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The Multimodal Safety with Longitudinal Homogeneity at Signalised Junctions– Looking at the Advance Stop Zone and Lane Design

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The prevalence of sideswipe collisions between motorbikes and cars in motorbike-dominated Asian cities underscores the need to suppress unsafety caused by the inhomogeneity of the flow—two modes with different operational characteristics travelling on the same carriageway. Given that motorbike ridership is higher than its car commuting counterpart, it is impractical to *physically* separate motorbikes and cars.

Achieving longitudinal homogeneity when with ASZ – Motorbikes can queue in front of cars
Source: Google Map (25.0192703,121.5469735)

Without ASZ – Motorbikes queue in between cars

Source: Google Map (13.7521425,100.5045116)

Advance Stop Zones (ASZs), allowing motorbikes to stop in front of car queues on red signals, are one of the most efficient measures to reduce motorbike-car collisions, and it has been deployed for decades for the following reasons:

- *Enhance the Chance of Being Seen:* Motorbikes in between cars may be in unsafe blind spots of vehicles, whereas ASZs allow motorbikes to appear in a visible position.
- *Offering Longitudinal Homogeneity*: Motorbike users are both motor vehicle users and vulnerable road users (VRU) as they are propelled by engines, meanwhile not designed with occupant-protecting by 'cages' (CROW, 2009). Hence, the homogeneity of the conventional sense cannot be offered. Instead, ASZ offers an alternative way of vehicle type homogeneity – motorbikes can creep between queued vehicles on red lights to reach the front of cars on red signals and discharge shoulder to shoulder with other motorbikes.

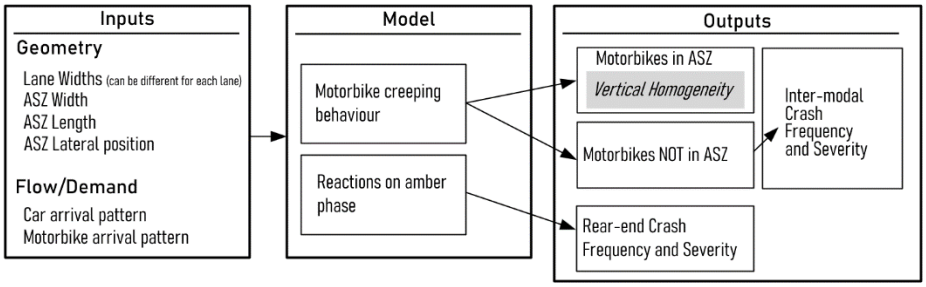
The fundamental difference between Motorbike ASZ and Cycle ASZ is offering *Longitudinal Homogeneity – human-propelled* pedal cycles in ASZ lose the relative front position once the *machine-propelled* cars discharge on the green phases. Yet, the motorbikes, with higher acceleration capability, can remain in the front position of cars if discharged from ASZ in urban signalised networks.

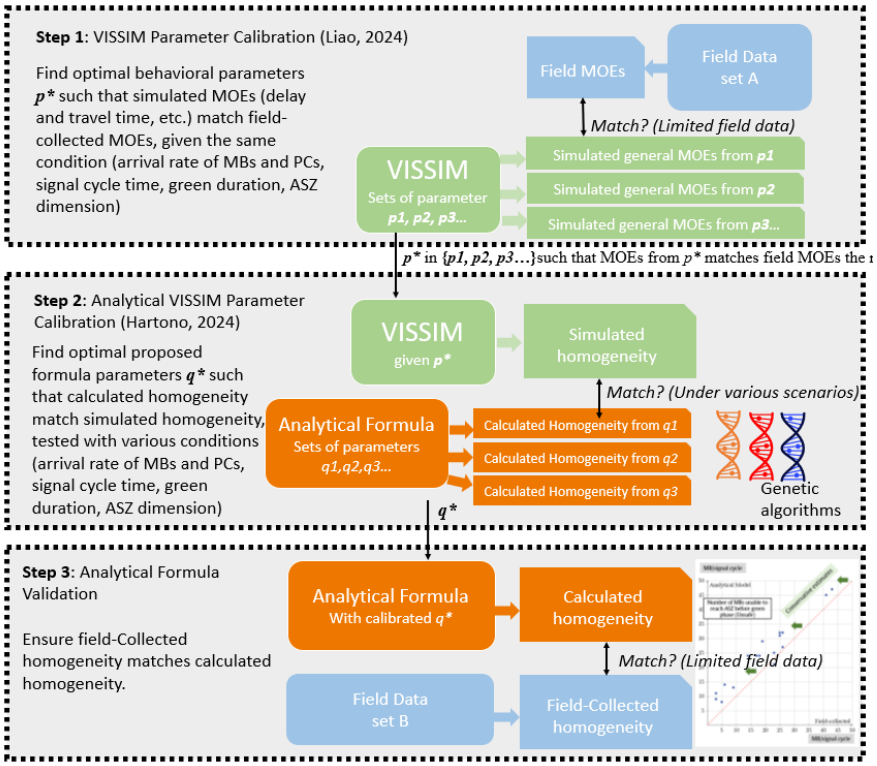
This study aims to enhance multimodal safety at signalled junctions. The research objectives are:

- To develop the complete framework of multimodal safety based on the problem nature with operational characteristics, but not merely regression research;
- To construct analytical models that can describe the number of motorbikes to arrive at ASZ before the signal transition from red to green phase.

- To construct models describing the design factors to enhance *Longitudinal homogeneity* can be achieved by motorbikes reaching ASZ;

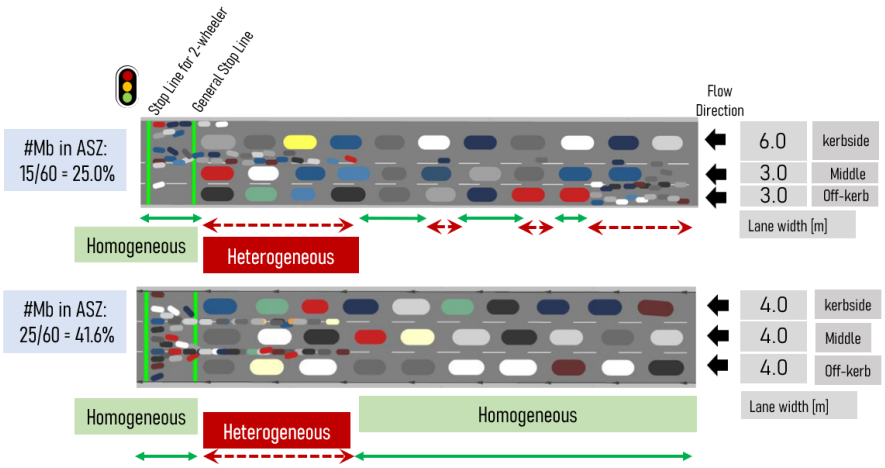
This study has developed the model framework with input factors and output regarding safety. The study's first phase is to investigate the effect of lane width design on *longitudinal homogeneity*.





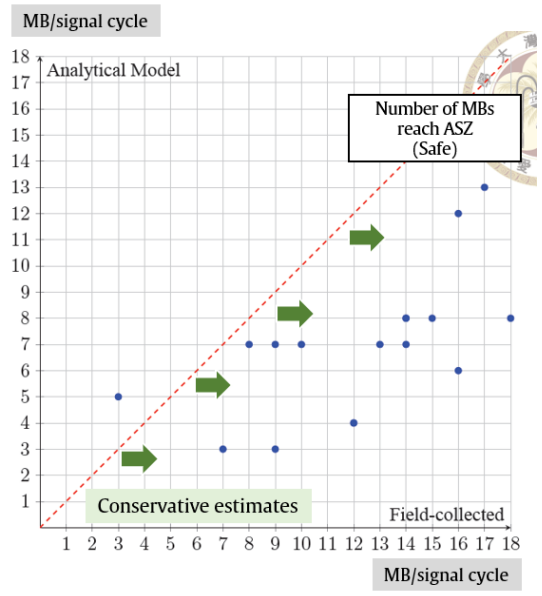
Since limited field data is possible, this study applied VISSIM simulations to expand the possible various scenarios covering the arrival rate of MBs and PCs, signal cycle time, green duration, and ASZ dimension, after calibrating from field data set A (see figure).

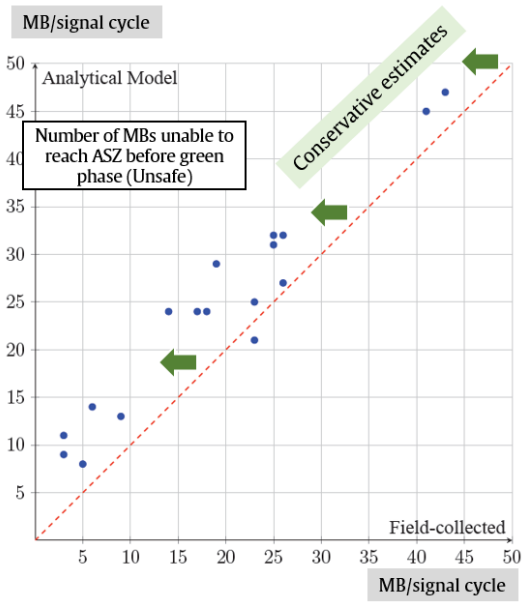
The figure shows one of the scenarios, and one can observe that the *longitudinal homogeneity* reaches 25.0% with the layout of (3.0,3.0,6.0) and can be better achieved (41.6%) with the layout of (4.0,4.0,4.0), defined by lane widths listed from the off-kerb to kerbside lane. With ten(10) replications with different random seeds and 24 cycles per replication of the same scenario, the average percentage of motorbikes in ASZ is



52.8% and 72.6%, respectively, for Layouts A and B. The equal lane widths suggest an outcome with better *longitudinal homogeneity* – this is a sharp contrast with the current design convention in Taiwan, where most engineers prefer a wider kerbside lane to serve motorbikes. A calibrated analytical model has been proposed in step 2 to capture such phenomenon in a compact form without extensive efforts via simulation.

	Lane width [m]			AVG percentage of Motorbikes in ASZ
	Off-kerb	Middle	kerbside	
Layout A	3	3	6	52.8%
Layout B	4	4	4	72.6%





Step 3 validates the proposed analytical formula and shows that the proposed analytical model is a conservative estimate of the field-collected data: the diagrams below show how the proposed analytical model (Hartono, 2024) can estimate *longitudinal homogeneity* by the number of MBs reaching ASZ, given the scenarios with the arrival rate of MBs, arrival rate of cars, signal cycle length, and green phase duration, as shown in the validated results.

Discussion: Although this study has preliminarily constructed the analytical model to estimate the *longitudinal homogeneity* with the number of MBs to arrive at ASZ before phases turn from red to green, this variable can only be regarded as a surrogate measure of safety (SMoS). Specifically, the relationship between achieving *longitudinal homogeneity* and resulting collision is still unclear in quantitative aspects. Data from a large sample of junctions may need to be further collected.

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