

# Abstract

Theme: Smart Data Management and Analytics Title: Measuring the Impact of Weaving on Motorway Capacity Author: Dr Hendrik Zurlinden (hendrik.zurlinden@ntro.org.au) Affiliation: National Transport Research Organisation

# Background

Easy access to arterial road networks and short and reliable travel times to reach destinations is critical in supporting thriving, productive and liveable communities. Efficient and effective road travel for people and freight in Australian metropolitan areas relies on functional motorways. However, inappropriate road design linked to insufficient capacity has in the past caused permanent bottlenecks built into the motorways network. If unaddressed such as through expensive retrofitting, permanent bottlenecks cause recurrent congestion with all the negative consequences on a large scale.

There is a causal relationship between concentrated lane changing intensity and capacity loss, specifically in weaving areas. The US Highway Capacity Manual defines weaving as follows:

'Weaving is generally defined as the crossing of two or more traffic streams travelling in the same direction along a significant length of a highway without the aid of traffic control devices (except for guide signs). Thus, weaving segments are formed when merge segments are closely followed by diverge segments. 'Closely' implies that there is not sufficient distance between the merge and diverge segments for them to operate independently'.

There is still no agreed and easily and universally applicable analytical methodology to quantify the relationship between high lane changing concentration and capacity loss. This severely impacts planning, design and operation of motorways, and prevents motorways from being effective and functional – supporting the accessibility and productivity of individuals and businesses.

Recent advancements in capacity analysis (Vic DTP Managed Motorway Design Guide/Motorway Capacity Guide which replaced 'capacity' by the Maximum Sustainable Flow Rate = MSFR concept) and groundbreaking innovative vehicle detection and tracking methodologies (TIRTL data and drone-based video analytics) provide a chance that this can change soon.



## **Research approach**

Weaving sections along motorway corridors can create bottlenecks. Establishing a numerical relationship between lane changing concentration and capacity loss is important for planning, design, and operation of motorways. This can enable road designers to precisely dimension the infrastructure and therefore save billions of dollars on construction or congestion costs. Due to technical measurement constraints, to date only very limited measurements of lane changing were undertaken. This came at the expense of deficiencies in the design methodologies included in the current guidelines. Next generation vehicle detection technology built into many kilometres of metropolitan Melbourne motorways (TIRTL detectors) allows for the ongoing quantification of lane changing in fine resolution. Based on unique characteristics and heuristic algorithms, almost every vehicle can be reidentified at adjacent detector sites. Measured characteristics include the lane that the vehicle drives in and potential changes between sites. Based on data from seven weaving sections located on two 3to 5-lane carriageway motorways, it was found that the relation between capacity loss in per cent and the (mandatory) lane changing concentration in lane changes per vehicle and kilometre is linear.

This research first presented at the 2021 TRB Annual Meeting is planned to be completed in cooperation between NTRO, Main Roads WA (MRWA) and Vic DTP in 2025/2026. This article presents the need for a refined approach compared to current methodologies, the steps that led to the methodology developed so far, the results of their initial application and the planned research, resulting in a proposal for an update of the Austroads Guide to Traffic Management (AGTM).

### **Completed and planned works**

### Completed work

The project work that was recently started builds on some earlier work undertaken by Vic DTP and presented in a preliminary form at the 2021 TRB Annual Meeting.

The following methodology was applied:

Task 1 - Determine the capacity loss (Delta MSFR) in weaving areas, compared to 'normal' motorway sections, caused by high lane changing concentration (i.e. many lane changes that must be made by weaving vehicles to progress from A to D or B to C, over a short distance)





Task 2 - Quantify the Lane Changing Concentration LCC based on the unit 'Lane changes per kilometre per vehicle per hour' (LC/km/veh/h)



Task 3 - Put Delta MSFR and LCC in relation (see diagram)

Task 4 - Develop MSFR reduction factors as a function of LCC (or establish a functional relationship as shown in the diagram)

If the LCC can be estimated for a planned weaving area, then the corresponding MSFR loss and the remaining MSFR can be reliably estimated. This allows for appropriate design, e.g. for the extension of a weaving area/auxiliary lane or for an additional lane if needed.

The work described was based on a low number of measurement sites and limited testing so that a continuation of the work as described under <u>Planned works</u> below has recently started. Once completed, this work can save many millions in congestion costs and/or infrastructure costs.

<u>Planned works</u> (funded by MRWA through its WARRIP program)

The Weaving Area Capacity Analysis (WACA) project with MRWA and Vic DTP that has recently started will encompass the following steps:

Task 1 – Review and comparison of existing and newly proposed WACA methodologies

- US Highway Capacity Manual (HCM) 7th Edition
- NCHRP Research Report 1038
- Vic DTP 2021TRB Annual Meeting contribution
- Others (German HCM, Dutch HCM, etc)

Task 2 – Data Sourcing and Validation

- Bottlenecks in the MRWA freeway network (for Task 3)
- Weaving areas (both MRWA and Vic DTP, for Task 4)
- Speed-Volume-Occupancy (SVO) and TIRTL lane changing data or Origin-Destination (OD) data

Task 3 - Definition of typical MRWA freeway capacity values (basic freeway sections, confirmation/adjustment of Vic DTP Motorway Capacity Guide values)

Task 4 - Analysis of weaving areas equipped with state-of-the-art detection (TIRTL or video analytics)

Task 5 - Development of a refined weaving area capacity determination methodology (and proposed guidance text for the Austroads Guide to Traffic Management - AGTM)

Task 6 - Testing of the developed methodology

The planned presentation will elaborate on the importance of appropriate capacity guidance for weaving areas, the shortcomings of current methodologies and real-life consequences, the approach selected for the current research, and the planned practical application to major infrastructure.