



WARRIP

WESTERN AUSTRALIAN
ROAD RESEARCH &
INNOVATION PROGRAM

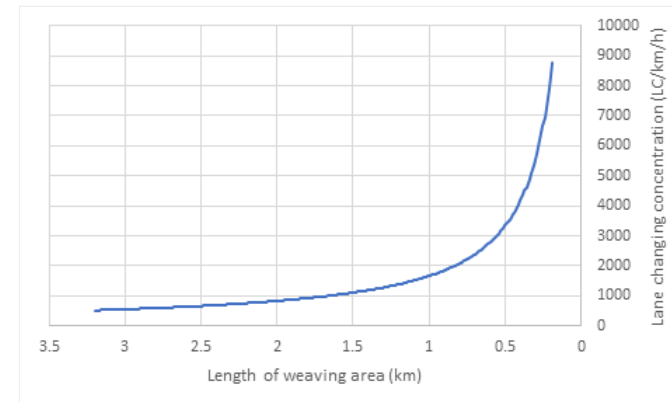
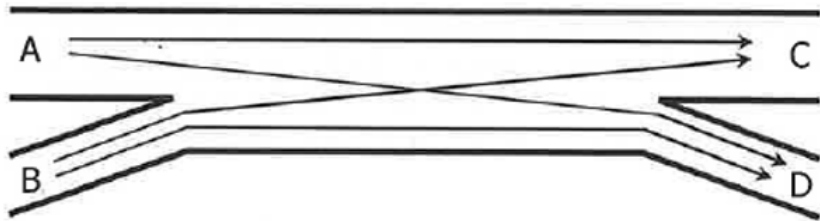
WARRIP 2025-002 Weaving Area Capacity Analysis (WACA)

Project presentation 29/07/2026

Weaving areas can severely reduce freeway capacity

High spatial lane changing concentration can create strong bottlenecks (e.g., through 'aggressive weaving' when drivers must get from their origins to destinations, e.g. A to D or B to C in the diagram)

Appropriate capacity guidance for freeway weaving areas is essential for freeway planning, design and operations

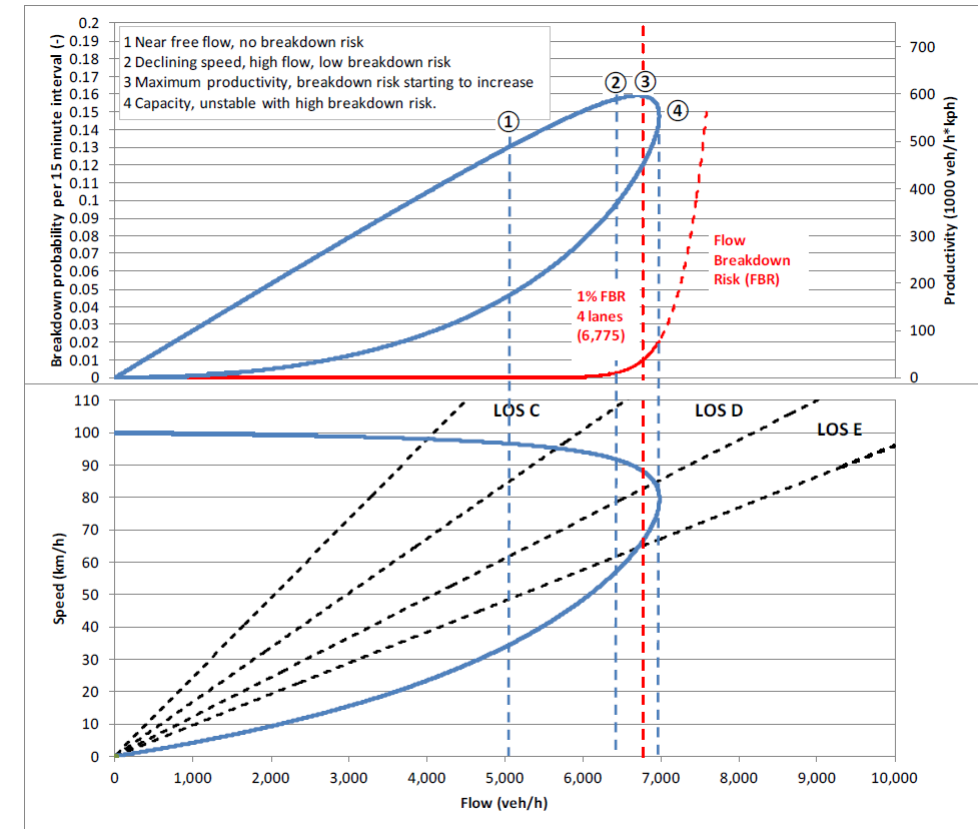


Research Need

Most Australian and New Zealand jurisdictions have now adopted the **Maximum Sustainable Flow Rate (MSFR)** concept for capacity analysis (rather than the traditional speed-flow curves)

MSFR is linked to the probability of flow breakdown = congestion risk for a certain traffic volume

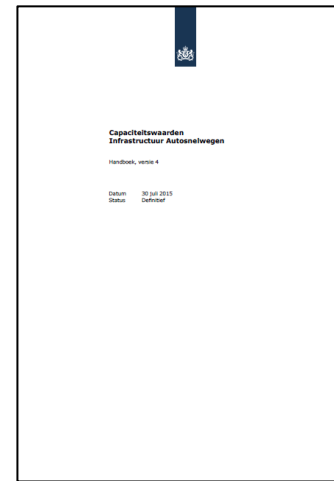
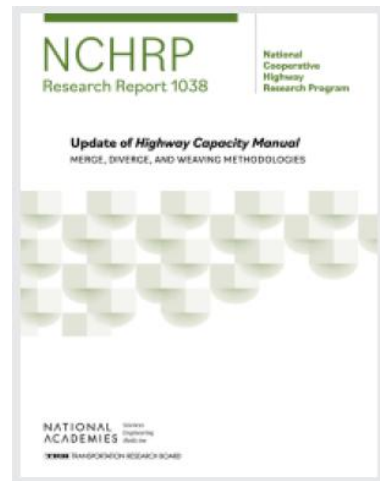
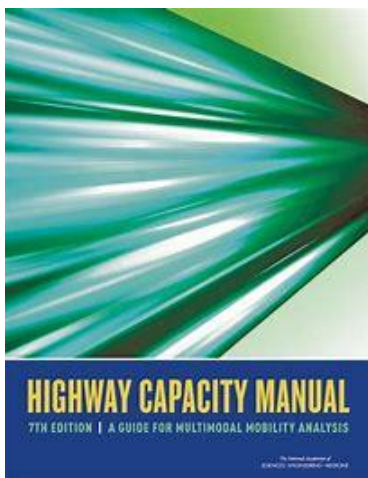
No weaving method aligned with MSFR has been developed yet - this project aims to close this gap



Research and assessment of the different methodologies for analyzing weaving area capacity that are available today

Focus on the USA, since the US HCM is regularly used in Australia and New Zealand, and on some European countries

Criteria used: Scope (coverage of real-world weaves including auxiliary lanes, lane drops and lane adds, bifurcations), user-friendliness and accuracy (plus risk of gross misjudgement)



Weaving Areas and Data



Twelve weaving areas in Western Australia and Victoria investigated (e.g. Kwinana and Mitchell Freeways)

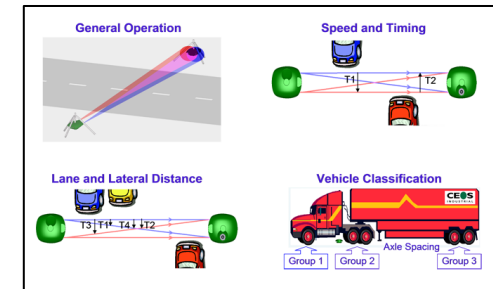
Analysis of lane changing linked to weaving and of capacity (MSFR), based on long-term measurements

Speed, volume and occupancy data (SVO) – routinely measured

Lane changing data (Automated Number Plate Recognition (ANPR) in WA, Advanced Freeway Data Stations (FDS) = TIRTL detectors in VIC)

Functional relationship established between the lane changing concentration (LCC) and the capacity loss (in percent), compared to a typical non-weaving freeway section

LCC unit is lane changes (LC) per vehicle per kilometre. This unit ensures that the method can be applied to different traffic volumes, e.g. linked to different carriageway lane numbers.



Capacity Estimation Method

A new methodology for weaving area capacity estimation was developed

Goal: Method for practitioners to reasonably estimate MSFR in weaving areas; this implies that not 100% accuracy was the goal, but to avoid gross misjudgement as was often the result of the US HCM methodology application

This methodology is supported by a detailed description of the process for estimating the number of essential LC, which must happen

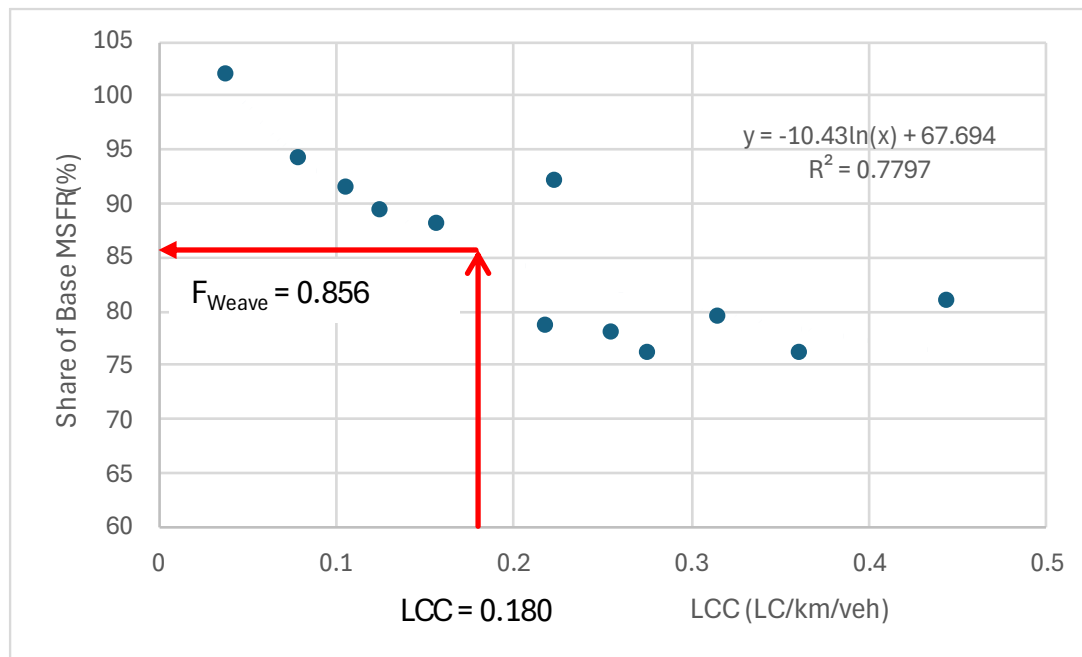
- 1. For the facilitation of OD movements (MLC), or**
- 2. Avoidance of capacity exceedance in a lane (EMLC)**

Estimation of LC is straightforward for simple weaves

Estimation of LC can be challenging for complex weaves (e.g. with multi-lane entry-ramps or exit-ramps, or multiple lane-adds or lane-drops such as at freeway bifurcations)

Capacity Estimation Method

A weaving adjustment factor F_{Weave} for the reduction of 'normal' capacity can be determined with a simple diagram, a mathematical function or tables



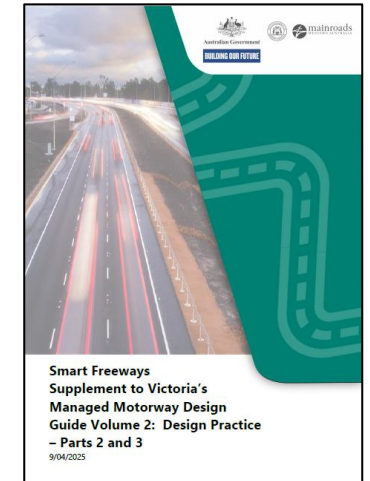
Resulting capacity/ $MSFR_{Weave}$:

$$MSFR_{Weave} = F_{Weave} * MSFR_{Base}$$

Base capacity/ $MSFR_{Base}$:

No. of Mainline Lanes	Gradient, s			
	$s \leq 2\%$	$2\% < s \leq 3\%$	$3\% < s \leq 4\%$	$4\% < s \leq 5\%$
1	1,983	1,876	1,781	1,639
2	4,175	3,950	3,750	3,450
3	6,050	5,750	5,450	5,025
4	7,800	7,400	7,025	6,475
5	9,275	8,800	8,350	7,700
6	10,685	10,138	9,619	8,870
7	11,967	11,354	10,774	9,935

Table 4.1: Smart Freeway Sections – MSFR design values (PCU/h)

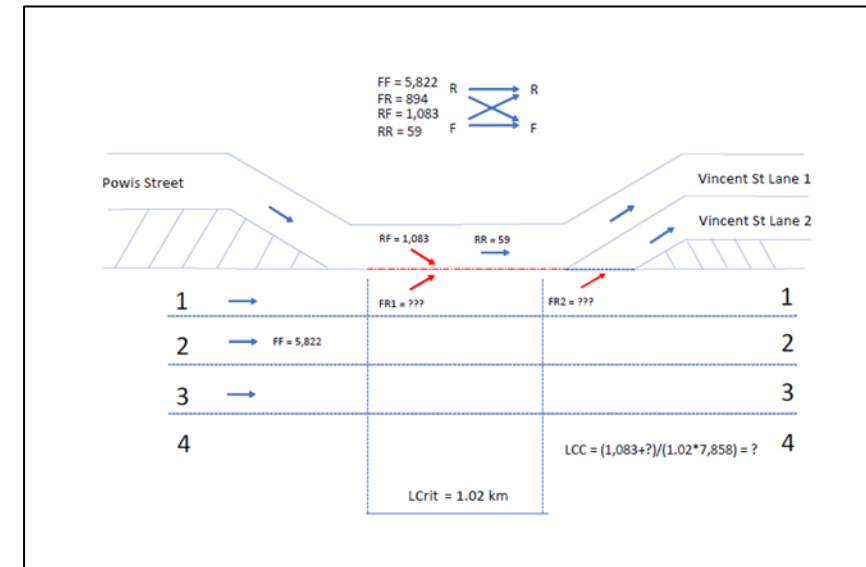
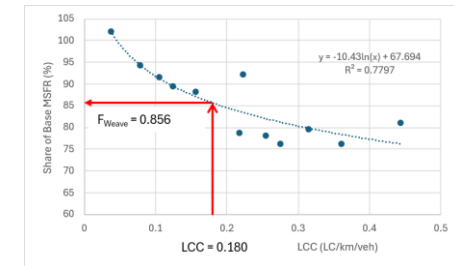
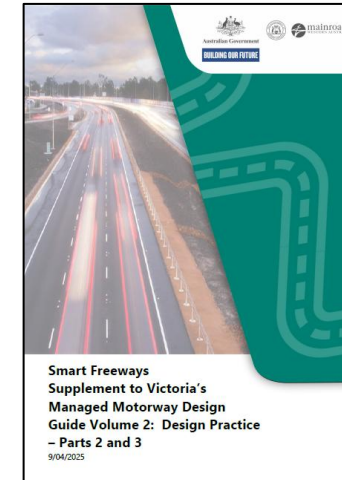


User Guidance for the New Method

A step-by-step guidance text for practitioners was provided:

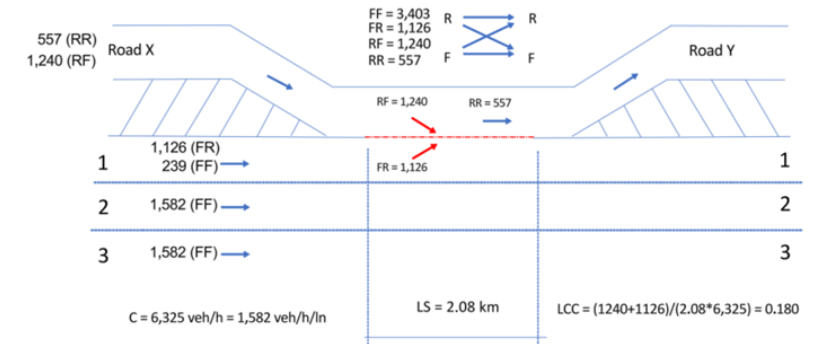
1. Collate the relevant geometrical and traffic conditions (e.g. No. of lanes, Origin Destination data)
2. Identify the base case capacity value $MSFR_{Base}$ (e.g. from Main Roads Smart Freeway Guidelines)
3. Estimate the number of essential lane changes $LC_{X_{Mand}}$ that must be made
4. Calculate the essential LC concentration $LCC_{X_{Mand}}$ (division by weaving length and no. of vehicles)
5. Look up F_{Weave} as the remaining percentage of $MSFR_{Base}$ from the diagram or table
6. Multiply this percentage by $MSFR_{Base}$

$$MSFR_{Weave} = F_{Weave} * MSFR_{Base}$$



Method Step 3: Estimation of the number of essential lane changes

1. Adoption of OD ratios (FF, FR, RF and RR percentages) from traffic counts, detector measurements, probe data or traffic modelling
2. Definition of the carriageway MSFR values for the upstream, weaving area and downstream sections/segments
3. Estimation of the per-lane mainline flow rates at the start of the section (for saturated conditions)
4. Estimation of the entry-ramp flow rates (per lane)
5. Assignment of initial (**primary**) MLC (based on the required OD movements)
6. Assignment of (**secondary**) EMLC caused by lane balancing (i.e. needed to avoid per lane MSFR exceedance)



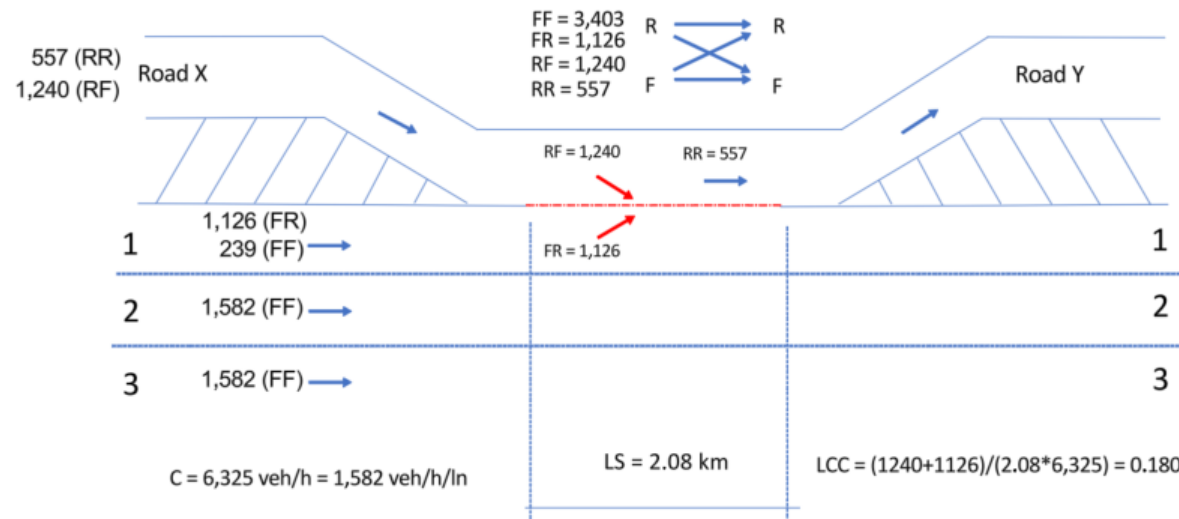
Step 3 can be complex!



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Estimation of the number of essential lane changes

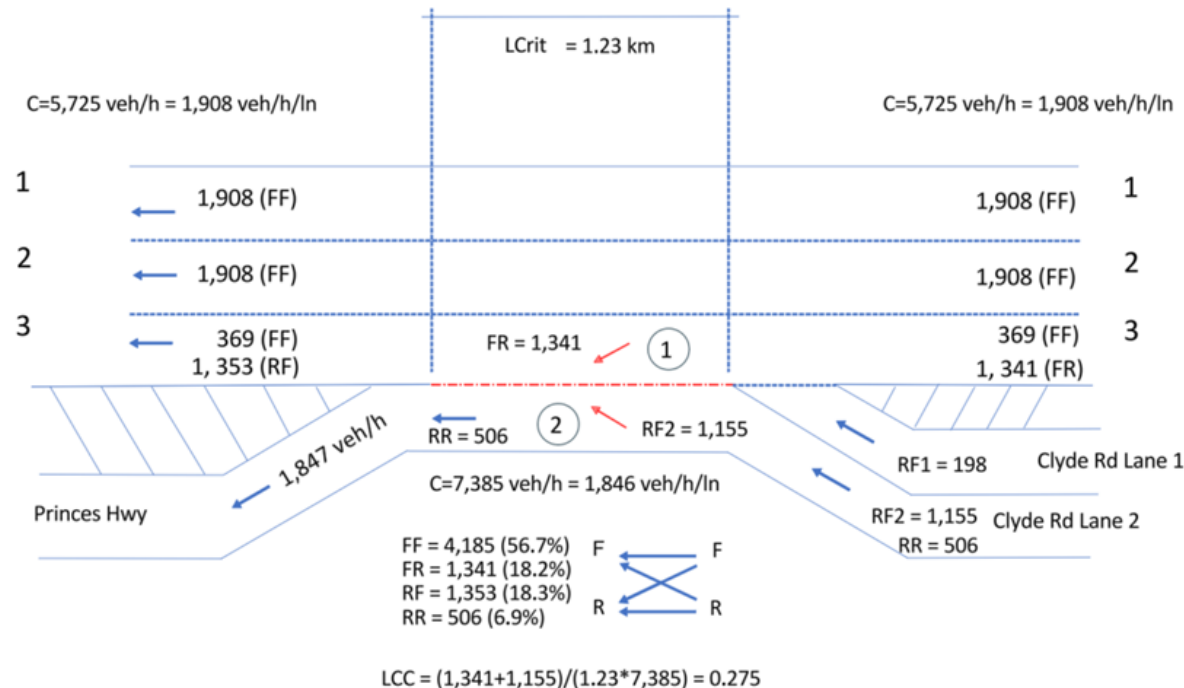
Simple example for the LC estimation



Step 3 is simple!

Estimation of the number of mandatory lane changes

Complex example for the LCC estimation (double-lane entry)



Step 3 is complex!

- Impacts on user-friendliness
- Potentially error source
- Application will show

Testing and Assessment

Comparison of the performance of a newly proposed US HCM methodology (NCHRP Project 07-26) and of the new WARRIP 2025-002 project methodology

Criteria:

- Scope (coverage of weaves - auxiliary lanes, lane drops and adds, bifurcations)
- User-friendliness (including suitability for scenario analysis)
- Accuracy (based on measured MSFR for test sites)

Criteria	WARRIP Method (Refined Vic DTP)	New US HCM (Extended STRIDE)	Comment
Scope (30%)			
User friendliness (20%)			
Plausibility of equations (10%)			
Accuracy (40%)			
Total			

Testing and Assessment

The new method performed better overall

Main advantages of the new WARRIP method:

- Aligns with the MSFR concept
- Estimates capacity directly, rather than originally optimises the speed/density fit
- Allows for scenario assessment (e.g., impacts of extending the weaving length)
- Limits the risk of gross misjudgement (e.g. negative speed estimates have been reported for the new US HCM methodology)

Criteria	WARRIP Method (Refined Vic DTP)	New US HCM (Extended STRIDE)	Comment
Scope (30%)	+	+	
User friendliness (20%)	0	+	Vic DTP: Increased lane changing estimation effort for complex weaves
Plausibility of equations (10%)	+	-	Extended STRIDE: Constant density assumption at flow breakdown appears unrealistic
Accuracy (40%)	+	-	
Total	+	0	

Testing and Assessment

Disadvantage of the new WARRIP project method:

- Estimation of the essential Lane Chances (LC) and LCC can be challenging
- Automation of estimation steps (e.g., MS Excel) and other methods such as micro-simulation can likely mitigate this

Criteria	WARRIP Method (Refined Vic DTP)	New US HCM (Extended STRIDE)	Comment
Scope (30%)	+	+	
User friendliness (20%)	0	+	Vic DTP: Increased lane changing estimation effort for complex weaves
Plausibility of equations (10%)	+	-	Extended STRIDE: Constant density assumption at flow breakdown appears unrealistic
Accuracy (40%)	+	-	
Total	+	0	

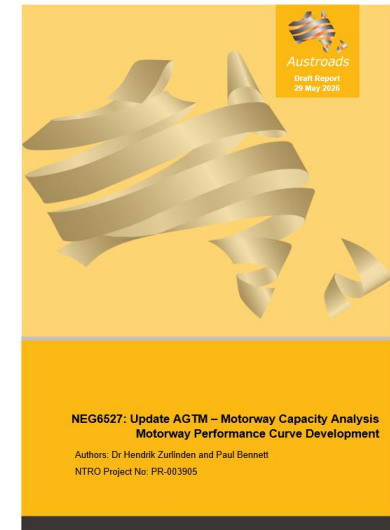
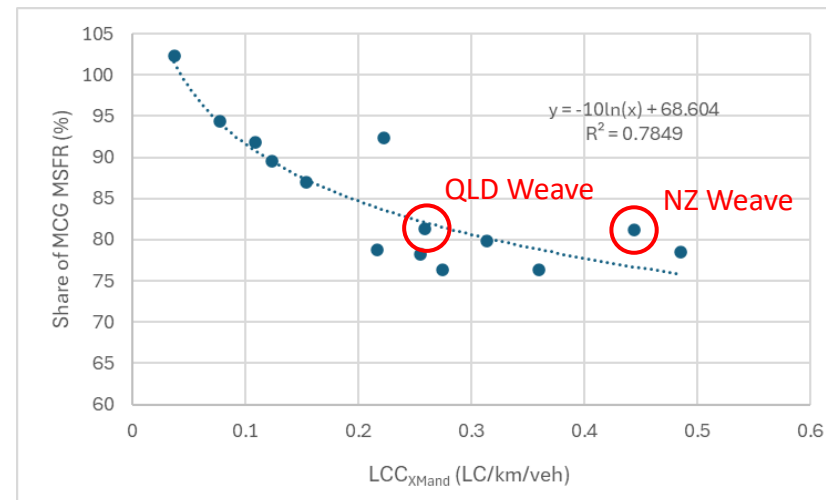
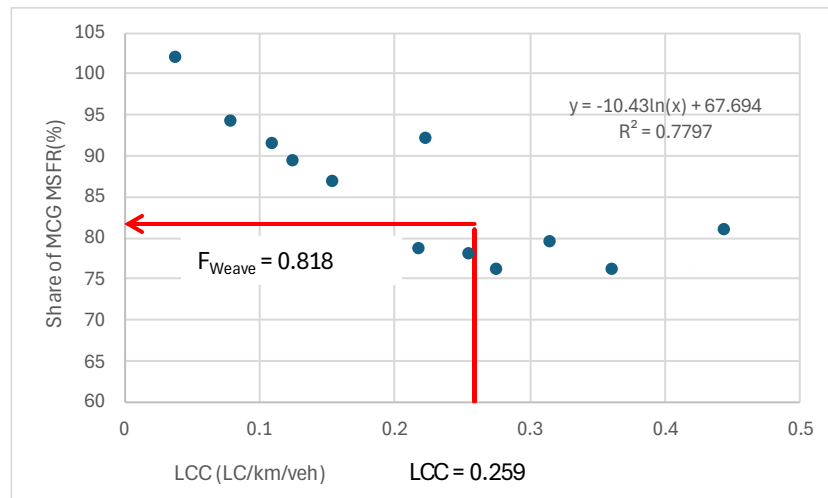
Overall, the new method performs better in combination with the MSFR concept!

Next Steps

It is planned to embed the new WARRIP project method into Main Roads guidance

Integration into Austroads guidance can happen as part of Austroads NEG6527 – AGTM Update – Motorway Capacity Analysis (undertaken by NTRO)

Weaving areas nominated by other jurisdictions can strengthen the findings (e.g. increase the Coefficient of Correlation and the statistical significance)



Thank You

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