HOW VARIABLE IS THE VARIABILITY IN TRAFFIC? HOW CAN TDM SUCCEED?

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ABSTRACT

The argument has been made that, with a few exceptions, travel demand management (TDM) measures have had little success and at most this has been local. An important assumption underpinning the application of TDM measures directed at changing vehicle occupancy, trip timing and route choice behaviour is that the traffic stream has a low level of variability from day to day because travel behaviour is habitual. In apparent contradiction to this assumption are the findings from traffic surveys that while traffic volumes are reasonably consistent, there is a high variability in those travelling on different days. This could explain why TDM measures have not been successful, either because the variability was too large for the change to be significant, or because the measures that were applied were based on incorrect assumptions.

The authors presented a paper at the 2006 SATC conference which reported the results of a licence plate recognition survey on an arterial route entering the Cape Town CBD. It reported levels of variability which, while consistent with similar international studies, were surprisingly high. This paper will describe the results of two follow up studies of traffic variability in two different environments; namely an arterial road in the suburbs, and a residential collector. For each study, vehicle registrations were noted for 90 minutes in the morning peak period on the week day of three weeks. These were compared to determine the variability within the traffic streams.

A comparison of the three datasets reveals that there is a significant difference in the degree of variability in the traffic streams of the three different environments. This significant difference provides an opportunity to reconsider the appropriateness and potential for TDM measures that assume habitual travel behaviour; more specifically those aimed at changing trip timing and route.

1. INTRODUCTION

Traffic congestion has been the concern of transportation planners for many years. The obvious solution has been to “predict and provide” more traffic capacity; by either increasing road space or managing the traffic system (TSM). Increasing congestion has proven that these initiatives have not been successful (albeit that more vehicles are able to use the roads.) This prompted the shift towards “predict and manage”; which is often referred to as travel Demand Management (TDM) (Saleh & Farrel,2005).

The objectives of TDM are essentially to reduce the amount of motorised travel in general and in the peak period in particular.

The 4-step transportation planning model to predict when the objective was to “provide” is based on two big assumptions; namely:

a) Travellers make choices so as to maximise their utility (or alternatively minimise the disutility of making the trip).
b) A state of equilibrium will exist in the utility / disutility to be obtained from using any of the competing alternatives.

In many instances, the 4-step model shave been shown to be inaccurate when applied to the “predict and provide” scenario. They can be expected to be even less accurate if they are applied to ”predict and manage” problems because these problems are aimed at changing behaviour which means destroying the equilibrium and surmounting the inertia to change.

Two research areas that have emerged are “How habitual are travellers?” (Behrens & Del Mistro 2006; Del Mistro & Behrens, 2006) and “What triggers travellers to change one habit for another?” (Behrens et al 2007, Del Mistro et al 2007)

This paper discusses only the first question. It is based on three studies of 90 minutes in the morning peak periods of the weekdays over three weeks on an arterial approach to the CBD, a suburban arterial and the collector from a residential area in Cape Town; carried out in 2005 and 2007.

The description and discussion of the studies and their findings are preceded by a brief literature review on traffic variability. The paper includes a discussion of the implications of these findings for transportation modelling and the selection of TDM measures.

2. TRAFFIC VARIABILITY: THE LITERATURE

The objective behind TDM is to change undesirable travel behaviour to desirable travel behaviour. *“The only successful pathway to substantial change in travel behaviour at the aggregate level is by intervening to secure ‘asymmetric churn’”* (Goodwin, 1994,4). The intention of asymmetric churn is “*seeking to increase a little the number of people already, every year, doing* [what is desirable] *in huge numbers, and reduce a little the number of people already, every year, doing the opposite in large numbers*” (Goodwin, 1994,4).

The concept is that most travellers do not have the same travel behaviour every day; and that some of these behaviours are more “desirable” than others. It is the internal variability that provides the opportunity to change travel behaviour in individuals. Since the traveller has already tried doing what is “desirable”, how can a TDM measure be better shaped to ensure that the desirable behaviour is repeated more frequently and becomes a habit.

If one was to interview travellers in a traffic stream one could find the following five types of habitual behaviour:

a) Recurrent or habitual travel behaviour; repeated on a daily basis.
b) Repetitive travel behaviour; repeated on a daily basis but not daily; e.g. on a weekly basis.
c) Once-off or ad-hoc travel behaviour.
d) Changing habitual behaviour by adopting a new behaviour (i.e. has just joined the traffic steam)
e) Changing habitual behaviour by rejecting an old behaviour (i.e. will leave the traffic stream)

The aspects of travel behaviour that can be varied include:

a) The time of the trip.
b) The route taken.
c) The origin.
d) The destination.
e) The mode.
f) Whether the trip is made at all. (Cherrett & McDonald,2004,42)

The literature provides the following evidence of churn in four of these aspects; namely:

a) Time
Cherret &d McDonald (2002,50) found that between 60% and 70% of returning vehicles appeared within 5 minutes of the time they were observed on the previous day.

b) Route
Bonsal et al (1983) found that 88 % of workers reported that they never changed their route. Behrens et al (2007) found the same reported percentage in a retrospective survey in Cape Town. In a later paper, Bonsal et al (1984) found that only 50 % of vehicles observed on a given day would also be found to use the road on the following day They also found that the way data was collected affected the responses. If this information was collected using direct interviews, it would be reported that 80% of vehicles would use the road the following day, whereas driver logs would reflect 74% and registration plates would reflect 50%.

c) Mode
Goodwin (1989) used the data from the Panel in the Netherlands to compare public transport use in 1987 with that in 1984. He found that of 1449 respondents in the sample 284 public transport users were reduced to 262 public transport users. More significant are the changes within the groups such as the decline high PT users declined from 141 to 123; that 58% of low users and 36% of high users became non-users; while 11 % of non-users became users.
Bonsal et al (1983) also found that 98 % of workers who drove on a given day said that they would also drive the following day.

d) Trip repeated on the next day
Cherret and McDonald (2002,50) found that the percentage of vehicles that would reappear on the subsequent working day ranged from 25% to 50%. They also found that on surveys done in 1994 and 1996 at two sites (the first over 10 days and the second over 11 days) that the percentage of vehicles that appeared only once during the survey period ranged between 23% and 50%.

Pas (1988) classified daily activity travel patterns for data collected in Reading-UK in 1973 into the following five categories:

D1 No trips.
D2 Single tour; predominantly to work and in the peak period.
D3 Two or three stops on one or two tours in the day.
D4 Three or four stops on generally two tours including a evening tour.
D5 Multiple out of home tours.

He compared the percentages of these types on the five days of the week and reported that there is a good level of consistency (in relation to the average values) on Monday, Tuesday and Friday, but that there were differences in respect of travel pattern types D5 on the Wednesday and D4 and D5 on Thursday.

In more general terms:

a) "*There are high levels of **interpersonal variability** in daily travel behaviour, that such variability differs across population groups*".(Pas & Koppelman,1987)

b) This is confirmed by Hanson & Huff (1988,112) who add the additional aspect that some of the variability can be accounted for by repetitious behaviour.

c) Individual behaviour is neither totally habitual nor totally random (Hanson & Huff,1988,115; Schlick & Axhausen,2003,34)

3. THE THREE STUDIES

3.1 Location

The locations of the three studies are shown in Figure 1.

Figure 1 Location of surveys

3.2 Time of surveys

Table 1 gives the dates and times of the surveys.

Table 1 Date and time of the surveys

	Residential	Arterial	CBD
Time	7:00 to 8:30	6:45 -8:15	7:30 to 9:00
Duration	17 September to 12 October 2007	16 April to 11 May 2007	25 July to 19 August 2005

3.3. Traffic volumes

Table 2 gives the number of vehicle registrations recorded and the number of trips that these vehicles made during the three surveys. Also shown are the number of registrations missed and the number of registered vehicles that had too many duplicates to be sure that the vehicles were the same. This resulted from the fact that only the last 4 digits of the registrations were recorded. This is a problem that occurs when a recorder cannot record all the vehicles that are passing and results in less matches between vehicles than the actual matches if all the digits had been recorded.

Table 2 Registrations, trips, missing data and "duplicates"

Residential	Trips #	Trips %	Plates #	Plates %
Total	5037	100.00		
Missed registrations	0	0.00		
Total recorded here	5037	100.00	1209	100.00
"duplicates"	867	17.21	84	6.95
"Usable"	4170	82.79	1125	93.05

Arterial	Trips	Trips %	Plates #	Plates %
Total	12953	100.00		
Missed registrations	15	0.12		
Total recorded	12938	99.88	4253	100.00
"duplicates"	692	5.34	369	8.68
"Usable"	12038	92.94	3884	91.32

CBD	Trips	Trips %	Plates #	Plates %
Total	38470	100.00		
Missed registrations	982	2.55		
Total recorded	37488	97.45	8123	100.00
"duplicates"	3718	9.66	1599	19.68
"Usable"	33770	87.78	6524	80.32

Missing registrations accounted for less than 3% of the trips made on the route with the highest volumes.

Trips made by vehicles which had duplicated registrations accounted for between 5 and 17% vehicles and for between 7% and 20% of trips observed.

4. FINDINGS OF THE STUDY

4.1 Overview

The variability of the traffic streams will be discussed in terms of:

a) Frequency of the same vehicles being observed in each week.
b) Frequency of each vehicle being observed over the 15 days of each study.
c) Frequency of each vehicle being observed on the following day.

d) Frequency of each vehicle being observed on the same day of the following week.
e) The variability in the time at which vehicles were observed on different days.

4.2 Weekly variability

Table 3 shows the number of registrations that were observed 1, 2, 3, 4 or 5 times during each of the three weeks at each location and the related number of trips made by these vehicles; as well as the related percentages.

Table 3 Weekly variability

Residential	Week 1		Week 2		Week 3		Week 1		Week 2		Week 3	
	Plates	%	Plates	%	Plates	%	Trips	%	Trips	%	Trips	%
if1	363	47.0	324	45.1	316	45.7	363	21.3	324	19.9	316	20.4
if2	146	18.9	133	18.5	125	18.1	292	17.1	266	16.3	250	16.1
if3	98	12.7	81	11.3	94	13.6	294	17.3	243	14.9	282	18.2
if4	76	9.8	109	15.2	83	12.0	304	17.9	436	26.8	332	21.4
if5	90	11.6	72	10.0	74	10.7	450	26.4	360	22.1	370	23.9
Total	773	100	719	100	692	100	1703	100	1629	100	1550	100
Trips/plate							2.20		2.27		2.24	

Arterial	Week 1		Week 2		Week 3		Week 1		Week 2		Week 3	
	Trips	%	Trips	%	Trips	%	Plates	%	Plates	%	Plates	%
if1	1553	66.8	1401	57.6	1394	57.5	1553	44.1	1401	32.8	1394	32.9
if2	462	19.9	499	20.5	511	21.1	924	26.2	998	23.3	1022	24.1
if3	213	9.2	310	12.7	309	12.7	639	18.1	930	21.8	927	21.9
if4	73	3.1	164	6.7	158	6.5	292	8.3	656	15.3	632	14.9
if5	23	1.0	58	2.4	53	2.2	115	3.3	290	6.8	265	6.3
Total	2324	100	2432	100	2425	100	3523	100	4275	100	4240	100
Trips/plate							1.52		1.76		1.75	

CBD	Week 1		Week 2		Week 3		Week 1		Week 2		Week 3	
	Plates	%	Plates	%	Plates	%	Trips	%	Trips	%	Trips	%
if1	2372	46.8	2301	45.0	2198	44.2	2372	21.5	2301	20.2	2198	19.3
if2	970	19.1	995	19.4	916	18.4	1940	17.6	1990	17.5	1832	16.1
if3	662	13.1	699	13.7	671	13.5	1986	18.0	2097	18.5	2013	17.7
if4	583	11.5	634	12.4	612	12.3	2332	21.2	2536	22.3	2448	21.5
if5	479	9.5	488	9.5	578	11.6	2395	21.7	2440	21.5	2890	25.4
Total	5066	100	5117	100	4975	100	11025	100	11364	100	11381	100
Trips/plate							2.18		2.22		2.29	

The following can be seen from table 2:

a) The average number of trips per vehicle is 2,2 for the CBD and residential routes and between 1,5 and 1,8 for the arterial route.
b) Less than 35% of vehicles on the CBD and residential routes and less than 20% on the arterial route were observed to make more than two trips per week. These account for 60%, 60% and 45% of all the trips made on the three routes respectively.
c) The distribution of the frequency that vehicles made trips was consistent across the weeks for the CBD and residential routes; but not so for the arterial route (although the difference was not statistically significant).
d) The registration frequency distributions for the CBD and residential routes were very similar; but significantly different to that of the arterial route with p =0.00 in comparison with the CBD and residential routes.
e) A similar conclusion can be drawn when the comparison is made with trips made on CBD and residential routes; where the p-values were 0.02 and 0.04 respectively.

4.3 3-week distribution

Table 4 shows the frequency with which vehicles we observed over the 15 day period of each survey.

Table 4 vehicle observations over 15 days

	Plates							Trips					
	Residential		Arterial		CBD			Residential		Arterial		CBD	
	plates	%	plates	%	plates	%		trips	%	trips	%	trips	%
if1	486	40.2	1969	46.4	2891	35.6	if1	486	10.0	1969	16.4	2891	8.6
if2	174	14.4	742	17.5	1310	16.1	if2	348	7.1	1484	12.3	2620	7.8
if3	96	7.9	399	9.4	749	9.2	if3	288	5.9	1197	9.9	2247	6.7
if4	74	6.1	256	6.0	511	6.3	if4	296	6.1	1024	8.5	2044	6.1
if5	45	3.7	213	5.0	426	5.2	if5	225	4.6	1065	8.8	2130	6.3
if6	55	4.5	191	4.5	327	4.0	if6	330	6.8	1146	9.5	1962	5.8
if7	39	3.2	132	3.1	277	3.4	if7	273	5.6	924	7.7	1939	5.7
if8	35	2.9	124	2.9	265	3.3	if8	280	5.7	992	8.2	2120	6.3
if9	43	3.6	76	1.8	260	3.2	if9	387	7.9	684	5.7	2340	6.9
if10	33	2.7	72	1.7	219	2.7	if10	330	6.8	720	6.0	2190	6.5
if11	31	2.6	39	0.9	217	2.7	if11	341	7.0	429	3.6	2387	7.1
if12	28	2.3	18	0.4	194	2.4	if12	336	6.9	216	1.8	2328	6.9
if13	36	3.0	10	0.2	213	2.6	if13	468	9.6	130	1.1	2769	8.2
if14	16	1.3	2	0.0	157	1.9	if14	224	4.6	28	0.2	2198	6.5
if15	18	1.5	2	0.0	107	1.3	if15	270	5.5	30	0.2	1605	4.8
Total	1209	100	4245	100.00	8123	100	Total	4882	100	12038	100	33770	100
							Trips/plate	4.04		2.84		4.16	

From this table it can be seen that:

a) Vehicles on the CBD and residential routes were observed to make 4 trips on average whereas those on the arterial route made less than 3.
b) As discussed in 4.2, the distribution of registration and trip frequencies was different between the arterial route and the other two routes. The difference was statistically significant for registrations between the arterial and the residential routes and for both routes compared to the arterial route for the distribution of the trips made.

4.4 Vehicles observed on the following day

Table 5 shows the frequency with which vehicles were observed on the following day. (For completeness Day 15 was compared to Day 1).

From this table it can be seen that:

a) Vehicles were observed more frequently on the following day on the residential route (5,00 times) than on the CBD route (4,82 times); and even less frequently on the arterial route (2,87 times).
b) Vehicles recorded on the following day accounted for 42%, 31% and 46% of all vehicles and 53%, 32% and 53% of all trips on the residential, arterial and CBD routes respectively.
c) Once again the arterial route is shown to be significantly different to the CBD and residential routes.

Table 5 Vehicles observed on the following day

Plates							Trips						
	Residential		Arterial		CBD			Residential		Arterial		CBD	
	plates	%	plates	%	plates	%		trips	%	trips	%	trips	%
if1	120	23.7	498	38.1	994	26.9	if1	120	4.7	498	13.3	994	5.6
if2	82	16.2	259	19.8	529	14.3	if2	164	6.5	518	13.8	1058	5.9
if3	49	9.7	178	13.6	350	9.5	if3	147	5.8	534	14.2	1050	5.9
if4	28	5.5	117	8.9	303	8.2	if4	112	4.4	468	12.5	1212	6.8
if5	36	7.1	72	5.5	235	6.4	if5	180	7.1	360	9.6	1175	6.6
if6	37	7.3	70	5.4	207	5.6	if6	222	8.8	420	11.2	1242	7.0
if7	30	5.9	46	3.5	173	4.7	if7	210	8.3	322	8.6	1211	6.8
if8	13	2.6	30	2.3	163	4.4	if8	104	4.1	240	6.4	1304	7.3
if9	27	5.3	19	1.5	152	4.1	if9	243	9.6	171	4.6	1368	7.7
if10	14	2.8	4	0.3	100	2.7	if10	140	5.5	40	1.1	1000	5.6
if11	30	5.9	7	0.5	182	4.9	if11	330	13.0	77	2.1	2002	11.2
if12	7	1.4	4	0.3	46	1.2	if12	84	3.3	48	1.3	552	3.1
if13	16	3.2	2	0.2	157	4.2	if13	208	8.2	26	0.7	2041	11.5
if14	0	0.0	0	0.0	0	0.0	if14	0	0.0	0	0.0	0	0.0
if15	18	3.6	2	0.2	107	2.9	if15	270	10.7	30	0.8	1605	9.0
Total	507	100	1308	100	3698	100	Total	2534	100	3752	100	17814	100
							Average	5.00		2.87		4.82	
%Allplates	41.94		30.81		45.53		%Alltrips	51.90		31.17		52.75	

4.5 Vehicles observed the following week

Habitual travel behaviour can also be exemplified by the same behaviour being repeated the next day. But a study of household activities will indicate that many are repeated on a weekly basis rather than on a daily basis. Table 6 shows the frequency with which this behaviour was observed. For completeness Week 1 was compared to Week 2, Week 2 with Week 3, and Week 3 with Week 1.

From this table it can be seen that:

a) Vehicles were observed on the same day in the next week 4,96; 2,59 and 4;78 times on residential, arterial and CBD routes respectively.
b) These frequencies are similar to those for vehicles observed on the following day; being within 1% for the CBD and residential routes and within 10% for the arterial route.
c) Once again the arterial route was found to be statistically different from the other two routes ($p \leq 0.01$)

Table 6 Vehicles observed in the following week

Plates							Trips						
	Residential		Arterial		CBD			Residential		Arterial		CBD	
	plates	%	plates	%	plates	%		trips	%	trips	%	trips	%
if1	138	28.9	752	48.8	1051	30.7	if1	138	5.8	752	18.8	1051	6.4
if2	53	11.1	224	14.5	409	11.9	if2	106	4.5	448	11.2	818	5.0
if3	41	8.6	189	12.3	323	9.4	if3	123	5.2	567	14.2	969	5.9
if4	39	8.2	123	8.0	247	7.2	if4	156	6.6	492	12.3	988	6.0
if5	28	5.9	70	4.5	214	6.2	if5	140	5.9	350	8.7	1070	6.5
if6	37	7.7	67	4.3	180	5.3	if6	222	9.4	402	10.0	1080	6.6
if7	26	5.4	40	2.6	165	4.8	if7	182	7.7	280	7.0	1155	7.1
if8	10	2.1	37	2.4	128	3.7	if8	80	3.4	296	7.4	1024	6.3
if9	16	3.3	13	0.8	138	4.0	if9	144	6.1	117	2.9	1242	7.6
if10	20	4.2	13	0.8	91	2.7	if10	200	8.4	130	3.2	910	5.6
if11	31	6.5	9	0.6	182	5.3	if11	341	14.4	99	2.5	2002	12.2
if12	5	1.0	1	0.1	35	1.0	if12	60	2.5	12	0.3	420	2.6
if13	16	3.3	2	0.1	157	4.6	if13	208	8.8	26	0.6	2041	12.5
if14	0	0.0	0	0.0	0	0.0	if14	0	0.0	0	0.0	0	0.0
if15	18	3.8	2	0.1	107	3.1	if15	270	11.4	30	0.7	1605	9.8
Total	478	100	1542	100	3427	100	Total	2370	100	4001	100	16375	100
							Average	4.96		2.59		4.78	
%Allplates	39.54		36.33		42.19		%Alltrips	48.55		33.24		48.49	

4.6 Time variability

The times that the vehicles were observed were compared to determine the variability. This is shown in Table 7 using the number and percentage of vehicles with the same registration that were observed to be within 5, 10 , 15 and 30 minutes of the average time for vehicles observed at least 3, 4 or 5 times over the 15 day period.

Table 7 Observed time variability

	Residential			Arterial			CBD		
	Matched at least “x” times			Matched at least “x” times			Matched at least “x” times		
	3	4	5	3	4	5	3	4	5
Matched trips	4048	3760	3464	7050	5910	4802	28655	26012	23968
Trips within "x" minutes of average									
5	2096	1942	1794	1918	1623	1345	9324	8767	8187
10	3051	2831	2621	3689	3106	2559	15910	14850	13819
15	3461	3213	2968	4888	4116	3356	20139	18752	17400
30	3907	3628	3345	6498	5459	4430	26060	24033	22187
Percentage of trips within "x" minutes of average									
5	51.78	51.65	51.79	27.21	27.46	28.01	32.99	33.70	34.16
10	75.37	75.29	75.66	52.33	52.55	53.29	56.30	57.09	57.66
15	85.50	85.45	85.68	69.33	69.64	69.89	71.27	72.09	72.60
30	96.52	96.49	96.56	92.17	92.37	92.25	92.22	92.39	92.57

From this table it can be seen that:

a) The residential route experienced the least variability with 52% of vehicles being within 5 minutes of the average; while the percentages were 27,5% for the arterial route and 33% for the CBD route.

b) The percentages of the vehicles that were within 10 minutes of the average was 75%, 53% and 57%; and within 15 minutes were 85%, 69,5% and 72% respectively for the residential, arterial and CBD routes respectively.

c) The variability of the residential route traffic is statistically different from that on the arterial and CBD routes ($p<0,01$) when examined for a minimum of 3, 4 or 5 trips recorded by each vehicle over the 15 days.

5. DISCUSSION

5.1 Methodological problems

It is important to note that this type of data collection suffers from methodological problems in recording data for traffic volumes exceeding 800 vehicles/hour/observer. It therefore cannot be applied to routes with higher lane volumes; such as arterials and freeways.

5.2 Degree of variability

The study found that only 50% of vehicles were observed on the following day on the CBD and residential routes and only 30% on the arterial route. This is similar to the degree of variability observed in the literature and to that found more recently by Hermant (2008). While the findings confirm the assumption made by Goodwin that churn occurs in the travel behaviour; the finding that 50% of vehicles were observed in the following week indicates the existence of a more complex habitual behaviour; which occurs from day to day and week to week.

5.3 Unobserved travel behaviour

However, this type of survey does not provide any information on what travellers were doing when they were not observed. It cannot be said that they travelled at another time, used another mode or route, travelled from a different origin or to a different destination; or even if they made a trip at all. For this, one needs a survey that includes a travel diary.

Salem & Farrell (2005) who found that habitual travel behaviour has an effect on the trade off between acceptable toll fees versus savings in travel time. These studies found a complex habitual behaviour to exist. Therefore one can conclude that current transportation planning models would be inadequate to model the impact of a TDM strategy that attempts to change individual travel.

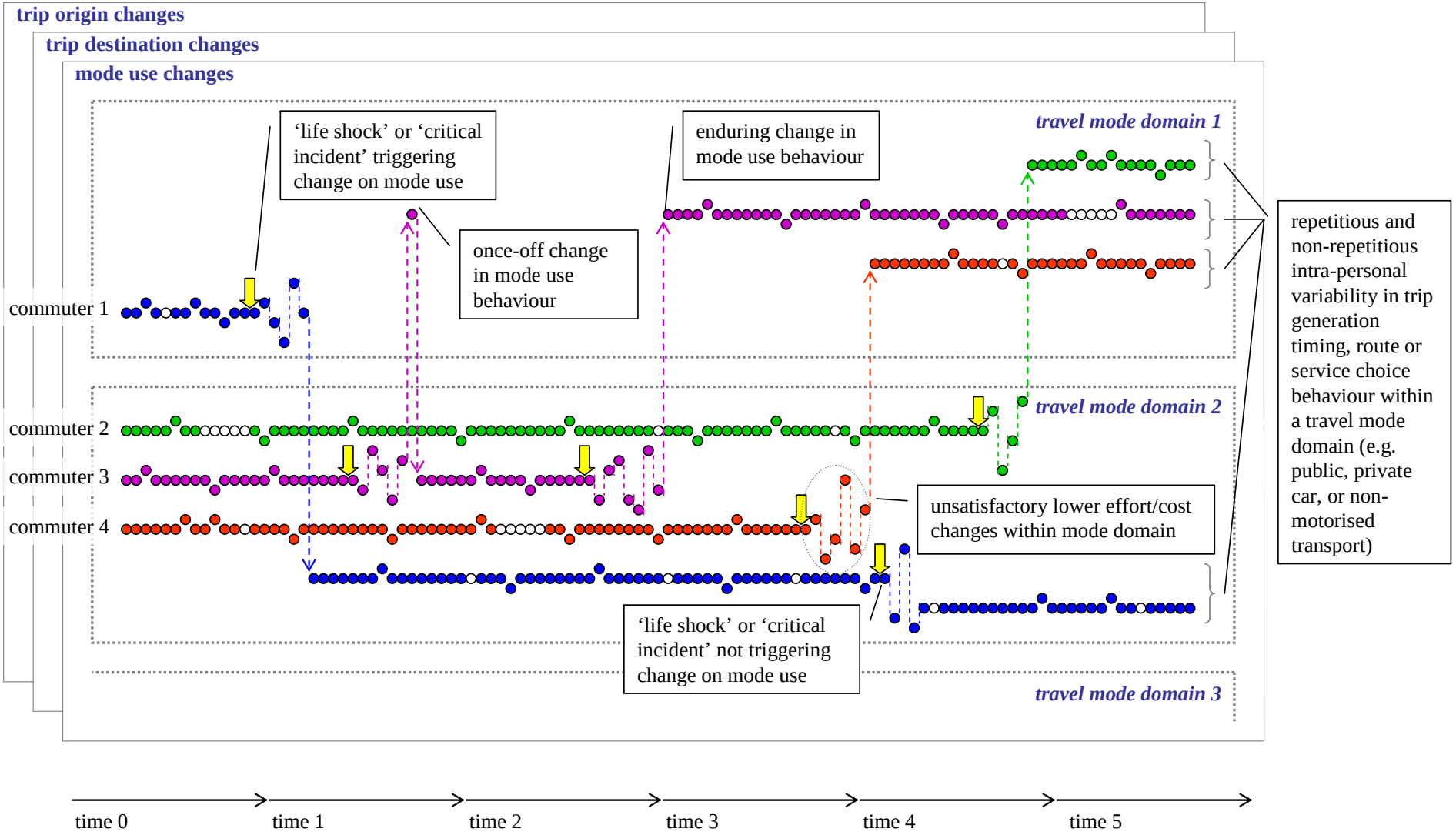
5.4 Conceptual framework

The identification of a complex habitual behaviour raises the need to develop a way to define habitual travel behaviour as a “package” of habits that are repetitive; be they daily, weekly, etc. (One could build on the work done by Pas (1988) to categorise weekly travel behaviour); that also accommodates some random travel behaviour.

Furthermore, other studies (Behrens et al.2007, Del Mistro et al.2007) suggest that the individual’s “package” of habitual travel behaviour will be subjected to “triggers” that prompt the reassessment and change of travel habits on a much less frequent basis; i.e. every few years.

Behrens and Del Mistro (2008,6-7) have developed figure 2 to reconcile these coexisting behaviour patterns. *The concept of ‘asymmetric churn’ offers a potentially more useful conceptual framework within which to formulate TDM strategies, than the conventional notion of incremental behavioural adaptation until some form of equilibrium end-state is achieved. In other words, if a desired TDM strategy outcome is an increase in public transport share of modal split at the expense of the motor car, then for every one person switching to a car from public transport use, more than one person would need to switch to public transport from car use. Our growing understanding of ‘habitual’ travel and ‘shocked’ change tells us that these changes are happening anyway.*

Figure 2 Diagrammatic representation of conceptualised commuter behaviour change dynamics, illustrating intra-personal variability within the use of individual modes, and more infrequent (asymmetrical) 'churning' patterns of mode use 'habits' broken by 'shocks'



The keys to effective TDM intervention are, on the one hand, understanding the triggers which lead individuals to deliberately reappraise their travel decisions and to change travel behaviour, and then influencing the variables that create the necessary circumstances that prompt decisions leading to the desired pattern of asymmetry, and on the other, understanding which groups are most susceptible to change so that TDM measures might be targeted strategically and most effectively."

5.5 Further study

Further research is therefore required to:

a) Determine what travellers are doing when they are not observed repeating the travel behaviour of the previous day. A travel or activity diary over the duration of a few weeks is needed.
b) If the travellers are fulfilling the trip in a more desirable way; ascertain whether this is the opportunity that Goodwin envisaged to achieve more habitual desirable travel behaviour through "asymmetric churn".
c) Develop a method to categorise "packages" of habitual travel behaviour.

6. CONCLUSION

The world is becoming increasingly aware of the effect of transportation on pollution and the use of its limited natural energy resource. The need to manage the demand for travel is obvious. What is not so obvious is how this is to be achieved. In a democratic society it requires the cooperation of the traveller. This in turn requires a better understanding of the consequences of continued and even increasing motorised travel. It also requires strategic interventions to prompt travellers to change to less polluting and resource consuming travel behaviour. These strategies can be referred to as TDM.

However, our current knowledge is insufficient to be able to predict the results of TDM strategies; and as such they are frequently quoted, sometimes applied, but in most cases only marginally effective.

This research serves to confirm the variability that exists within apparently consistent travel behaviour. The studies found that less than 50 % of motorists repeat their travel pattern on the next day, or the next week. This can be considered to be the short term variability. It might provide the opportunity for travellers to test alternative transport behaviours; and if they find them attractive might prompt them to churn towards changing to a new habit and include these new habits. If they do not change, the travellers retain the experience to be recalled when a major "shock" is experienced that requires a reassessment of the appropriateness of their current travel behaviour and a quest for a "better" travel habit.

In parallel to the research on the variability in habitual travel behaviour and its impact on the effectiveness of TDM strategies; there is a second area of research that is aimed at understanding the triggers that prompt the reassessment of travel habits and the conditions under which a change occurs; so that TDM strategies can be selected and targeted with greater certainty of success.

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