CONGESTION MONITORING ON SCOTTISH TRUNK ROADS

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1 INTRODUCTION

This paper describes how the Traffic Controller's Unit of the Scottish Executive Enterprise Transport and Lifelong Learning Department (now the Traffic Controller's Unit of Transport Scotland) developed a measure of congestion on the Scottish Trunk Road Network. The work was undertaken through the Scottish Roads Traffic Database (SRTDb) Contract by Atkins Transport Planning with their partners Datagen Limited and Edina Software Limited.

1.1 Policy Context

In March 2002 the Executive published "Scotland's Transport: Delivering Improvements". This set out what had been achieved since 1997, the (then) current programme of transport improvements and a vision for the future. It recognised that for both economic and environmental reasons there was a need to contain traffic growth and tackle congestion. Subsequently in December of 2002 the Executive published "Scotland's Transport: Delivering Improvements – Transport Indicators for Scotland". This recognised a need for effective monitoring as an invaluable tool which would allow the Executive to make best use of its resources in the long term, allowing adjustments to both policies and programmes, and funding, whilst keeping the long-term transport vision in place.

Eleven transport indicators were chosen that aligned closely with that vision and with the core themes in the transport policy. These indicators were selected to not only enable the charting of progress, but also enable to allow stakeholders and delivery partners to assess the outcomes of the policies. The eleven transport indicators were given names which provided descriptions of their relevance to the transport vision, policies and programmes. The indicators chosen were:

1. Road traffic volumes
2. Passenger journeys by public transport
3. Freight lifted
4. Road traffic congestion
5. Condition of the road network
6. Transport emissions
7. Accessibility of local bus services
8. Modal shift on short journeys
9. Modal shift on travel to work and school journeys
10. Road accident casualties
11. Access to public transport information

1.2 Road Traffic Congestion

In the section of the report dealing with Road Traffic Congestion the report recognised that road traffic congestion was a significant issue in and around Scotland's major metropolitan areas and was the overriding transport challenge that faced the Scottish Executive. If nothing were done to tackle this problem, road traffic was predicted to increase by up to 27% over the following two decades, with much of this increase in and around the four main cities (Glasgow, Edinburgh, Dundee and Aberdeen). Congestion was considered to be hampering the economy and damaging the environment.

The Scottish Executive stated it was developing a congestion indicator and has commissioned research to determine an appropriate methodology for monitoring trunk road congestion. This was a precursor to implementing a monitoring regime which was to begin monitoring and reporting from 2003. It was stated that "the intention is that this will be based on a methodology which will allow monitoring and reporting on the severity of delays at the height of peak periods to monitor peak trends; the duration of the peak periods, in order to monitor peak period spread or contraction; and the difference between journey times in congested and free-flow conditions".

1.3 Pilot Study

In December 2003 a report was produced based on a pilot study carried out on the A720 Edinburgh City Bypass looking into the technologies available at that time for the collection of speed and / or journey time data and the use of these data for the production of congestion indicators.

That report concluded:

- Automatic Number Plate Recognition (ANPR)
  - while this type of equipment produced real journey time data, the cost of rolling out this technology over the entire trunk road network would be prohibitive, although where ANPR equipment was to be installed for other purposes, then it might also be used to collect congestion data.
- Floating Vehicle Data (probe vehicles)
  - This involved a number of vehicles with Global Positioning System (GPS) equipment spread throughout the traffic stream collecting location, speed and direction data every second – while this also collected true journey time information it was a sample in time only and would be very costly to use over the entire trunk network on a permanent basis. It did have the benefit, however, of being able to be used on any part of the road network – trunk or otherwise – at little notice.
- Floating Vehicle Data (fleet vehicles)
  - The data available (at that time) was coarse, with a GPS reading only every minute, and the sample was small. This type of data was not fine enough for detailed network congestion monitoring.
- Automatic Traffic Counter (ATC)

- o These sites produced spot speed data which is not always suitable for the extrapolation of journey time data when used in isolation. In particular, in situations where traffic queues formed at junctions even outwith congested periods (roundabouts for example) ATC data on its own would be biased depending on the location of the sites.

However, since the Scottish Executive already had access to over 1,000 ATC sites on the trunk road network through the Scottish Roads Traffic Database (SRTDb) and the busiest sections of that network tended not to have priority junctions, the report concluded that a practical approach to congestion monitoring in the short to medium term would be realised from using ATC speed and flow data calibrated by sample Floating Vehicle Data.

In June 2003 the Scottish Executive decided to proceed with the recommendations of the A720 Pilot Study report.

2 Deployment of Congestion Monitoring

A consultation exercise had been carried out in March 2003 to decide on the areas of trunk road network to be monitored. Figure 1 shows the areas and Table 1 details the routes involved – each route is monitored in each direction, making 44 routes in total.

Table 1: Congestion Areas and Routes

Area	Description	Route
1	Aberdeen	A90 South
		A90 North
		A96
2	Dundee	A90 North and A92
		A90 West
3	Perth	A9
		M90
4	Forth Bridge Approaches	M90 & A90 & A92
5	Kincardine Bridge Approaches	A977 & A876 & M876
6	Erskine Bridge	A898 & M898
7	Edinburgh	A1
		A720
		M9 & M8
8	Glasgow	M77
		M8
		M73 & M74
		A80 & M80
		A725
9	Glasgow to Edinburgh	A8 & M8
10	Ayrshire	A77 North
		A78
		A77 South

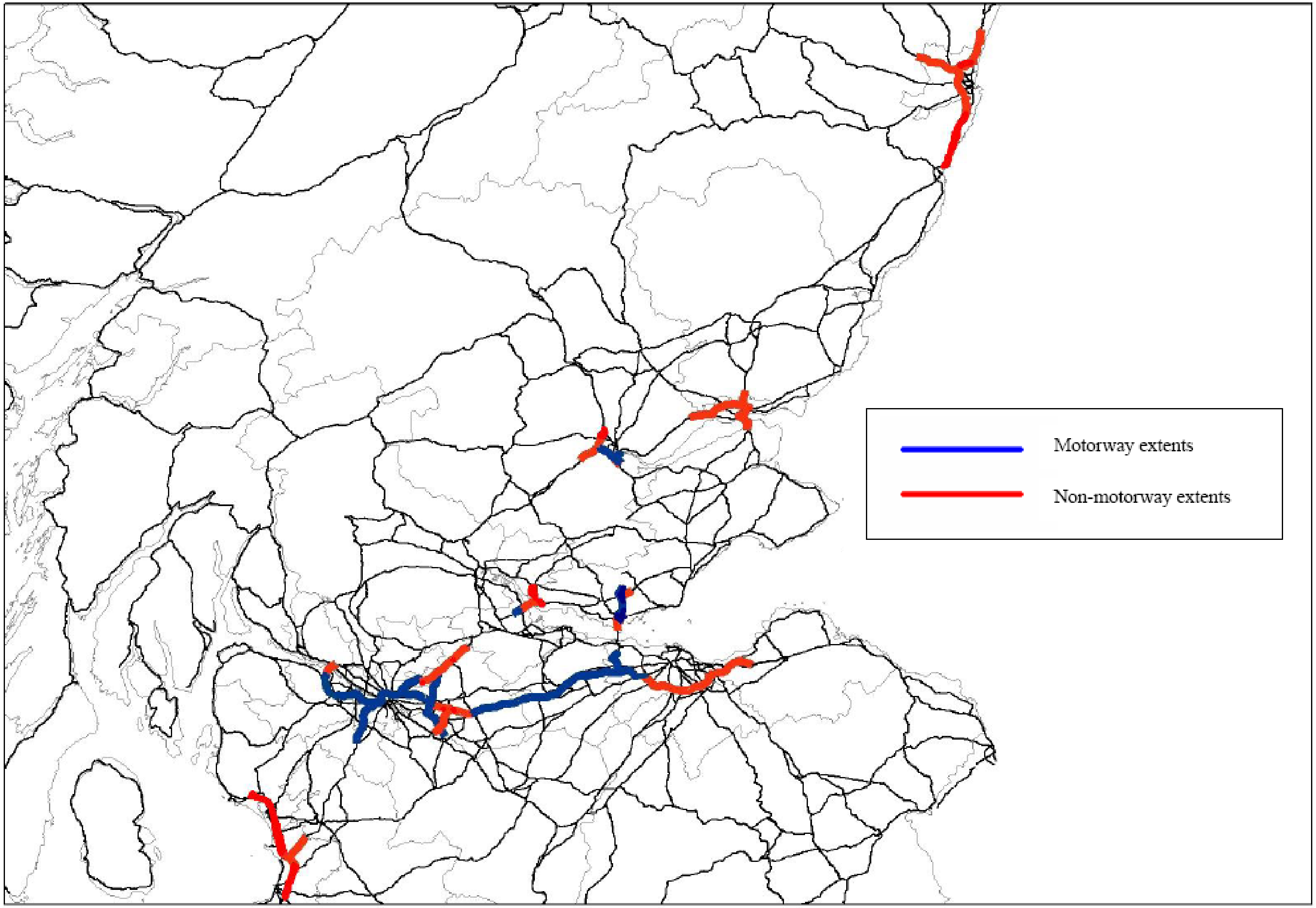


Figure 1: Map of Congestion Monitoring Coverage

In all, 492 sites were involved and the total length of network covered (both directions combined) in 2003 was just under 650 km.

Since the methodology requires speed data as well as flow data, a number of sites had to be upgraded to being speed-capable and a number of sites were added to fill in gaps. This work and the procurement of the necessary counting equipment took some time to achieve and, as a result, the 2003 indices were based on incomplete data.

2.1 Floating Vehicle Surveys

A series of Floating Vehicle (FV) surveys was carried out in the Autumn of 2003. Each survey involved between four and six vehicles with GPS equipment driving continually – with appropriate breaks – along sections of the 44 routes between the hours of 07:00 and 19:00 for between five and six days. The aim was to achieve a 15 minute frequency of survey vehicles in the traffic stream. A total of 344 vehicle survey days were achieved, with each vehicle producing 12 hours of time, speed, direction and location data at one second intervals.

A method was set up, using Microsoft Excel and Visual Basic for Applications (VBA) to analyse these data files in order to allow comparison of spot speeds and average link speeds.

In this method, each ATC site was allocated a section of road in a given direction based on junctions, separation of sites etc. The location of each ATC site was listed as well as the location of the start and end of each road section. The application then took each one-second record from the file being analysed and looked to see if the point was within a user-defined proximity of either a road section end or an ATC site. If it was, then the GPS speed and time information was stored in a “hits” file. Once every record in the GPS file had been checked then the “hits” file was analysed to note all sensible sequences of section-end, ATC location, section-end. For each one it then noted the time difference between the two ends, and used the length between them to calculate an average section speed and compared this with the speed noted at the ATC site. The same data was compiled from all vehicles from all survey days for the route in question and the ATC-speed and section-speed numbers collated for each ATC site, resulting in an average of 250 pairs for each site. A simple regression analysis was then carried out for each of the 492 sites.

As expected, where sites were located on motorways and the frequency of the sites was high enough – for example on the M8 in Glasgow – the calibration factor was very close to 1.0 – i.e. average speed over a section of road was more or less the same as that measured at any point on that section. However, where the length of road associated with a site was greater, or where priority junctions such as roundabouts were involved, the factor was not so close to 1.0 – some values higher and some lower.

This calibration factor was then used throughout the congestion calculations to convert ATC speed to average link speed.

2.2 What is Congestion?

There is no universally accepted definition of what congestion is let alone how to measure it. To some road users congestion might mean that a single journey takes longer than usual due simply to the number of other vehicles on the road at that time, while to others it might mean stop/start conditions or even lengthy queues at junctions.

The A720 Pilot Study Report recommended that the simple, objective definition of lost time per journey, trip, kilometre, vehicle etc, should be used. That is the definition used.

Although the additional time taken on a journey is important to the individual, the number of vehicles involved in congestion incidents is also important to the road operator and manager. It was therefore clear that a variety of indices would be required to satisfy all potential users of the results.

Although the original purpose of the congestion monitoring work was to demonstrate the overall network change in congestion over a number of years, this does not give a flavour of local situations. Indeed, some work has already been carried out, since the 2003 congestion report was produced, to investigate how selected congestion indices and related data might be used by the road operator to design road works more efficiently, or to employ traffic management with minimal disruption to road users.

2.3 Methodology

The basis of the congestion monitoring work is simply ***s = d / t***
(where s = speed, d = distance and t = time)

This can be rewritten as ***t = d / s***

To simplify matters further, considering just 1 km, then ***t = 1 / s***

Over any given period of time, for a one kilometre length of road, the lost time per vehicle kilometre will be ***1/s – 1/ffs*** where ***ffs*** is the free flow speed of that section of road. That is, the time lost due to the prevailing traffic conditions is equal to the current travel time minus the travel time when there is no congestion.

All ATC sites used are set up to store traffic volume and average traffic speed in 15 minute bins. The congestion software in SRTDb therefore calculates the lost time per vehicle kilometre for each fifteen minute period of every day. An average weighted by traffic flow in each time period is then produced for each day and a similar weighted average for any time period being investigated – for example for the entire year.

Almost all other congestion indices for any site spring from this single number. Lost time per kilometre, for example, takes into traffic flow.

Once all congestion indices are produced from the raw flow and speed data for all sites on the congestion network for a given time period (for example, for the year 2003), the same indices are then produced for the 44 routes themselves by appropriate additions, averages etc of the individual site indices.

Note that the method is therefore not restricted to the production of indices for the 44 routes but can also produce values for smaller parts of those routes – potentially useful when considering the use of selected congestion indices to plan traffic management or works.

2.4 Summary of Indices Produced

Indices are produced for individual routes and for all routes combined. In the published report indices produced for a route are named LC and for the whole congestion network as NC. Table 2 shows the main indices produced.

Table 2: Local Congestion Indices

Index	Definition	Comments
LCI 1	Lost time per annum	This is the total time lost to congestion over the entire length of the route over the whole year for all vehicles totalled. This might total thousands of hours.
LCI 2	Average lost time per vehicle kilometre	Usually expressed in seconds.
LCI 3	Cost of LCI 1	At the moment the value of £10 is attributed to each hour lost. This figure is within the range of values of time normally used in traffic modelling.
LCI 4	Journey Time Reliability	This is a measure of how consistent the journey time is for any given 15 minute time period within a day.
LCI 5	Total time lost per km per day	Expressed in hours
LCI 6	Congestion bands	This is a tabular presentation of a number of congestion-related values by three different degrees of congestion (or speed loss). Table 5 shows an example.
LCI 7	Daily Congestion Index	This is simply a weighted average of speed to free flow speed and is produced to allow comparison with other systems.

Tables 3 and 4 show examples of some of the indices produced. Figures 2 and 3 are samples of the detailed data which drives the indices.

Table 3: Sample Monthly Values for LCI 2

Route Description	Route Ref	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A1	A07_R13_NB				2.23	1.69	1.76	2.31	2.69	2.69
	A07_R13_SB				1.88	1.34	1.21	2.66	2.02	2.07
A720 City Bypass	A07_R14_EB	5.16	6.99	4.95	4.55	5.73	4.87	6.51	6.48	6.46
	A07_R14_WB	7.49	7.04	5.45	6.05	7.36	5.34	9.64	8.30	9.03
M9	A07_R15_NB		6.39	7.25	9.84	10.97	5.67	6.68	4.21	4.65
	A07_R15_SB		5.74	5.55	2.26	10.32	6.62	9.49	10.80	9.61

Table 4: Sample Yearly Values for selected LC Indices

	Lost Time Values (hours)					
		(LCI_2)	(LCI_5)		(LCI_1)	(LCI_7)
Route	per Veh	per Veh.km	per km (daily)	per day	Total lost time	Congestion. Index
A07_R13_NB	0.0087	0.0007	11.14	133.0	48539	1.07
A07_R13_SB	0.0064	0.0005	10.20	118.3	43166	1.07
A07_R14_EB	0.0312	0.0017	46.13	854.3	311813	1.15
A07_R14_WB	0.0325	0.0019	46.72	813.0	296731	1.17
A07_R15_NB	0.0115	0.0016	26.54	185.5	67717	1.14
A07_R15_SB	0.0039	0.0021	26.98	51.8	18908	1.15

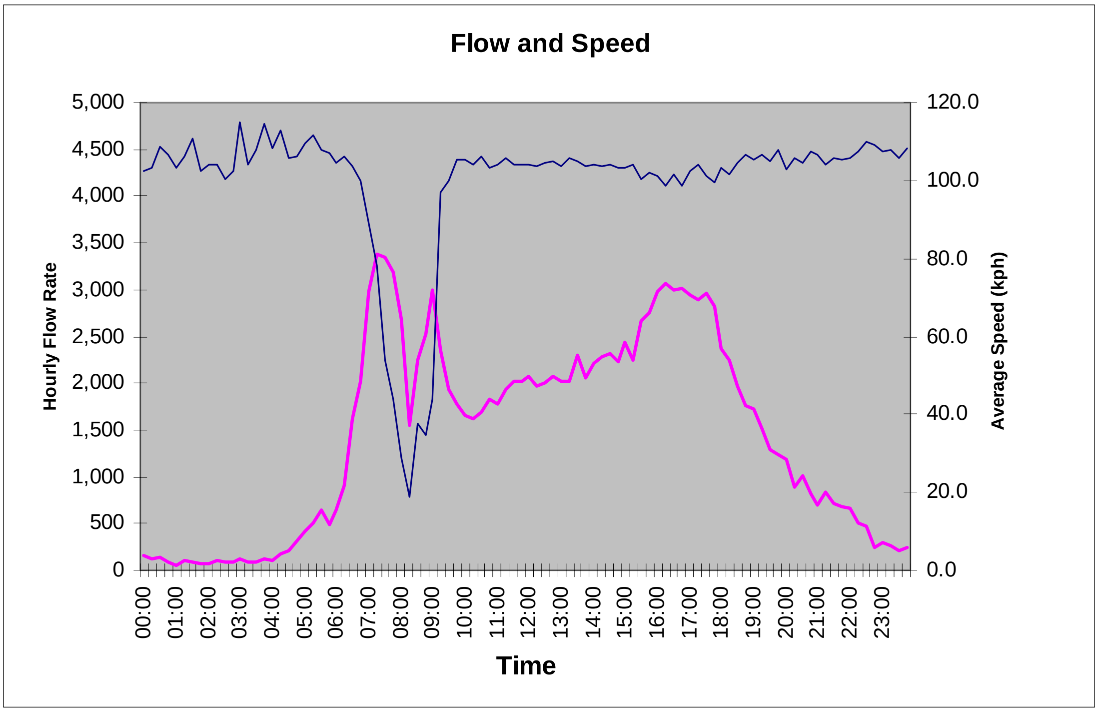
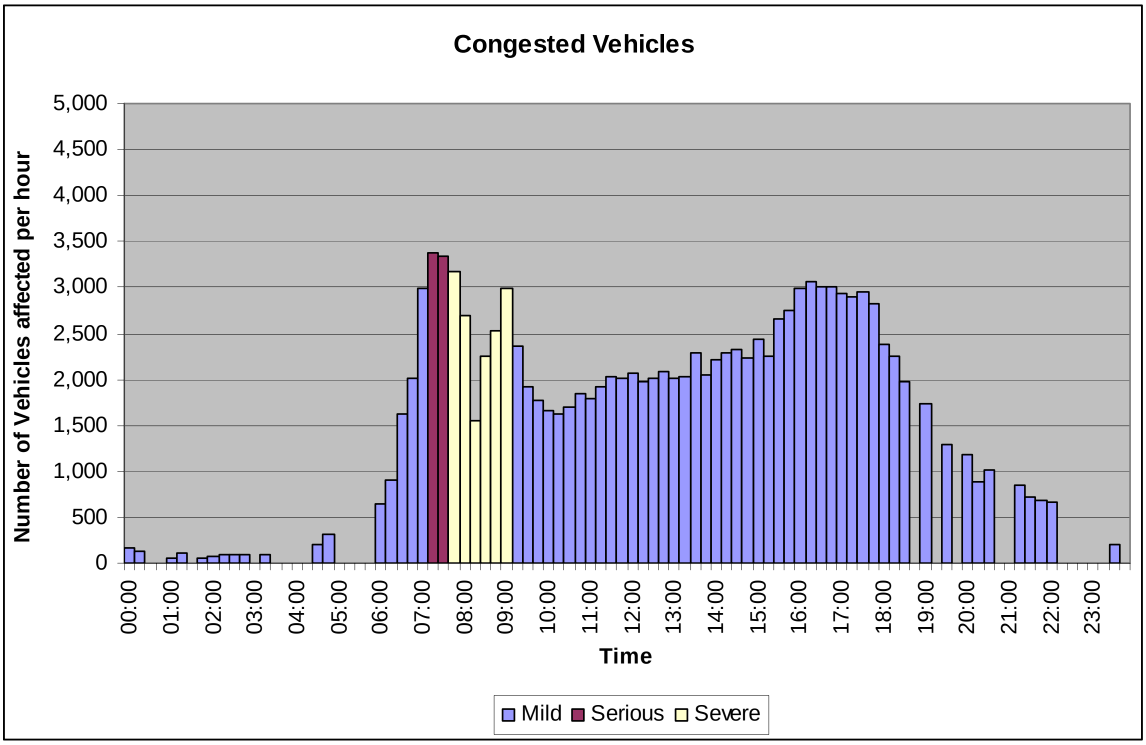


Figure 2: Sample Speed and Flow Curve (one site one day)



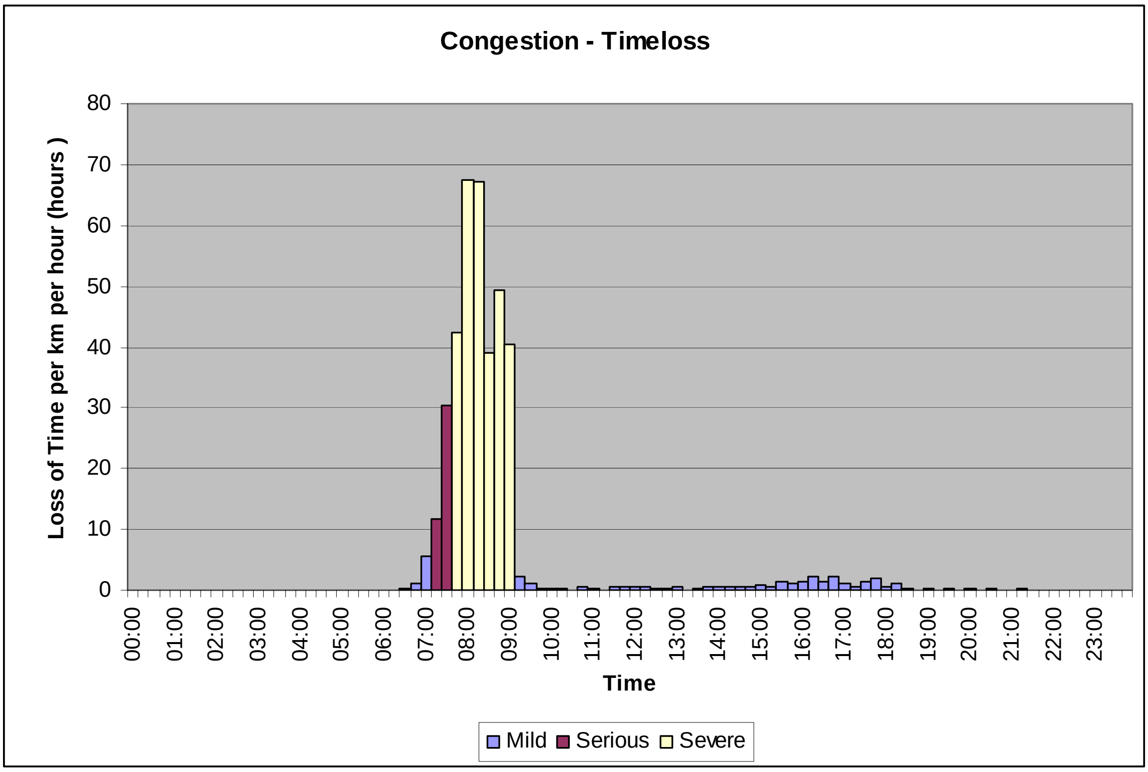


Figure 3: Sample Congestion (one site one day)

Table 5 shows an example of the congestion bands produced under the heading of LCI 6. This shows the number and percentage of vehicle, and the number of hours and percentage of time, where congestion falls into the categories of mild, serious and severe, where each is defined as:

Mild: speed drop is > 10% but <= 25% of free flow speed
Serious: > 25% but <= 50%
Severe: > 50%

Table 5: Congestion Bands

Congestion Type	Speed Drop >	Vehicles Affected		Congestion Duration		Time lost per km (hrs)
		Number	%	Hours	% of day	
Mild	>10<=25%	26359	76.21%	16.25	67.71%	9.7
Serious	>25<=50%	1679	4.85%	0.5	2.08%	10.5
Severe	>50%	3799	10.98%	1.5	6.25%	76.3
					Total	**96.5**

In order to allow a more detailed analysis of how congestion is changing over time – i.e. to consider peak hour spread – a development is currently under way to increase the number of congestion bands from the three shown above to ten.

Journey Time Reliability

LCI 4 is a measure of how many journeys on a given section of road experience a reliable journey. That is to say, how often is a journey time close to the average journey time at this time of the day? Journey Time Reliability (LCI 4) is therefore not derived from the basic lost time per vehicle kilometre as used for most other indices.

The average journey time is calculated for each 15 minute time period and all journeys throughout the year (e.g.) for that time period which are within 15% of that average are deemed to be reliable. The LCI 4 value is then calculated as the ratio of reliable journeys to all journeys.

The results for 2003 for the LCI 4 values are higher than might be expected and it is possible that this is due to the “generous” definition of reliable. The congestion software is currently being enhanced to allow multiple runs each one with a different percentage definition of reliable (i.e. to allow the value of 15% to be varied). This will in turn allow some sensitivity testing to be carried out.

AM and PM

All congestion indices are currently produced for the whole day. A further enhancement is being carried out to allow production of appropriate indices for AM and PM periods of the day.

3 RESULTS FOR 2003

The results for 2003 were published in 2005 in the report “Congestion on the Scottish Trunk Road Network 2003”. Subsequent to the publication of these results a number of anomalies were identified and as a consequence some of the results have been revised [1]. In this report we refer to the revised results.

3.1 National Trunk Road Congestion Indices

Three national indices were produced, as detailed in Table 6.

Table 6: National Indices

Indicator	Definition	Value
NCI - 1	Additional Travel time per Annum	7,455,691 hours
NCI - 2	Average Lost Time per Vehicle Kilometre	4.94 sec
NCI - 3	Cost of Trunk Road Congestion per Annum	£74,556,910

Having produced these indicators the first question was: are they reasonable? There was some comment in the technical press that the value was low compared to other figures put forward by bodies such as the Confederation of British Industry who had estimated the UK figure at about £20 bn. However it was also pointed out that this was the first time that any part of the UK government had made an estimate of the monetary cost of congestion.

A number of points need to be considered in deciding the reasonableness of the figures:

- They relate only to trunk roads and then only to part of the network (albeit those sections expected to suffer the most from congestion).
- As a result almost all “urban congestion” is excluded from the figures.
- If we assume an average travel speed on the trunk road network of 80 kph (for all classes of vehicle over all times of day) then the delay equates to some 6 minutes 35 seconds per hour or 11%. This would appear to be within the range of expectations.
- The value of time used, £10 per hour, was chosen as being within the normal range of values of time used in Transport Economics; web-TAG currently give the average value per vehicle as £11.28 per annum (2002 prices).
- This value of time is however based solely on the value of time of vehicle occupants. It does not include and we have no knowledge of:
    - the value (to their owners) of the contents of freight vehicles; or
    - the consequential costs of delays to people and freight.
- It was not possible for us to make an estimate which would take these factors into account, whilst other estimates do attempt to allow for such business costs.
- Accordingly a “round figure” estimate of £10 is not unreasonable.

3.2 Local Trunk Road Indices

LCI 1 and LCI 2

The local indicators have been compiled for all 44 routes across ten areas (see Figure 1). LCI 1 and LCI 2 for each route are given by direction in Table 7. The range of results shows considerable variation as might be expected across such a diverse network. If we consider LCI 2 (Average Lost Time per Vehicle Kilometre) first we see this varies between 1.0 seconds (A9 north of Perth - southbound) and 11.1 seconds (at Kincardine Bridge - northbound).

The range of values for LCI 1 is more variable but as it depends on two additional factors: the route length and the volume of traffic this is understandable. The range of values here extends from under 10,000 (M90 south of Perth – northbound) to over 1,000,000 (for the M8 though Glasgow, including Kingston Bridge - westbound). This variability is illustrated in Figure 4 showing lost time by route where we can see the variation in LCI 1 and LCI 2. It will be noted that no real pattern emerges – there is no direct correlation between the indicators. For LCI 1 the largest value is over 100 times the smallest whereas for LCI 2 the largest value is just over 10 times the smallest.

That is because they provide two very different views of congestion. They are both valid but the one to be used depends on the goals and objectives against which the network performance is being measured. LCI 1 tells you the gross impact on all users of a route and thus is a direct measure of the economic impact on the wider economy; whereas LCI 2 tells you how delay affects the individual user of the route and gives a much more local indication of how delay impacts. This confirms what most traffic engineers and transport planners know – no two roads are the same and there are many local features and issues to be considered. It is not the purpose of this paper to seek to delve into these matters.

LCI 4; LCI 5 and LCI 7

As noted earlier (see Table 2) other local indicators have been produced. In this section we consider LCI 4; LCI 5 and LCI 7, we will look at LCI 6 in the next section.

Two versions of LCI 4 have been produced for 5 days and for 7 days as shown in Table 8 and Figure 5. The intuitive response would be to expect that 7 day indicator would be better than the 5 day as there is less congestion in general at weekends; however this is not the case. In all cases the 7 day is either equal to or poorer than the 5 day figure. This arises from the definition of LCI 4; it measures the consistency of the journey time reliability for any given 15 minute period over the day throughout the year. When the weekend days, with their very different temporal traffic distributions, are included there is greater variability and thus less 15 minute periods fall within the criteria.

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Table 7: Revised 2003 Congestion Indices

Route	Location	LCI 1 (Hours)	LCI 2 (secs)
A01_R0_NB	A90(S) Muggiemoss Roundabout to Stonehaven Northbound	138,704	3.7
A01_R0_SB	A90(S) Muggiemoss Roundabout to Stonehaven Southbound	204,226	5.7
A01_R1_NB	A90(N) Balmeddie to Muggiemoss Roundabout Northbound	50,764	4.2
A01_R1_SB	A90(N) Balmeddie to Muggiemoss Roundabout Southbound	55,135	4.7
A01_R2_EB	A96 Muggiemoss Roundabout to Blackburn Eastbound	91,991	5.7
A01_R2_WB	A96 Muggiemoss Roundabout to Blackburn Westbound	50,591	3.6
A02_R3_NB	A90 Forfar Rd (Tealing) via Tay Br to Forgan Roundabout Northbound	77,323	4.0
A02_R3_SB	A90 Forfar Rd (Tealing) via Tay Br to Forgan Roundabout Southbound	80,252	4.1
A02_R4_EB	A90 Inchture to A90 Forfar Road Eastbound	183,700	7.6
A02_R4_WB	A90 Inchture to A90 Forfar Road Westbound	77,484	3.3
A03_R5_NB	A9 from junction with B934 to Luncarty Northbound	22,808	1.4
A03_R5_SB	A9 from junction with B934 to Luncarty Southbound	15,965	1.0
A03_R67_NB	M90 Bridge of Earn to Broxden and Friarton Northbound	9,901	1.2
A03_R67_SB	M90 Bridge of Earn to Broxden and Friarton Southbound	55,813	3.0
A04_R89_NB	A92 Cowdenbeath Jcn and M90 Jcn 4 to Forth Road Br Northbound	240,977	6.2
A04_R89_SB	A92 Cowdenbeath Jcn and M90 Jcn 4 to Forth Road Br Southbound	195,426	4.9
A05_R1011_NB	A977 Gartarry Roundabaout / A985 Longannet / A876 / M876 to M9 Jcn 7 Northbound	117,859	11.1
A05_R1011_SB	A977 Gartarry Roundabaout / A985 Longannet / A876 / M876 to M9 Jcn 7 Southbound	67,607	8.0
A06_R12_NB	M898 / A898 Northbound	24,425	4.4
A06_R12_SB	M898 / A898 Southbound	19,078	5.4
A07_R13_NB	A1 Macmerry to A720 Jcn Northbound	48,539	2.6
A07_R13_SB	A1 Macmerry to A720 Jcn Southbound	43,166	2.0
A07_R14_EB	A720 City Bypass from A1 to M8 Eastbound	307,793	5.9
A07_R14_WB	A720 City Bypass from A1 to M8 Westbound	300,384	6.9

Route	Location	LCI 1 (Hours)	LCI 2 (secs)
A07_R15_NB	M9 from M8 Claylands to M9 Spur Northbound	67,717	5.9
A07_R15_SB	M9 from M8 Claylands to M9 Spur Southbound	18,908	7.4
A08_R16_NB	M77 Jcn 4 (Greenlaw) to M8 (Plantation Interchange) Northbound	121,413	5.0
A08_R16_SB	M77 Jcn 4 (Greenlaw) to M8 (Plantation Interchange) Southbound	50,623	2.3
A08_R1718_EB	M8 St James Interchange to Baillieston Interchange Eastbound	895,726	9.1
A08_R1718_WB	M8 St James Interchange to Baillieston Interchange Westbound	1,043,410	10.9
A08_R19_NB	M73 to M74 J7 Northbound	140,484	2.7
A08_R19_SB	M73 to M74 J7 Southbound	144,951	3.0
A08_R20_NB	M80 Stepps Bypass / A80 to M80 J4 Northbound	543,591	8.1
A08_R20_SB	M80 Stepps Bypass / A80 to M80 J4 Southbound	416,750	6.7
A08_R21_NB	A725 Northbound	217,216	8.8
A08_R21_SB	A725 Southbound	218,514	7.8
A09_R22_EB	A8/M8 Baillieston[2] to Hermiston Gait Eastbound	375,120	3.6
A09_R22_WB	A8/M8 Baillieston[2] to Hermiston Gait Westbound	363,384	3.6
A10_R23_NB	A77 nr Fenwick to Dutch House Roundabout Northbound	35,212	1.6
A10_R23_SB	A77 nr Fenwick to Dutch House Roundabout Southbound	39,707	1.8
A10_R24_NB	A78 Stevenson to Dutch House Roundabout Northbound	59,227	3.5
A10_R24_SB	A78 Stevenson to Dutch House Roundabout Southbound	45,813	3.1
A10_R25_NB	A77 Dalrymple to Dutch House Roundabout Northbound	76,238	5.0
A10_R25_SB	A77 Dalrymple to Dutch House Roundabout Southbound	81,737	5.2

Key:

LCI 1 Additional Travel time per Annum
LCI 2 Average Lost Time per Vehicle Kilometre

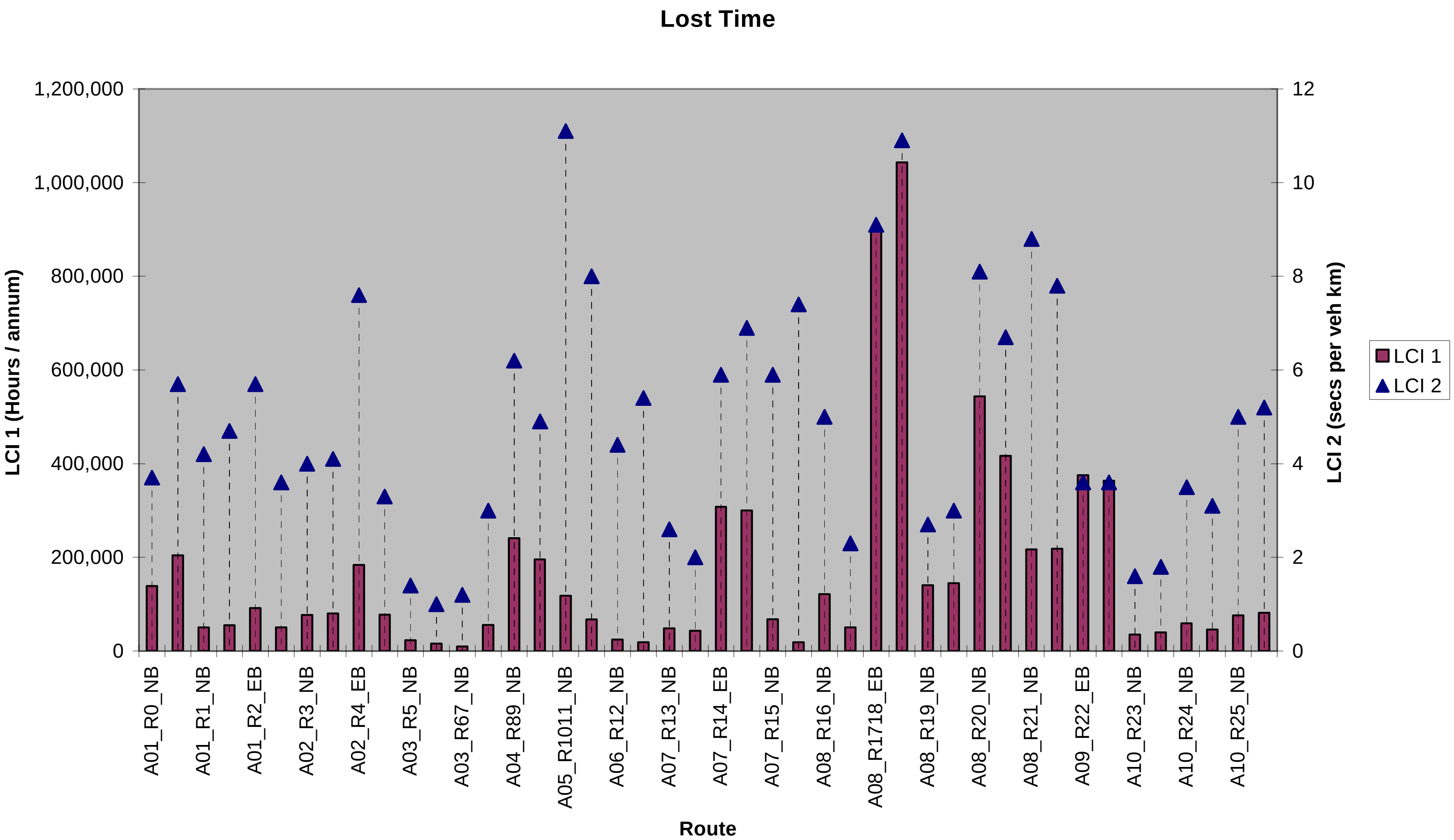

Figure 4: Lost Time by Route

Table 8: Values Local Congestion Indicators LCI-4; LCI-5 and LCI-7

Route	LCI-4 Veh 5 day	LCI-4 Veh 7 day	LCI-5 per km (daily)	LCI-7 Index
A01_R0_NB	99.0%	98.8%	16.35	1.07
A01_R0_SB	97.4%	96.9%	24.01	1.10
A01_R1_NB	98.1%	97.7%	10.54	1.09
A01_R1_SB	95.7%	94.7%	11.42	1.09
A01_R2_EB	96.9%	96.7%	23.45	1.12
A01_R2_WB	98.4%	98.3%	12.92	1.07
A02_R3_NB	99.5%	99.5%	12.50	1.06
A02_R3_SB	98.6%	98.5%	13.33	1.08
A02_R4_EB	97.9%	97.7%	38.33	1.17
A02_R4_WB	99.5%	99.4%	16.16	1.08
A03_R5_NB	99.4%	99.1%	5.02	1.04
A03_R5_SB	99.7%	99.6%	3.39	1.03
A03_R67_NB	99.5%	99.3%	5.52	1.04
A03_R67_SB	99.2%	98.8%	11.30	1.08
A04_R89_NB	98.5%	96.4%	36.18	1.15
A04_R89_SB	97.4%	97.2%	33.85	1.12
A05_R1011_NB	90.2%	90.0%	33.42	1.23
A05_R1011_SB	98.0%	97.9%	19.15	1.11
A06_R12_NB	98.8%	98.6%	15.67	1.10
A06_R12_SB	97.9%	97.9%	19.90	1.10
A07_R13_NB	99.3%	99.3%	11.14	1.07
A07_R13_SB	99.3%	99.3%	10.20	1.07
A07_R14_EB	95.4%	94.7%	45.53	1.15
A07_R14_WB	95.0%	94.6%	47.30	1.17
A07_R15_NB	97.6%	96.1%	26.54	1.14
A07_R15_SB	97.2%	97.2%	26.98	1.15
A08_R16_NB	95.7%	95.6%	36.00	1.14
A08_R16_SB	98.6%	98.4%	16.47	1.06
A08_R1718_EB	91.7%	90.9%	104.07	1.24
A08_R1718_WB	90.0%	89.1%	108.16	1.28
A08_R19_NB	97.8%	97.4%	19.54	1.08
A08_R19_SB	98.4%	98.2%	26.69	1.09
A08_R20_NB	95.2%	94.4%	66.04	1.20
A08_R20_SB	95.4%	94.6%	50.66	1.16
A08_R21_NB	96.2%	94.5%	45.32	1.21
A08_R21_SB	96.5%	96.1%	45.29	1.23
A09_R22_EB	96.4%	95.7%	25.90	1.11
A09_R22_WB	97.5%	97.3%	25.63	1.11
A10_R23_NB	99.2%	99.1%	6.81	1.05
A10_R23_SB	99.7%	99.6%	7.65	1.06
A10_R24_NB	98.6%	98.6%	11.28	1.13
A10_R24_SB	99.3%	99.1%	8.82	1.08
A10_R25_NB	99.4%	98.9%	19.81	1.11
A10_R25_SB	99.4%	97.7%	21.20	1.12

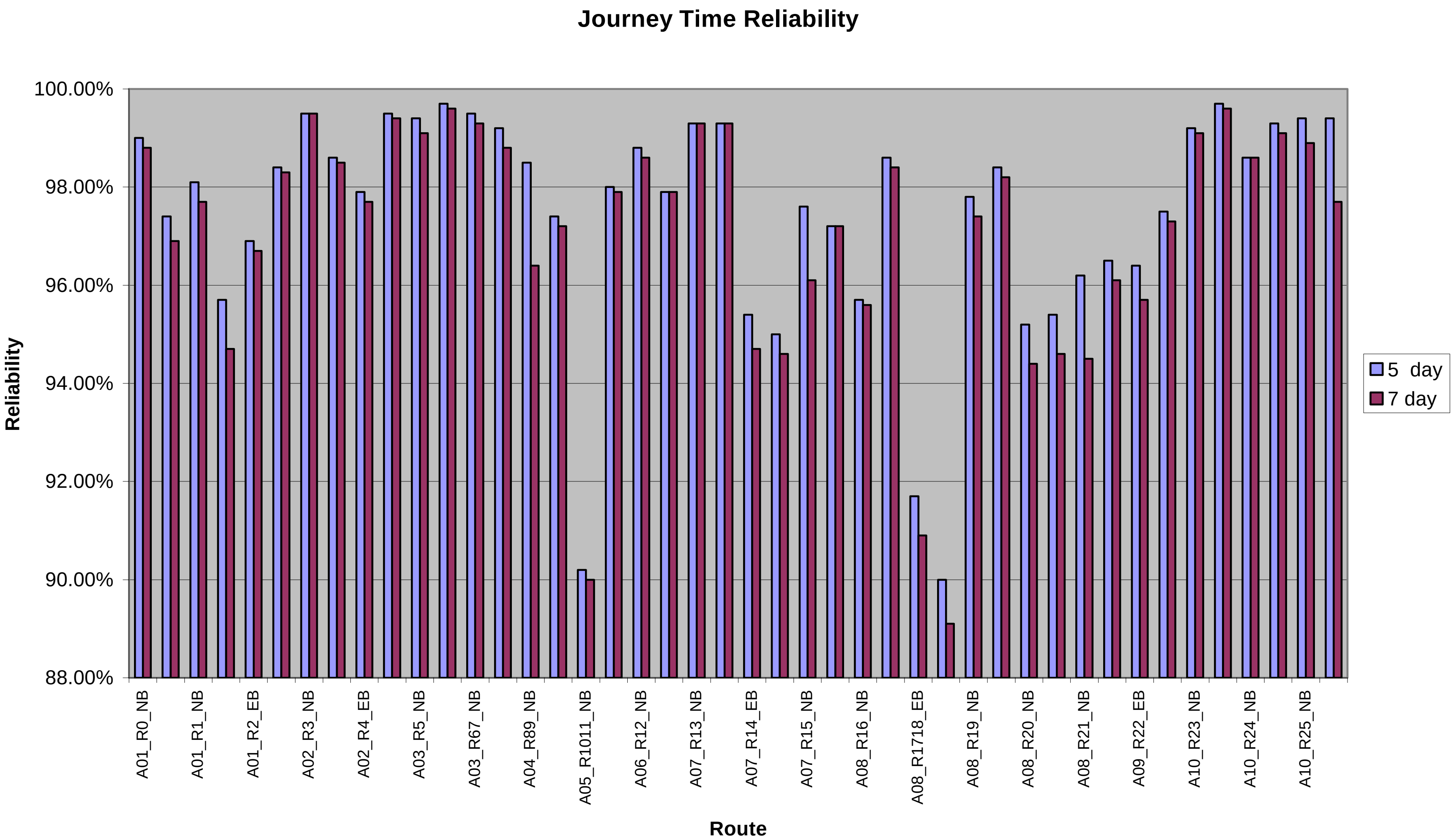

Figure 5: Journey Time Reliability by Route

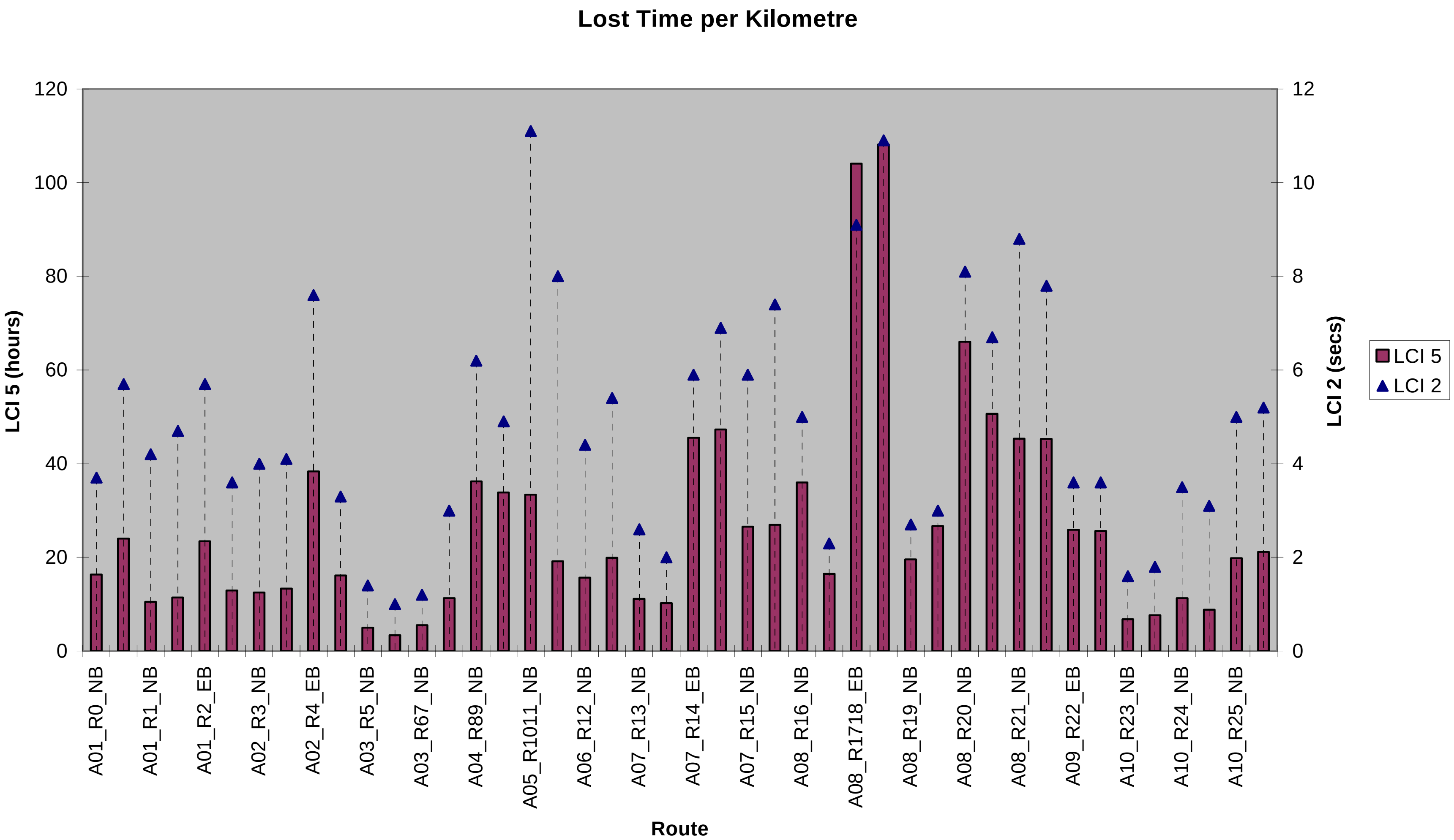

Figure 6: Lost Time per Kilometre by Route

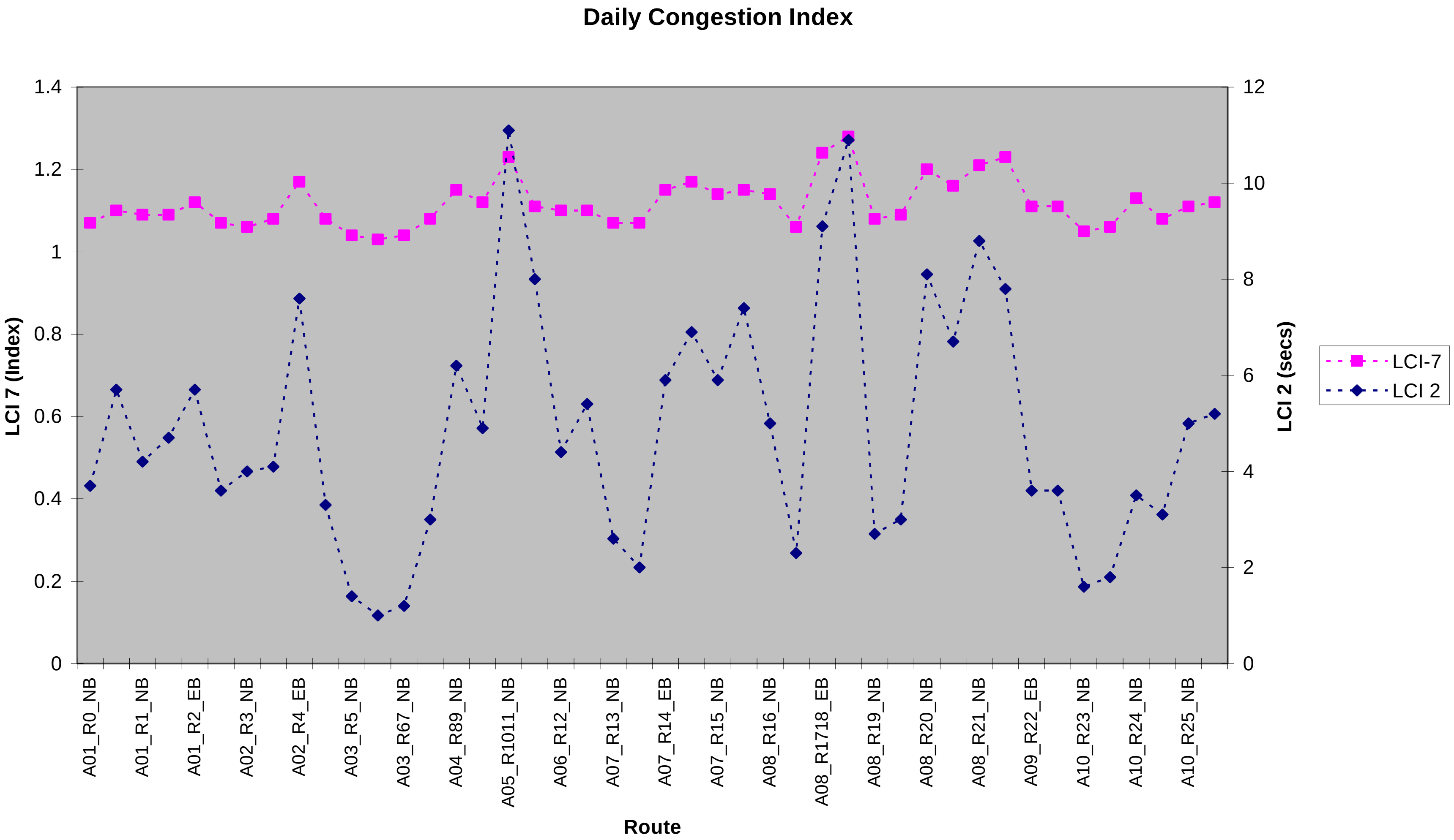

Figure 7: Daily Congestion Index (and LCI 2) by Route

LCI 5 provides a measure of the lost time per kilometre per day. It thus combines both the congestion and the volume effects in a single figure. It should thus be less volatile than LCI 1 (which also depends on the route length). The values by route are given in Table 8 and are shown, together with LCI 2, in Figure 6. The range of values for LCI 5 is between 3 hours (A9 north of Perth – southbound) and 108 hours (for the M8 though Glasgow, including Kingston Bridge - westbound) i.e. a factor of about 30. Given that the first route is a rural all purpose two lane dual carriageway and the other a high capacity urban motorway with cross-sections of up to six lanes this is understandable. Whilst the general pattern of LCI 5 is similar to that of LCI 1 there is less variability.

LCI 7 provides an index of the weighted average speed relative to the free flow speed (see Table 8). Intuitively it would be expected that this will vary as does the absolute value of congestion (i.e. the delay per vehicle - LCI 2). In Figure 7 LCI 7 is plotted alongside LCI 2 and indeed it can be seen that they have very similar shapes demonstrating the strong correlation between the two indices. This provides confirmation that the more congestion traffic is subject to the more variable the speed of traffic.

LCI 6 – Congestion Bands

Table 9 details the proportion of traffic on each route which was subject to some form of congestion (mild / severe / serious) as measured by LCI 6. This is also illustrated in Figure 8. On no route did the proportion of traffic subject to congestion exceed 50%. The highest levels were 46.9% the M 80 / A80, northbound; and 46.8% of traffic on Kincardine Bridge, northbound. The vast majority of congestion was “mild” with many routes having less than 1% of traffic subject to “severe” congestion. A significant number of routes also have low levels of “serious” congestion.

4 Conclusions

In Section 3 we have seen that there is a huge amount of data. At present it has only been analysed at National and Route levels to get a flavour of what is happening. Clearly there is much scope to break down the analysis into smaller more targeted sections and examine how traffic conditions vary between such sections. This will help identify the key pinch points on the network and assist in targeting improvements.

Also as noted in Section 2 there are refinements to the indicators such as more congestion bands and AM / PM peak period indices to be developed. This will all add to the value of the data. Of course once we have access to time series data it will be possible to track trends and to use the system as a tool to establish if projects actually achieve their goals.

We are keen to see others who are working within; in partnership with; and for Transport Scotland to start using this as part of the armoury of tools available to transportation professionals seeking to monitor and improve Scotland’s transport network.

Table 9: Values Local Congestion Indicators LCI-6

Route	Percentage Vehicles Subject to Congestion Category			
	Mild	Serious	Severe	Total
A01_R0_NB	15.3%	0.7%	0.3%	16.3%
A01_R0_SB	10.1%	0.9%	0.9%	11.9%
A01_R1_NB	24.7%	1.0%	0.6%	26.2%
A01_R1_SB	15.3%	3.6%	0.3%	19.2%
A01_R2_EB	7.2%	1.0%	1.9%	10.1%
A01_R2_WB	13.3%	1.6%	0.5%	15.4%
A02_R3_NB	13.4%	0.2%	0.2%	13.9%
A02_R3_SB	16.0%	0.8%	0.4%	17.2%
A02_R4_EB	35.9%	8.2%	1.6%	45.6%
A02_R4_WB	28.8%	0.2%	0.2%	29.2%
A03_R5_NB	3.9%	0.3%	0.2%	4.4%
A03_R5_SB	1.9%	0.1%	0.1%	2.1%
A03_R67_NB	3.4%	0.2%	0.1%	3.7%
A03_R67_SB	29.8%	0.4%	0.1%	30.4%
A04_R89_NB	19.6%	5.0%	1.5%	26.1%
A04_R89_SB	11.2%	1.2%	3.1%	15.5%
A05_R1011_NB	34.5%	6.7%	5.6%	46.8%
A05_R1011_SB	36.7%	0.8%	0.9%	38.4%
A06_R12_NB	32.9%	0.6%	0.1%	33.6%
A06_R12_SB	23.7%	0.7%	0.1%	24.5%
A07_R13_NB	22.8%	1.6%	0.0%	24.5%
A07_R13_SB	11.1%	0.2%	0.1%	11.4%
A07_R14_EB	24.0%	4.2%	2.3%	30.4%
A07_R14_WB	21.5%	4.3%	2.7%	28.5%
A07_R15_NB	32.7%	1.0%	1.5%	35.2%
A07_R15_SB	7.5%	1.2%	2.4%	11.2%
A08_R16_NB	6.1%	1.3%	3.3%	10.7%
A08_R16_SB	9.7%	1.0%	0.2%	10.9%
A08_R1718_EB	19.5%	5.3%	5.5%	30.3%
A08_R1718_WB	17.9%	6.4%	6.3%	30.6%
A08_R19_NB	23.0%	1.8%	0.6%	25.4%
A08_R19_SB	30.1%	1.8%	0.3%	32.2%
A08_R20_NB	40.1%	3.4%	3.5%	46.9%
A08_R20_SB	30.1%	4.9%	2.1%	37.1%
A08_R21_NB	32.1%	2.3%	2.7%	37.1%
A08_R21_SB	32.7%	2.3%	2.8%	37.8%
A09_R22_EB	20.7%	4.6%	0.9%	26.2%
A09_R22_WB	30.4%	3.1%	0.4%	34.0%
A10_R23_NB	5.3%	0.3%	0.0%	5.7%
A10_R23_SB	7.9%	0.1%	0.0%	7.9%
A10_R24_NB	27.0%	0.9%	0.7%	28.5%
A10_R24_SB	20.3%	1.5%	0.2%	21.9%
A10_R25_NB	46.2%	0.9%	0.1%	47.2%
A10_R25_SB	35.9%	3.8%	0.3%	40.0%

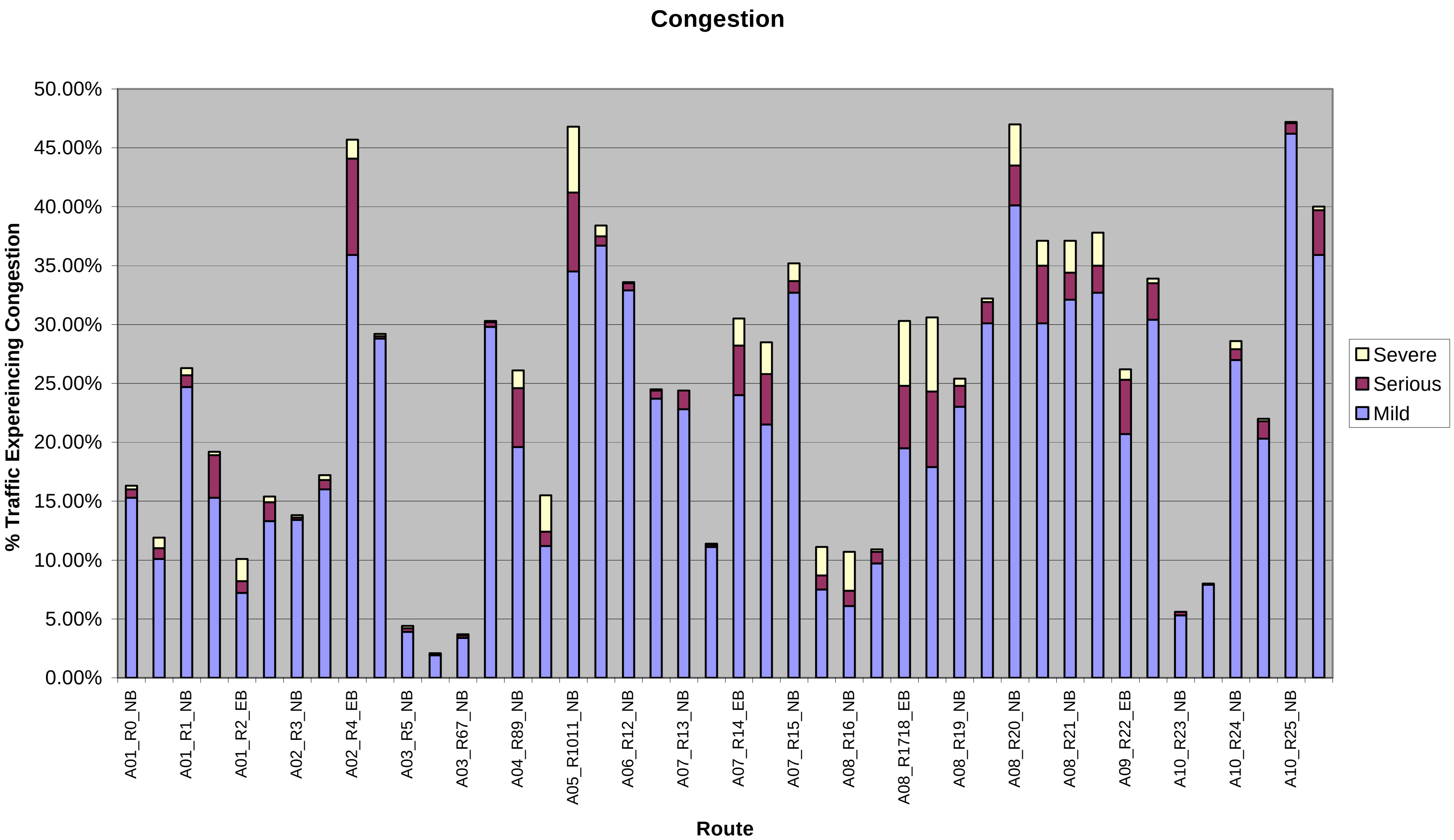

Figure 8: Congestion by Route

Notes

[1] The 2003 Congestion Indicators were revised as set out below:

Site Corrections - After publication of the 2003 report it was found in that 23 of the 492 sites used in the calculation of the 2003 indices the site directions had been changed during the upgrade of the sites to speed-capable and this information had not been taken into account at the time. The data for the sites in question were corrected and the 2003 indices were recalculated after publication of the 2003 report.

While this revision made slight differences to some directional congestion indices it made no significant difference to the total time lost when combining both directions of a single route or, indeed, the total lost time for the network. (NCI 1).

Assessment of NCI 1 - The calculation of NCI 1 is described in Section 1 as the aggregation of route figures. However, some of the network-wide indicators can be calculated only by analysing all of the sites in one run. In normal circumstances, the resulting "direct" NCI 1 would be almost identical to the aggregation of the 44 LCI 1 values.

Any gaps in data from ATC sites are patched automatically by the congestion software. In the case of LC indicators, the patches come from sites on the route in question only, but for NC indicators, the patches come from all sites in the monitored network. There will, therefore, be some difference between the "direct" NCI 1 and the "sum of LCI 1" NCI 1 values.

However, in 2003 the gaps were significant (only 37% of data available) and the two different methods of calculating NCI-1 produced answers which were of the order of 5% different. The value in the published 2003 report was taken from the direct calculation. Since local patching is clearly more appropriate than network-wide patching, it has been decided that the NCI 1 resulting from the sum of the 44 LCI 1 values is more accurate and will, therefore, be used.

[2] In 2003 route 22 started just west of Newhouse Junction, due to major roadworks between there and Baillieston.

Bibliography

Congestion on the Scottish Trunk Road Network 2003 (2005) Scottish Executive, Edinburgh (http://www.scotland.gov.uk/Publications/2005/05/06110913)

Scotland's Transport Delivering Improvements - Transport Delivery Report (2002) Scottish Executive, Edinburgh (http://www.scotland.gov.uk/library3/transport/stdi-00.asp)

Scotland's Transport Delivering Improvements: Transport Indicators for Scotland (2002) Scottish Executive, Edinburgh (http://www.scotland.gov.uk/library5/transport/stdi-00.asp)

web-TAG (Transport Analysis Guidance) Unit 3.5.6 (paragraph 1.2.30) Department for Transport, London (http://www.webtag.org.uk/webdocuments/3_Expert/5_Economy_Objective/3.5.6.htm#1_2f)