NTNU
Traffic Engineering
Research Centre

Managed motorways

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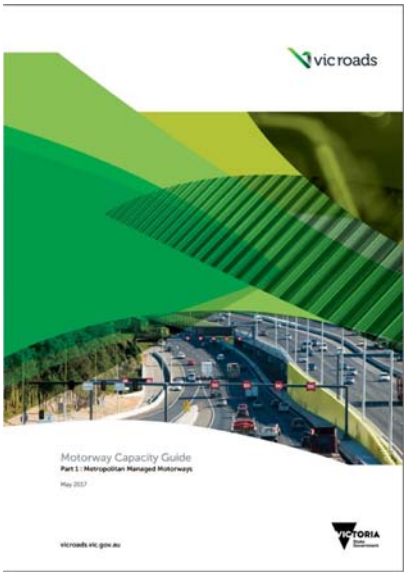
- Terminology; Managed motorway, Capacity and Productivity
- Brief summary of the Motorway Capacity Guide
- Measurement results
- Recommended values for design
- Future work
- Some comments on Norwegian and Nordic conditions

Introduction - background

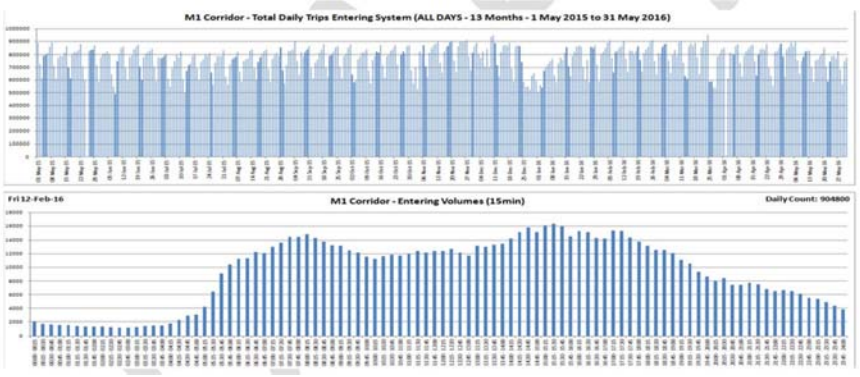
- Motorway Capacity Guide
  Part 1: Metropolitan Managed Motorways (Draft May 2017)
- Authors: John Gaffney and Hendrik Zurlinden, VicRoads, Melbourne, Australia



Introduction – Melbourne motorway network

- Melbourne is the capital of Victoria southeast in Australia
- Area ~ 10.000 km^2
  (~ Oslo + Akershus + Østfold)
- Population ~ 4.6 mill
  (~ Slightly less than Norway)
- Motorway network covers
  - 7% of the urban arterial road lane kms
  - 40% of the urban arterial road travel (increasing)
  - M1 corridor from west to east of the map is about 70 km

Introduction - M1 Corridor



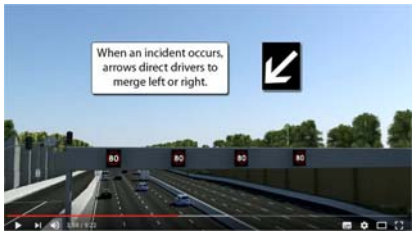
- 70 km motorway corridor
- Total entering volume ~ 900.000 vehicles a day
- More than 1 million trips each day (1.2 persons per vehicle)

Speed limits and enforcement

- Australian urban motorways have a maximum speed limit of 100 km/h
- A very active and strict enforcement regime
- In Victoria the tolerance is only +3 km/t
- -> relative small speed differences

Managed motorways

- A managed motorway is a motorway which uses different traffic management measures to enhance quality of traffic flow
- Examples of such measures are variable speed limits, ramp metering, hard shoulder running, traffic information, alternative routes, ITS measures, lane signals, traffic data collection and monitoring, incident detection etc
- John Gaffney: **«A congested motorway is a poorly managed motorway»**

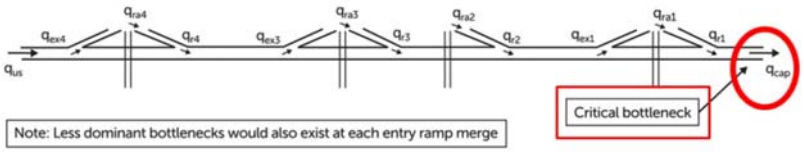


https://www.youtube.com/watch?v=SYbceSqk_Mk

https://www.youtube.com/watch?v=XCEBpgEv_QQ

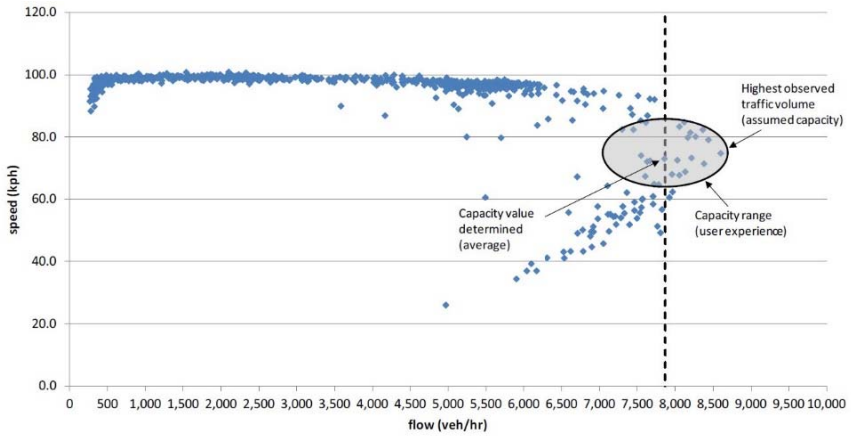
Capacity

«The maximum sustainable flow rate at which vehicles or perons can be expected to traverse a point or uniform segment of a lane or roadway during a specified time period under given roadway, geometric, traffic, environmental and control conditions»
(HCM 2016)



Capacity values are measured at **active bottlenecks** and determined on the basis of **systematical analysis** of data to capture the effect of **systematic** and **random** fluctuations under a wide range of **demand patterns**

Capacity



- Capacity should be based on **long-term measurements**
- Should not use short term traffic counts on a single day
- Each dot above is a one hour measurement

Factors impacting on capacity

- Cross section
  - Lane and shoulder width
  - Visibility
- Alignment
  - Gradient
  - Curvature
  - Sags and crests
- Traffic
  - Vehicle type distribution
- Location
  - Share of commuters
- Other
  - Merge, diverge, weaving
  - Auxiliary lanes
  - Acceleration, deceleration lanes
- Traffic management
- Ramp metering
- Maintenance
- Work zones
- Enforcement regime
- Driver behaviour
  - Headways
  - Braking
  - Lane changing activity
  - Compliance with road rules

Productivity

- Productivity is defined as the **product of traffic speed and traffic flow**
- Unit is **vehicle-kilometers travelled on a road segment per time unit**
- High productivity is achieved when both traffic flow and traffic speed are maintained near maximum values
- Efficient energy use align closely with the point where the motorway operates at maximum productivity
- Productivity is a good measure for efficiency, safety as well as environmental conditions

Measurements

Cross-section	from	to	Capacity	Number of lanes	Capacity per lane	Gradient	HGV percentage	Normalised Capacity per lane 4)
			veh/hr		veh/hr/Lane	%	%	veh/hr/Lane
14456 IB	Ernst-Wanke/Tinks	Belgrave-Hallam	3,963	2	1,982	2.5	11	1,954
14456 OB	Belgrave-Hallam	Ernst-Wanke/Tinks	4,111	2	2,056	<=2	11	1,976
14542 IB	Warrigal	High	7,280	4	1,820	<=2	13	1,784
14547 OB 1)	High	Warrigal	5,176	3	1,725	<=2	13	1,692
14547 OB 2)	High	Warrigal	6,652	4	1,663	<=2	13	1,630
14571 IB 1)	Huntingdale	Warrigal	6,140	3	2,047	<=2	13	2,007
14571 IB 2)	Huntingdale	Warrigal	7,342	4	1,836	<=2	13	1,800
14573 OB	Huntingdale	Forster	7,938	4	1,985	<=2	11	1,908
14779 IB	Toorak	Yarra Blvd	7,334	4	1,834	<=2	15	1,834
14587 IB	Jacksons	Wellington	7,876	4	1,969	<=2	11	1,893
14428 EB 3)	Williamstown	Todd	8,417	5	1,683	3.5	17	1,757
14427 WB 3)	Todd	Williamstown	8,451	5	1,690	3.9	17	1,803

- Please remember, a flow rate of 1800 veh/hour means:
  - an average time headway (front-front) of 2 seconds
  - An average time gap (front-back) of about 1.8 sec (depending on speed and vehicle length)

Measurements

	Measured	Reduction compared to 2 lanes baseline	Rounded
	veh/hr/Lane	%	veh/hr/Lane
2 lanes	1,965	NA	1,975
3 lanes	1,849	5.9	1,850
4 lanes	1,808	8.0	1,800
5 lanes	1,780	9.4	1,775

Measurement results only - not to be used for design (compare to Section 9)			
	Measured	Reduction compared to 2 lanes baseline	Rounded
	veh/hr/Lane	%	veh/hr/Lane
2 lanes	1,943	NA	1,950
3 lanes	1,819	6.4	1,825
4 lanes	1,745	10.2	1,750
5 lanes	1,726	11.2	1,725

- No interaction between sections; elimination of downstream bottlenecks (above)
- Interaction between sections, no elimination of downstream bottlenecks (below)

Recommended values for design

	Design (Factor 0.9)	Rounded	Reduction compared to 2 lanes baseline (rounded values)
	veh/hr/Lane	veh/hr/Lane	%
2 lanes	1,769	1,775	NA
3 lanes	1,664	1,675	5.3
4 lanes	1,627	1,625	8.1
5 lanes	1,602	1,600	9.6

- Design values are typical about 90% of observed capacity
- See also more complex theoretical methods and models

Managed motorway – probability for breakdown

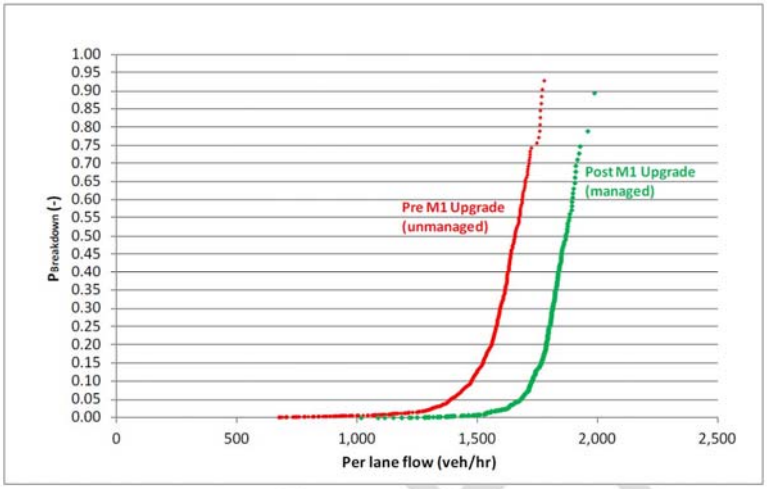


Figure 13 – Flow breakdown probability at Warrigal Road - before and after M1 Upgrade (7839 OB and 14547 OB, 15 min intervals)

Managed motorway – probability for breakdown

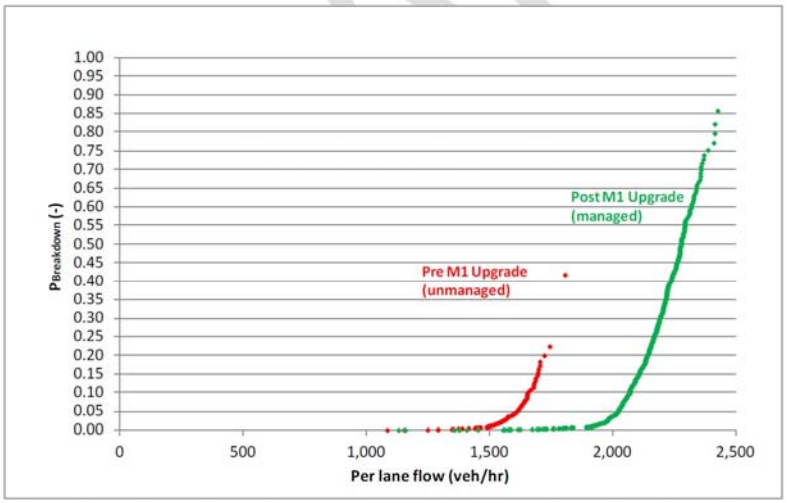


Figure 14 – Flow breakdown probability on Hallam Bypass – before and after M1 Upgrade (14316 OB and 14456 OB, 15 min intervals)

Design of unmanaged and managed motorways

	Capacity - based on Table 4	Rounded	Design (Factor 0.9) - based on Table 11	Rounded
	veh/hr/Lane	veh/hr/Lane	veh/hr/Lane	veh/hr/Lane
2 lanes	1,670	1,675	1,503	1,500
3 lanes	1,572	1,575	1,415	1,425
4 lanes	1,537	1,525	1,383	1,375
5 lanes	1,512	1,500	1,362	1,350

	Design (Factor 0.9)	Rounded	Reduction compared to 2 lanes baseline (rounded values)
	veh/hr/Lane	veh/hr/Lane	%
2 lanes	1,769	1,775	NA
3 lanes	1,664	1,675	5.3
4 lanes	1,627	1,625	8.1
5 lanes	1,602	1,600	9.6

- Design of unmanaged motorways (above)
- Design of managed motorways (below)

Future work and investigations

- Merging, diverging and weaving
- Differences between unmanaged and managed motorways
- Capacity loss and recovery
- Congestion and safety
- Lane changing activity and capacity
- Effect of geometric parameters and heavy vehicles

What about Norwegian / Nordic conditions?

- Swedish guidelines are reviewed in the Australian Motorway Capacity Guide together with the US (HCM), UK, German and Dutch guidelines
- We have limited experiences with Norwegian conditions, but the values from Australia seems to be useful also in Norway
- Norwegian motorways have a very limited degree of management
- There is a large potential for improvement

Thank you for your attention

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