10.6	10.3	10.0	10.1	10.7	10.6	12.5	13.7
Parramatta		19.5	16.4	11.8	12.7	14.1	14.8	14.8	15.0	15.2	7.2	13.2
Campbelltown				27.3	27.3	25.3	34.3	25.3	28.5	28.6	2.9	9.6
South Sydney Industrial				19.3	24.0	19.6	19.3	19.1	20.1	20.2	10.1	11.8

Notes:
(1) Shaded cells contain data which appears to have been wrongly transcribed in the original report
(2) Average trip length segmentation for HTS analysis is based on industry of employment of the individual rather than the classification of the area
(3) There may be differences in the geographic scope of the centres between SATS and HTS
(4) The HTS sample size for Campbelltown centre is small and the results may not be statistically significant

From Table 16 it can be seen that the 1,103,700 work trips in 2001 obtained from the HTS (considering just the outward journeys from home to work, ie excluding the return journey from work to home) for the whole day is close to the forecast level of travel by SATS (approximately 1,080,000 trips depending on the option) for the two hour am-peak period. By contrast the HTS has 631,00 trips for the two hour peak period. Likely reasons for this significant difference is a combination of lower than expected workforce, some peak spreading and the adoption of the HTS definition of a work trip which classifies work related business travel separately to commute (home to work) travel. Inclusion of the broader definition would result in the addition of approximately 300,000 tours in a day for 2001. Approximately one quarter of the home based business travel (80,000 trips) occur in the two hour am peak period.

From Table 16, it can be seen that the average trip lengths are comparable. It is likely that different methodologies have been use to calculate the trip lengths. SATS probably used road network distances from the model (with only a subset of roads included) whereas the HTS results were calculated using GIS based networks. There are also some differences in the zonal systems with the HTS being more detailed than SATS. SATS predicted that trips lengths to industrial areas would be slight shorter than to non-industrial areas. The HTS analysis was based on the industry classification and found that the trip lengths for people working in manufacturing were slightly longer than those in other industries.

With results for 10 different scenarios available from SATS there is a reasonable probability that the HTS results will be within the SATS range of estimates. The overall SATS public transport mode share estimates range from 29.9% to 46.0% compared with the HTS result of 30.8%. By contrast, the SATS car driver mode shares ranged from 35.6% to 48.2% compared with the HTS result of 58.5%. The SATS forecasts for other modes ranged from 16.4% to 23.9% compared with 10.8% from the HTS. For the other modes trips in the HTS, just over half are car passenger journeys with approximately one third walk trips. Clearly car driver has a higher mode share than was predicted and conversely public transport a lower mode share.

SATS also reported public transport mode shares to high density employment areas and other employment areas. The HTS analysis defined high density employment as the key centres in Sydney. The SATS public transport mode shares for high density employment areas ranged from 56.0% to 76.1% compared with a HTS derived estimate of 54.3%. For the other employment areas, the SATS public transport mode shares ranged from 17.1% to 23.9% compared with a HTS derived estimate of 15.0%.

The first SATS modelled scenario with medium level of highway and public transport investment, dispersed land use and low parking cost resulted in the lowest forecast public transport mode share. SATS also reported forecast number of work trips in the am-peak and mode-share for a number of centres. This reporting was not undertaken for first model run of the system and two additional centres, Campbelltown and South Sydney Industrial were included for the fourth and subsequent model runs. Using the dispersed land use scenario and the HTS all day results a number of observations can be made. The SATS forecast number of trips to the CBD was approximately 173,000 compared with HTS result of 172,000. For North Sydney, the comparison is 18,000 and 28,000. The HTS analysis includes travel to Milsons Point which is part of the larger North Sydney CBD area and the large difference is possibly a result of different boundary definitions being adopted. For Parramatta, SATS forecast approximately 62,000 trips compared with 28,000 from the HTS. Interesting under the concentrated employment scenario the number of trips forecast to be made to Parramatta was 29,100, quite close to the HTS value of 28,000. The concentrated scenario with lower employment in Parramatta was assessed to evaluate the situation where the CBD maintains a high share of employment with a smaller amount available to be dispersed to the centres. Under the dispersed scenario the SATS forecast number of trips to

Campbelltown was 17,100 compared with the HTS value of 6,400. The HTS shows approximately double the number of trips to South Sydney Industrial Area, however again this could be a definitional issue with the HTS analysis including the airport precinct.

4 Implicit Assumptions in Modelling

Section 2 of this paper outlines the population and land use assumptions used as inputs to modelling. The scenarios reported in Section 3 contained assumptions about the transport system (highway and public transport), parking costs and public transport fares. There are a number of other changes which have occurred during the period which will have an impact on travel behaviour. Examples include an increase in the proportion of people with a drivers licence, real growth in incomes, and changes to the population age structure. It is possible to incorporate these types of variables within a model system. This is becoming more common in modern model systems, an option which was not available when SATS was undertaken with vastly inferior computing resources.

Litman (2005) shows that fuel costs per mile have decreased in real terms from 1970 to 2000 in the USA, with a spike in the mid 1970s and another spike in the early 1980s. The general trend has been downwards, although there has been a real increase since 2000. Whilst taxation rates in the USA are different to Australia, the same general trend is probably applicable to Sydney. Over the SATS forecast period there have been a number of demographic changes including an ageing of the population, increased workforce participation rates by females, changes in household and family structures (eg higher proportions of single parent families). Again these types of changes can be implemented within model systems either directly or by creation of alternative future scenarios.

An integral part of transport model systems are the mathematical equations that have been estimated to explain the travel choices that people make, which when combined with the transport system and demographic assumptions produce travel forecasts. Whilst the transport and demographic inputs are routinely adjusted for future years it is standard practice for the mathematical equations to remain unaltered, that is individuals choice preferences stay constant over time. This is an area of research that needs to be investigated, but it is beyond the scope of this paper. People's attitudes to a number of issues have changed over the last twenty five years with the environment being one such example. Not all aspects of the transport system were envisaged, for example whilst there was a toll on the Sydney Harbour Bridge, it is unlikely that the SATS team anticipated that some of the proposed new roads would operate as toll roads. The people who build model systems should design them in a manner that allows as many variables, inputs and assumptions to be adjusted as practical to provide flexibility to the users of such models. This approach will limit the number of implicit assumptions. However, it is not possible to envisage every possible change that what occur. Even if changes are contemplated, these model systems need a mechanism to be able quantify the effect the changes have on travel demand.

5 The Accuracy of the SATS Forecasts

With the benefit of hindsight, did the SATS project produce "good" travel forecasts? How and on what grounds should this be assessed? Rodier (2003) suggests that an accuracy of up to 30 precent is typical.

> It is widely acknowledged, however, that forecasts produced by travel and emission models are typically inaccurate; it is not uncommon to find large differences between predicted and actual outcomes. Some transportation professionals believe that current

state-of-the-art methods can forecast emissions with an accuracy of plus or minus 15 percent to 30 percent (Chatterjee et al. 1995).

One theoretical approach to assess the quality of the forecasts that could be undertaken would be to rerun the SATS model with the actual 2000 population, land use and transport systems. In practice, this is not possible as the detailed network coding, model implementation and etc is not available. This approach would eliminate any forecast differences from these inputs. It is likely that there will still be differences. How large can / should the difference be whilst we still conclude that the model was acceptable? There are formal techniques for assessing and validating travel models (TMIP 1997). These generally prescribe how model outputs for the base year can be validated but can also extend to reasonableness checks, for example elasticities of key parameters. However, they apply to checks that model developers can undertake during the model building process and not with the benefit of hindsight. Figure 2 shows the key socio-demographics in the modelling process. As outlined in Section 2, SATS over-estimated the population growth. A consequence of this over-estimation was the growth in number of households and the workforce were also over-estimated. SATS also over-estimated the growth in vehicles, although it can be concluded the 123% growth which has occurred is reasonably close to the 149% growth that occurred.

Figure 2 Comparison of Socio-Demographics Growth from 1971

As outlined in Section 4 the predicted results were broadly consistent with the actual outcomes, although public transport mode share is lower than predicted with car driver mode share higher. Figure 3 shows the mode shares in 1971 and 2001 and also the minimum and maximum mode shares from Table 15. From Figure 3, it can be seen that SATS were expecting that the public transport mode shares would increase in most scenarios. Somewhat surprising is the public transport mode shares in 2001 are comparable to the 1971 levels.

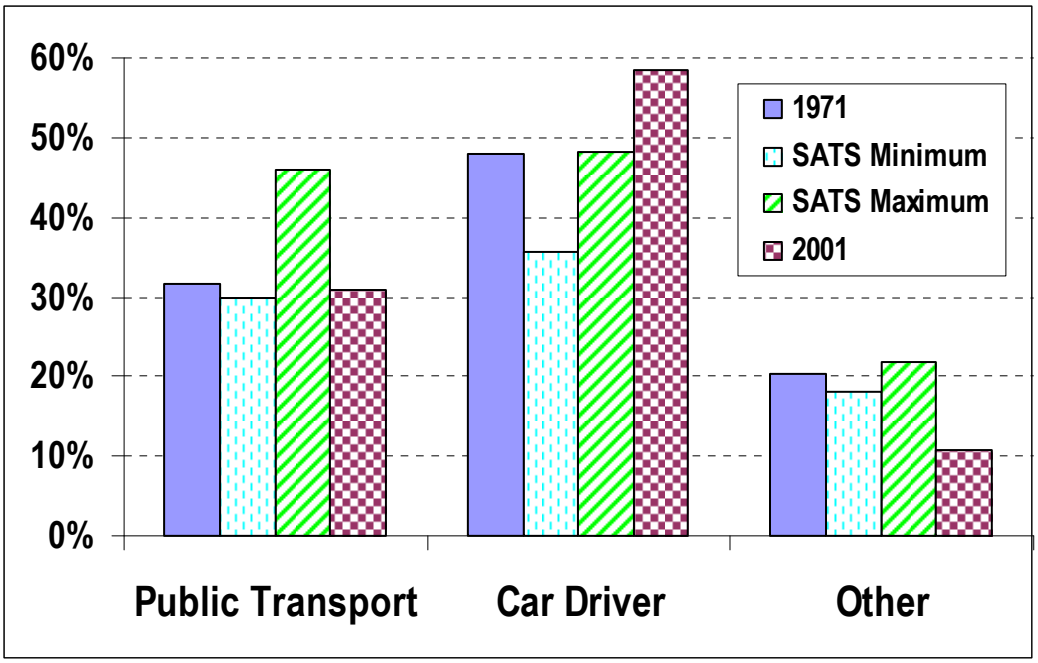

Figure 3 Comparison of Work Mode Shares

Flyvbjerg et al (2005) present results from what they claim is the first statistically significant study of forecasts for transport infrastructure projects. They conclude that passenger forecasts are overestimated in 9 out 10 rail projects with the average overestimation being just over 100%. Meanwhile for half of the road projects that they examined, difference between actual and forecast traffic is more than ±20%. They also conclude that forecasts have not become more accurate over the thirty year period that they have studied. Niles and Nelson (2001) observe that there have been relatively few systematic attempts to measure and analyse the uncertainty in the predictions from regional transport planning. Whilst SATS did not get all of forecasts "correct", perhaps the forecasts that are being produced today are no more accurate.

6 Conclusions

It was only possible to write this paper because of the thorough and comprehensive nature of the documentation contained in the reports that were produced by SATS. The documentation is of a higher standard than is typically found for many projects undertaken today. Perhaps this is partially because of our increased referral of readers to electronic attachments, an option not available to the SATS team. Despite the level of documentation there were difficulties in understanding some of the definitions that were adopted.

The SATS team undertook a number of model runs, however they did not look at alternative distributions of the population. It is unclear whether this was contemplated, or if it was deemed that other issues were more important to evaluate. They considered a range of explicit assumptions for their model, including transport systems, employment distributions, fares and parking polices. It is not clear whether they considered the impact of the implicit assumptions may have on their forecasts. Generally the explicit assumptions have proved to be reasonable, although a consequence of the greater decrease in household size than anticipated (probably partially a consequence of lower fertility rates) has resulted in Sydney having a lower population than predicted in 2000. Perhaps fortunately, there is less travel than was predicted. The SATS forecast mode shares for car driver were generally very good.

The public transport mode shares estimates were generally too optimistic. The "other" mode shares, mostly car passenger and walk have decreased much more than SATS anticipated.

There are difficulties in applying formal statistical tests to assess the quality of the forecasts produced in a before and after evaluation such as outlined in this paper. The literature suggests that current models may not produce results that are any more accurate. Given these limitation it would be appropriate that the SATS forecasts were a good effort. Maybe, SATS had a “perfect” model, but we do not have tools available to prove this.

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