WARRIP

WESTERN AUSTRALIAN ROAD RESEARCH & INNOVATION PROGRAM

Understanding Filtered Right-turn Through Crashes at Traffic Signal Intersections

WARRIP 2022-011

18 September 2025

Acknowledgement of Country

I begin today by acknowledging the Traditional Custodians of the land on which we meet today and pay my respects to their Elders past and present. I extend that respect to Aboriginal and Torres Strait Islander peoples here today.

Welcome

About WARRIP

The Western Australian Road Research and Innovation Program is a joint initiative between Main Roads Western Australia and the National Transport Research Organisation.

The program has a strategic commitment to the delivery of collaborative research and development that positively contributes to the design, construction and maintenance of safe, sustainable transport infrastructure in Western Australia.

Agenda

1. Project background
2. Project Purpose, Objectives & Limitations
3. Project Approach
4. Project Tasks
5. Run Through Findings
6. Conclusions

Project Background

Background

- Filtered right-turn movements are used for:

1. Intersection Efficiency and Capacity
2. Flexibility for Low-Volume Right-turns
3. Road Design and Policy Considerations
    - Not always within site constraints.

- Filter right-turn crashes at signalised intersections:
    - one of the most dangerous intersection conflicts on the network
    - multiple complex factors for drivers

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Project Purpose, Objectives & Limitations

Project Purpose

Project Hypothesis

1. A major cause of right turn/thru crashes and near misses at signalised intersections at filtered right turns may be the **lack of driver's understanding** for negotiating this type of traffic signal.
2. Most of the crashes and near misses are **likely to occur at the late amber stage** of the signals.

Project Purpose

To understand the nature and timing of right turn/thru crashes at signalised intersections and how to potentially manage filtered traffic signals to minimise the risk of this crash type occurring.

Project Objectives

Objectives

- To examine right turn/thru crashes and near-miss incidents at signalised intersections under right turn filter control, with a view to improving the **understanding of factors contributing to crashes**, particularly at **what time in the signal phasing** they are most likely to occur.

Project Limitations

- Eight representative sites, with high crash history
- Site specifics always influence factors
- Sampling of timeframe and conditions, only
- Video capture of near-miss incidents, only
- No crash reconstruction

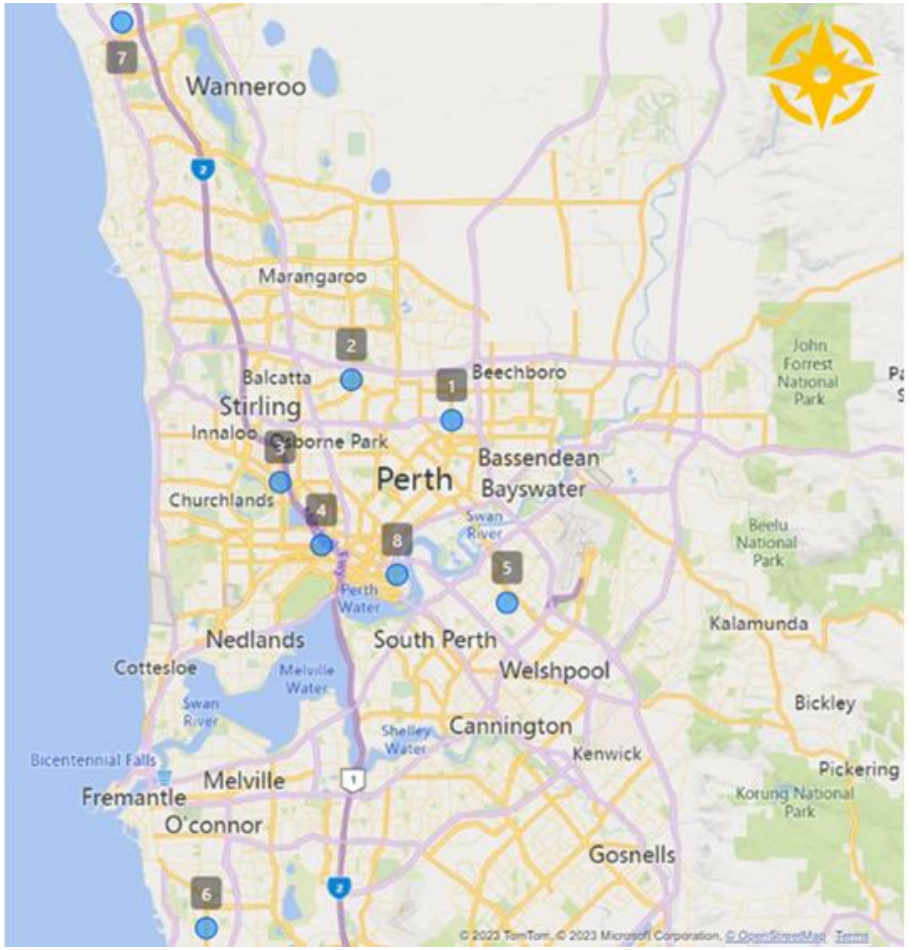
Project Approach

Project Approach

- Literature review
  - Jurisdictional guidance and practice
  - Data collection and analysis methods
- Field sampling and observation
  - Eight intersections around metropolitan Perth (next slide)
  - Subcontractor (Real Time Traffic (RTT))
    - Pilot site
    - Lessons applied to other seven sites
    - Surrogate safety measures – PET, TTC, Delta-V
    - Analysis dashboard

Project Approach - Sites

No.	Location	Suburb	Right turn arrangements
1	Karrinyup-Morley Rd/Crimea St.	Morley	Filter right turn on all approaches
2	Mirrabooka Ave/Ravenswood Dr/Yirrigan Dr.	Nollamara	Filter right turn on all approaches
3	Harborne St/Scarborough Beach Rd/Frobisher St.	Osbourne Park	Combination of filter right turn and partially controlled filter right turn
4	Southport St/Cambridge St.	West Leederville	Combination of filter right turn and partially controlled filter right turn
5	Belmont Ave/Wright St.	Kewdale	Combination of filter right turn and partially controlled filter right turn
6	Spearwood Ave/Rockingham Rd	Spearwood	Combination of filter right turn and partially controlled filter right turn
7	Connolly Dr/Selkirk Dr.	Kinross	Combination of filter right turn and partially controlled filter right turn
8	Plain St and Royal St. (**Pilot study site**)	East Perth	Filter right turn on all approaches



Project Approach – Data Collection Plan

Item	Data collection component	Arrangement	Comments/Notes
1.	Site installation	• 2x Realite Safety Cameras (RSC): – solar battery powered – local and cloud-based data storage – 4G communications link.	• Traffic control signal lanterns to be within RSC field of view to observe signal phasing. • RSC to capture vehicle categorisation, driver hesitance and conflict analysis.
		• 2x Automatic Traffic Counters (ATC).	• ATC used to 'ground-truth' video survey data (speed – mean and 85th%, vehicle classification, volume).
		• Appropriate approvals from MRWA/LGA required	•
2.	Survey period	• Four 'typical traffic' days of data collection for each site. • 16 hours of observations per day, 6 am to 10 pm.	• Days to include weekends and week days, but not public/school holidays. • Fine weather days
3.	Video imagery	• Colour • Personal identifiable information pixelated for privacy.	
4.	Video analytics - Near-miss detection criteria	• Surrogate safety measures: – Post Encroachment Time (PET) – Time to collision (TTC) – Delta-V, a measure of severity – Stop line Compliance – Lane positioning – Time Headway. • Road user traffic unit combinations. • Classified traffic counts. • Traffic speed • MRWA RUM code to describe detectable incidents.	• Surrogate safety measures for detected incidents form output of site surveys and inputs for data analysis as part of risk factor assessments. • Road user combinations include – pedestrian/light passenger vehicles (LPV), – bicycle/truck, – LPV/LPV – bus/truck, etc.
5.	Site traffic set-up	• Information about the set-up for each of the nominated locations.	• Assist in identifying risk factors

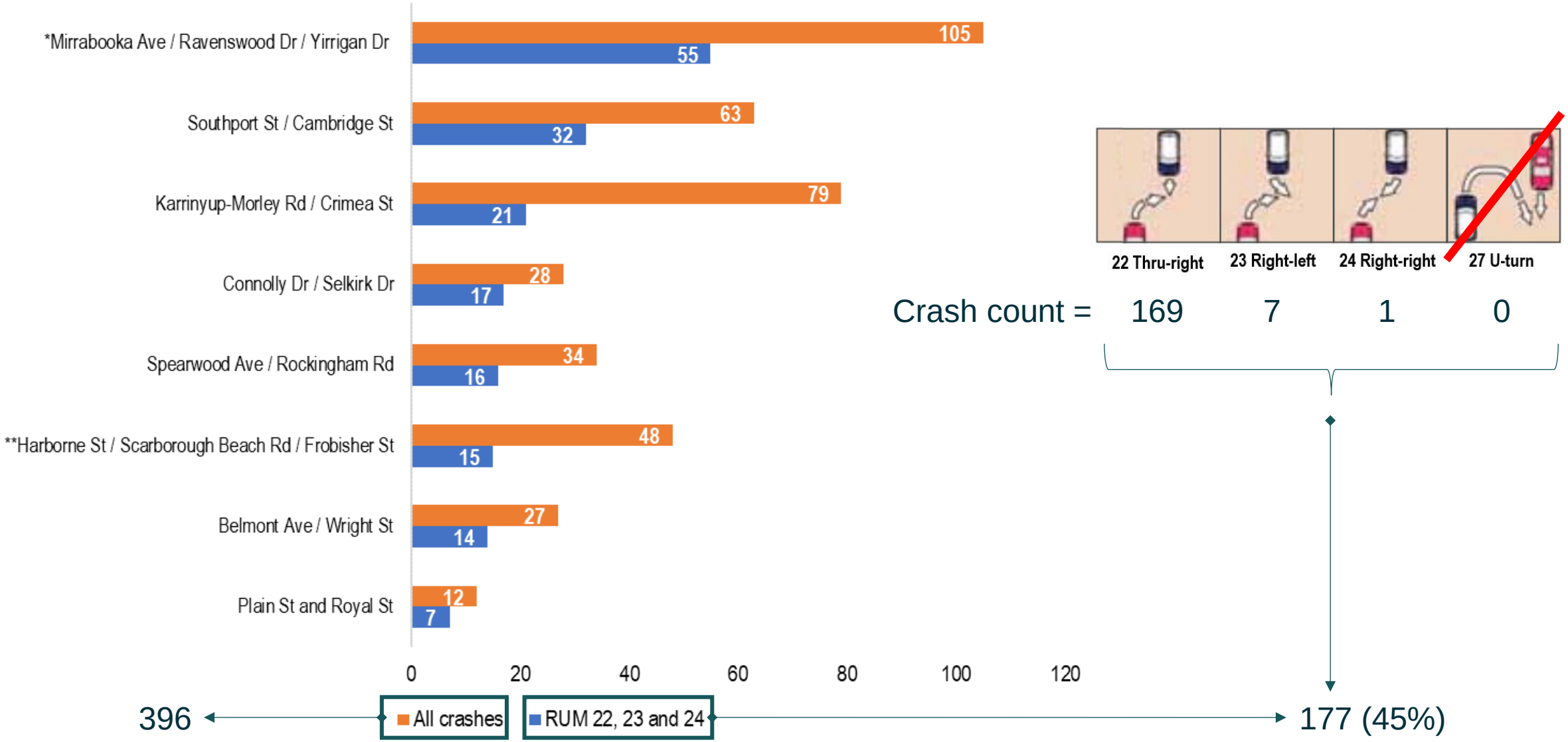
Project Approach – Analysis Method

Analysis	Arrangement	Comments/Notes
Frequency and Distribution Analysis		
Road User Combinations and Signal Colours	• histogram road user combination	This function calculates the frequency of different types of road users involved in traffic conflicts (e.g., 'Car-Car', 'Car-Bike'). It then generates a histogram to visualize these frequencies, making it easy to identify the most common types of conflicting road users.
	• frequency traffic signal color	This function analyses the frequency of traffic signal colours ('Red', 'Yellow', 'Green') at the time of right-turn incidents. A bar plot is created to display these frequencies, which can help in identifying potential issues related to signal compliance or timing
Speed and Safety Metrics (TTC and PET)	• histogram speed user	This function generates histograms of vehicle speeds for both right-turning and opposing traffic. This allows for a direct comparison of their speed distributions and helps in understanding the speed dynamics at the time of the conflict.
	• kde TTC PET	A Kernel Density Estimation (KDE) plot is created for Time to Collision (TTC) and Post Encroachment Time (PET). KDE plots are used to visualize the probability density of these critical safety metrics. The script also includes vertical lines at 1.5 seconds on these plots, a commonly used threshold to distinguish between high-risk and low-risk events.
	• hist PET TTC 1 • hist PET TTC numbers • hist PET TTC with percentage	These functions create detailed histograms for PET and TTC with 0.25-second intervals. These plots provide a more granular view of the distribution of these metrics and can display either the absolute counts or the percentage of events in each bin. A vertical line at the 1.5-second threshold is also included for easy identification of high-risk events.
Crash Severity Indicators (Delta V and Kinetic Energy)	• plot delta v histogram	This function generates a histogram of Delta V (the change in velocity during a crash). Delta V is a key indicator of crash severity, and its distribution can provide insights into the potential for injury.
	• KE histogram numbers • KE histogram percentages	Histograms of Kinetic Energy (KE) are created for both the right-turning and opposing movements. This analysis helps in assessing the potential severity of a crash by visualizing the energy involved.

Project Approach – Analysis Method

Analysis	Arrangement	Comments/Notes
Relationship and Correlation Analysis		
Relationship between PET and TTC	• scatter plot PET TTC numbers • scatter plot PET TTC percentages	These functions generate scatter plots to visualize the relationship between PET and TTC. Events where both PET and TTC are below the 1.5-second threshold are highlighted as 'hazardous situations'. The plots also provide a quantitative measure of these high-risk events, either as a total number or as a percentage of all events.
	• plot PET TTC scatter interactive	For a more dynamic exploration of the PET vs. TTC relationship, this function creates an interactive scatter plot using plotly.express. This allows for hovering over individual data points to get more detailed information about each event.
Relationship between Kinetic Energies	• plot kinetic energy relationship • plot kinetic energy relationship normalised	These functions create scatter plots to visualize the relationship between the kinetic energies of the two conflicting vehicles. The total kinetic energy of the event is represented by a color gradient, providing a quick visual assessment of the potential crash severity.

Project Approach – Site Crash History



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Project Tasks

Project Tasks

- ✓ Task 1 - Inception meeting with Main Roads PM
- ✓ Task 2 - Economic Benefit Preliminary Analysis
- ✓ Task 3 - Table of contents
- ✓ Task 4 - Literature Review
- ✓ Task 5 - Data Collection Plan and Analysis Methodology
- ✓ Task 6 - Undertake Data Survey and Data Collection
- ✓ Task 7 - Data Analysis
- ✓ Task 8 - Project Report
- ✓ Task 9 - Project Presentation
- ✓ Task 10 - Economic Benefit Analysis
- ✓ Task 11 - Project Summary

Run Through Findings

Near Miss Incident Frequency and Time-of-day

Figure 5.1: Right-turn/through near-miss frequency – by site

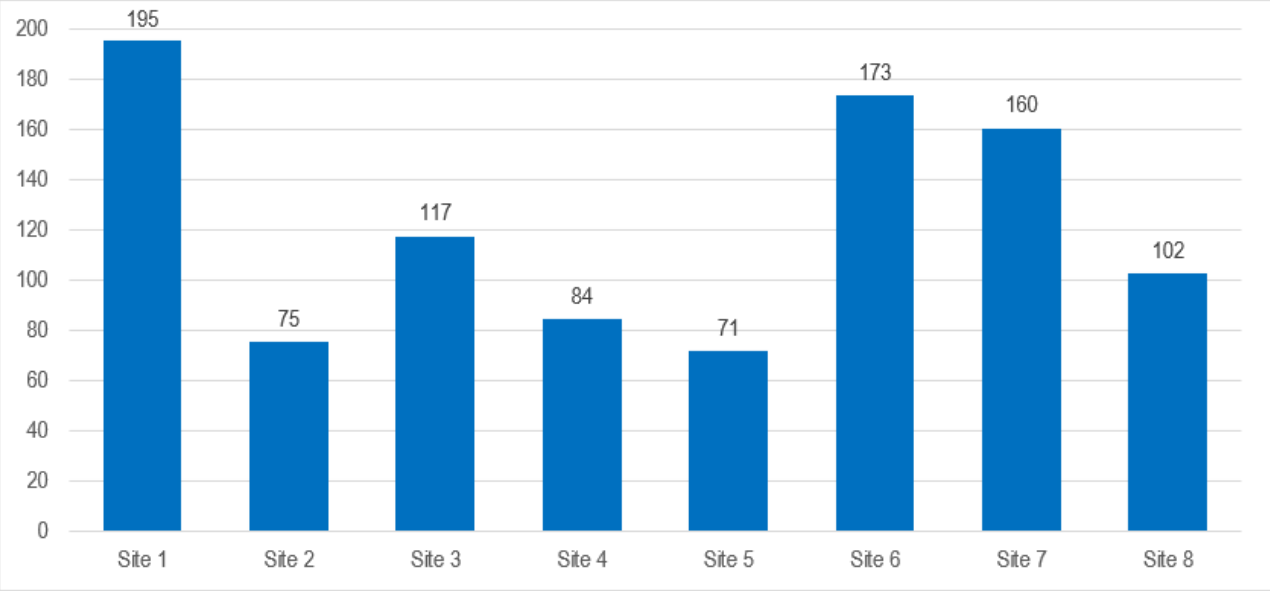
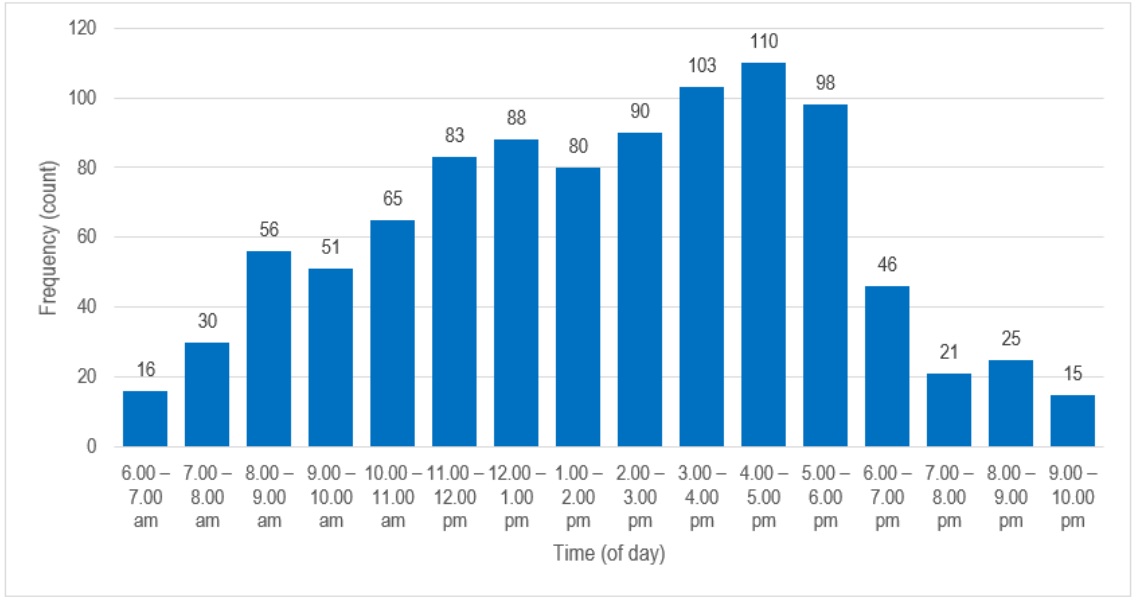
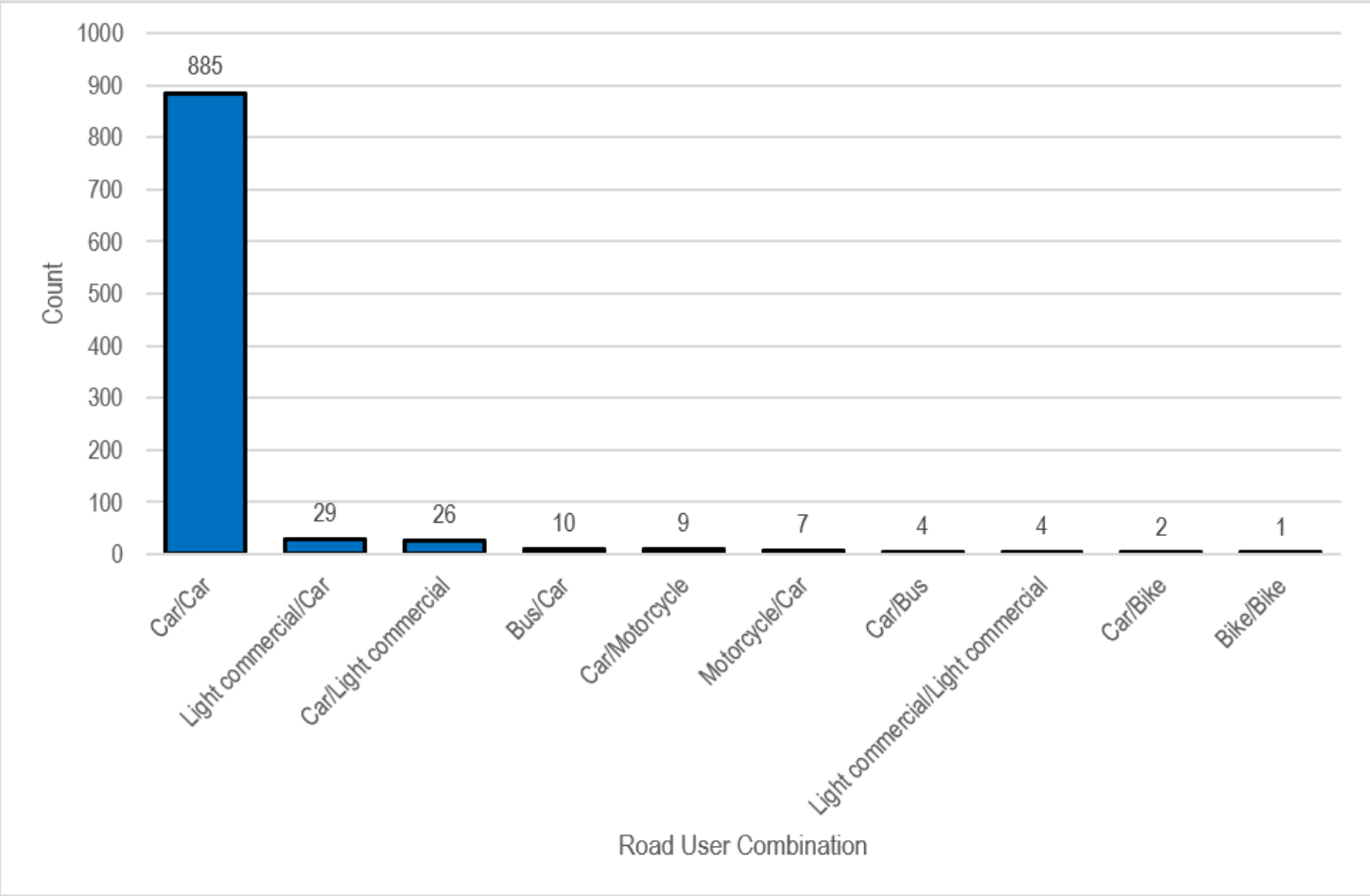


Figure 5.2: Right-turn/through near-miss frequency – by time of day



Road User (Vehicle) Combinations

Figure 5.3: Frequency of road user combination in filter right-turn near-miss incidents



Note: First listed vehicle is turning right; second listed vehicle is the opposing movement

Movement Speed Profiles

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Table 5-1: Speed data for each site – right-turn movement

Site no.	Count	Min of Speed (km/h)	Max of Speed (km/h)	Average of Speed (km/h)	StdDev of Speed (km/h)
Site 1	195	8.31	38.52	17.37	4.83
Site 2	75	11.34	35.50	23.56	4.95
Site 3	117	10.74	32.47	22.89	5.10
Site 4	84	12.54	28.70	20.95	3.42
Site 5	71	8.75	59.03	22.74	8.92
Site 6	173	7.73	57.29	21.19	6.92
Site 7	160	9.05	56.44	31.10	9.45
Site 8	102	15.68	38.49	26.56	5.14
Total	**977**				

Table 5-2: Speed data for each site – opposing movement

Site no.	Count	Min of Speed (km/h)	Max of Speed (km/h)	Average of Speed (km/h)	StdDev of Speed (km/h)
Site 1	195	15.21	75.99	52.50	10.99
Site 2	75	31.63	78.62	57.98	9.20
Site 3	117	24.73	78.25	53.42	10.03
Site 4	84	28.11	63.02	50.08	8.18
Site 5	71	13.83	86.48	56.26	15.42
Site 6	173	17.00	81.34	54.18	15.65
Site 7	160	13.87	80.60	54.65	9.51
Site 8	102	11.42	99.80	57.73	30.26
Total	**977**				

Movement Speed Profiles

Figure 5.5: Frequency of speed bins for right-turn movement vehicles

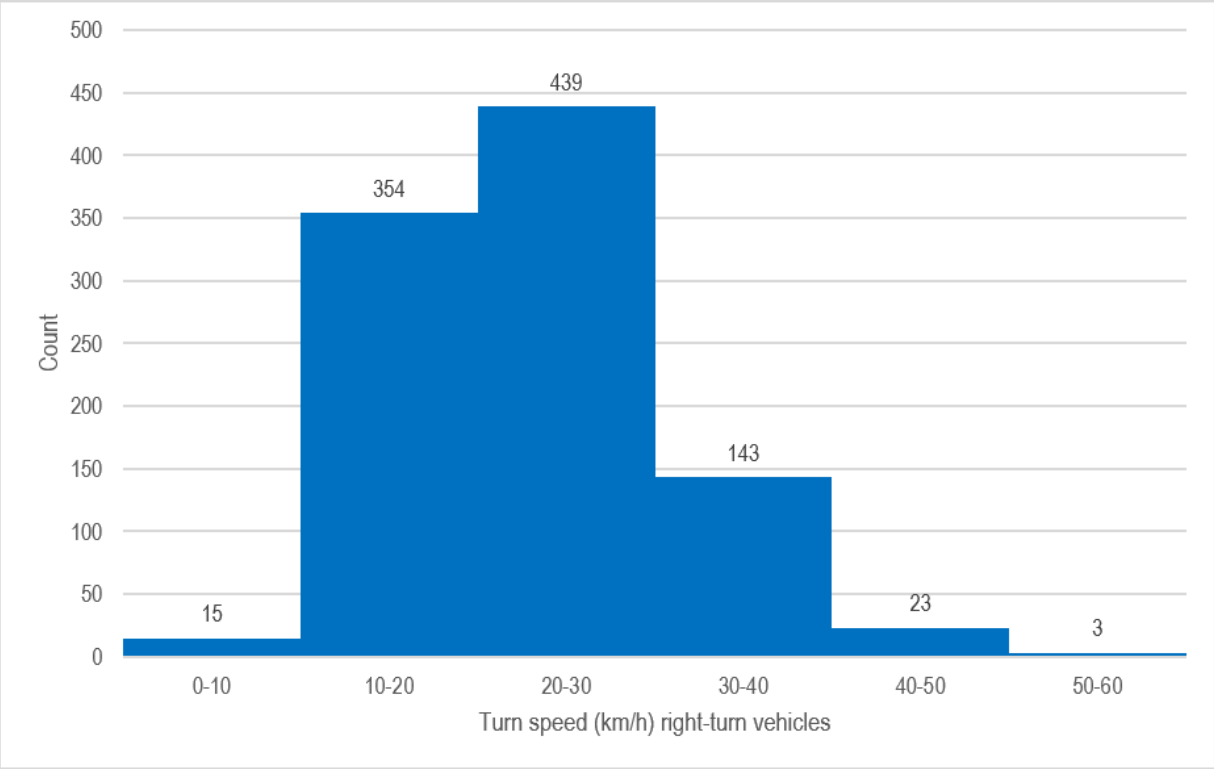
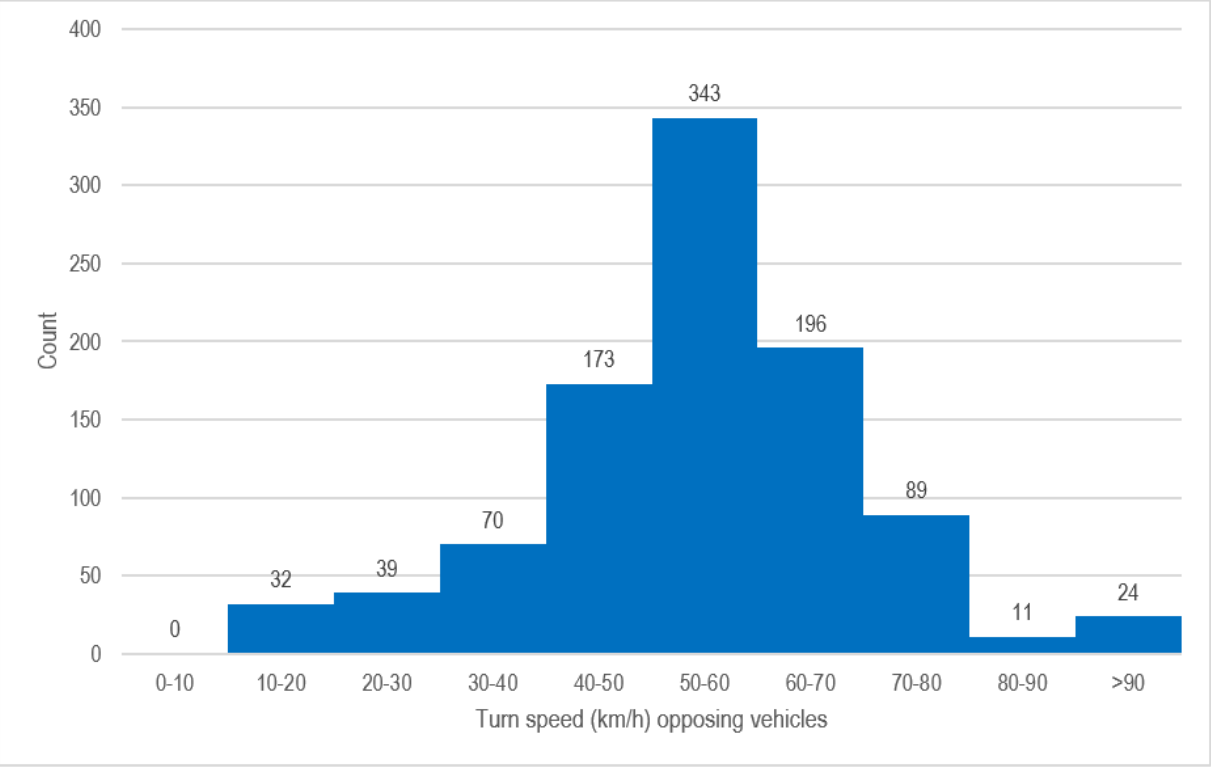
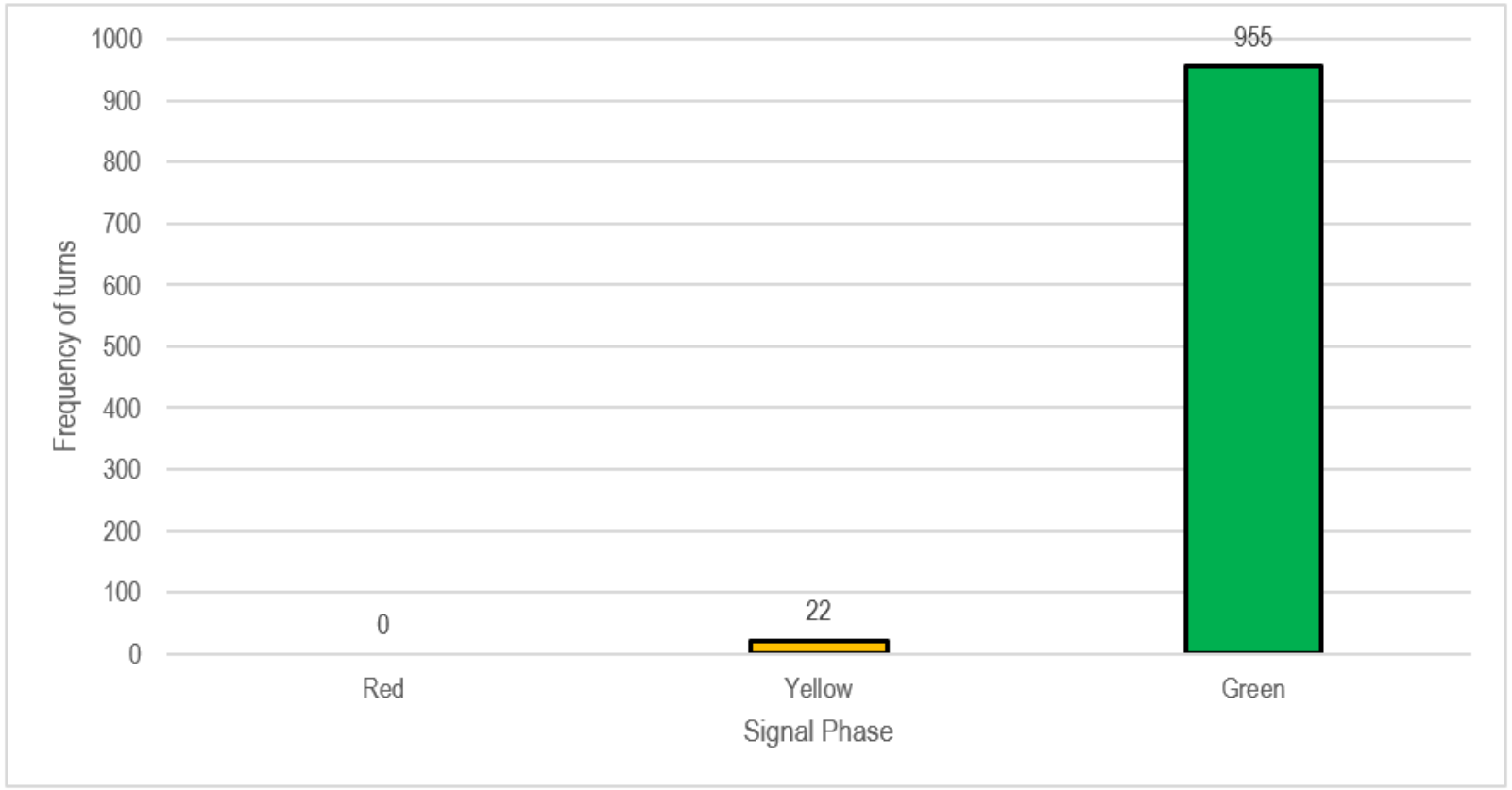


Figure 5.6: Frequency of speed bins for opposing movement vehicles

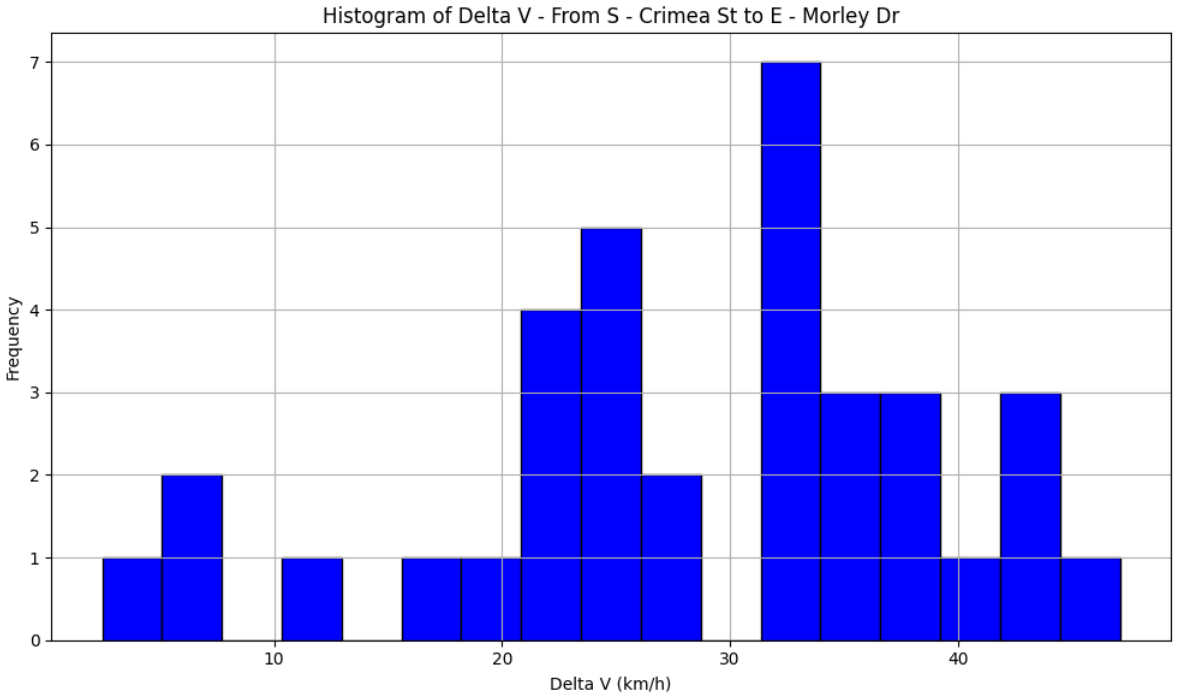


Timing in Signal Phasing

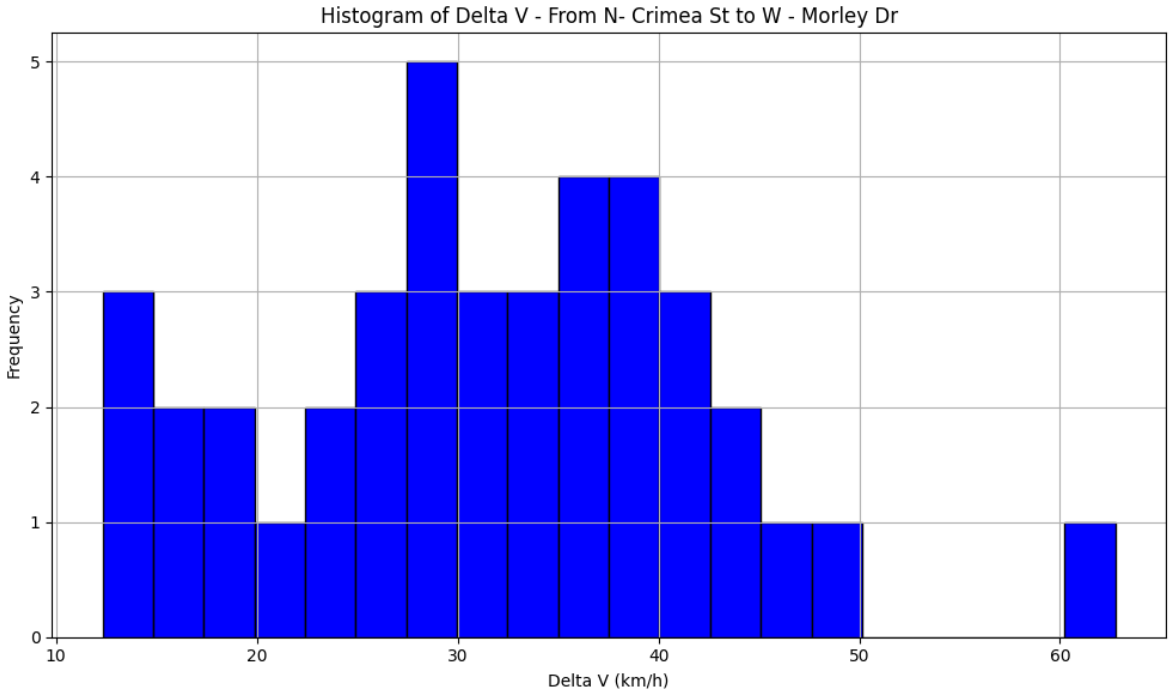
Figure 5.4: Frequency of right-turns in signal phase



Delta-V

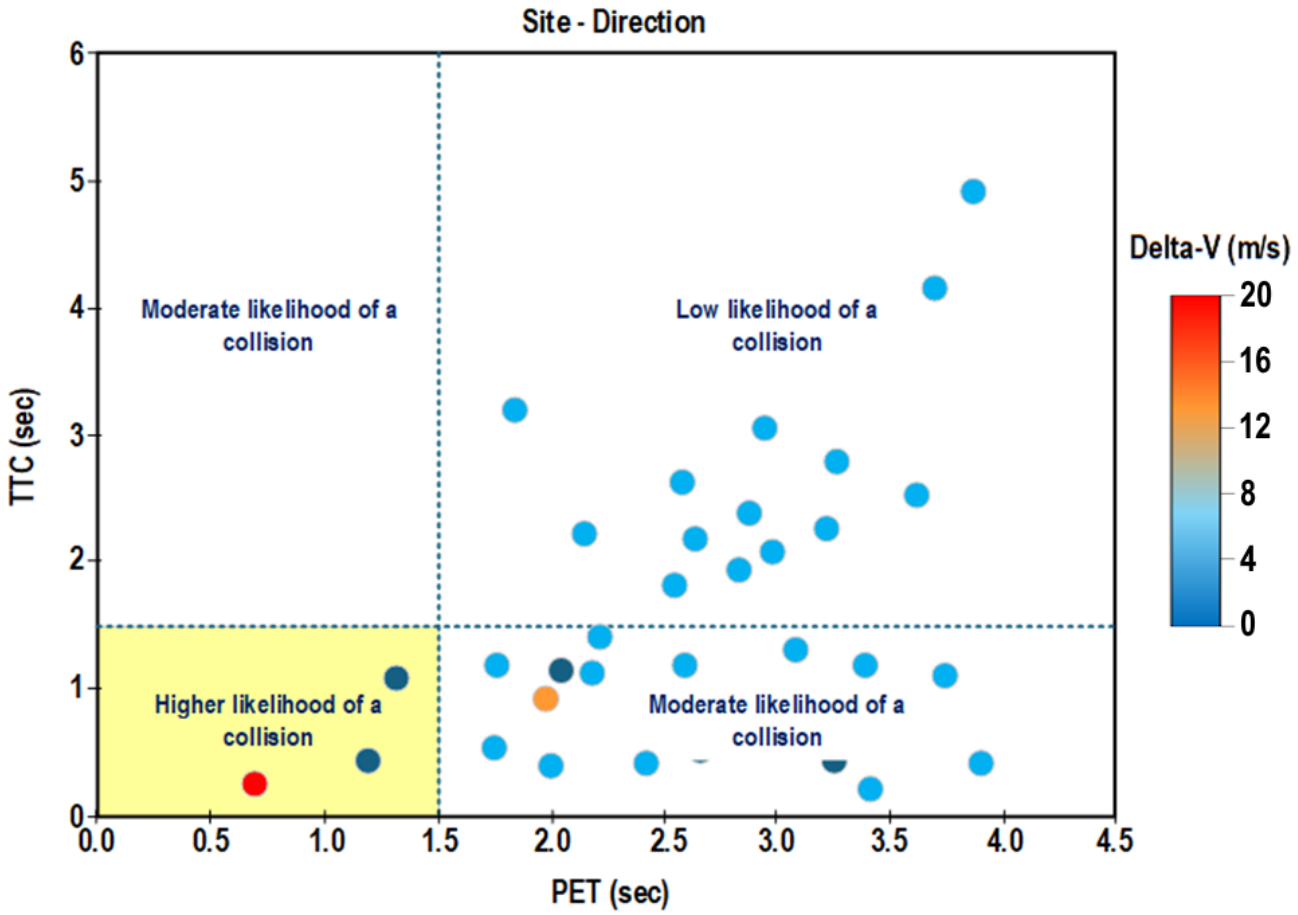


Karrinyup-Morley Rd Crimea St



Karrinyup-Morley Rd Crimea St

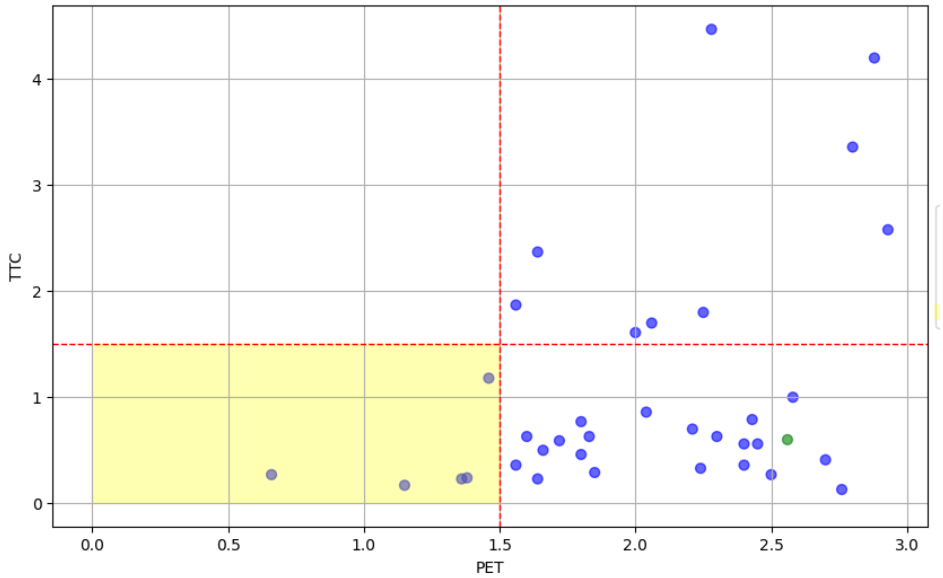
Crash Likelihood/Severity

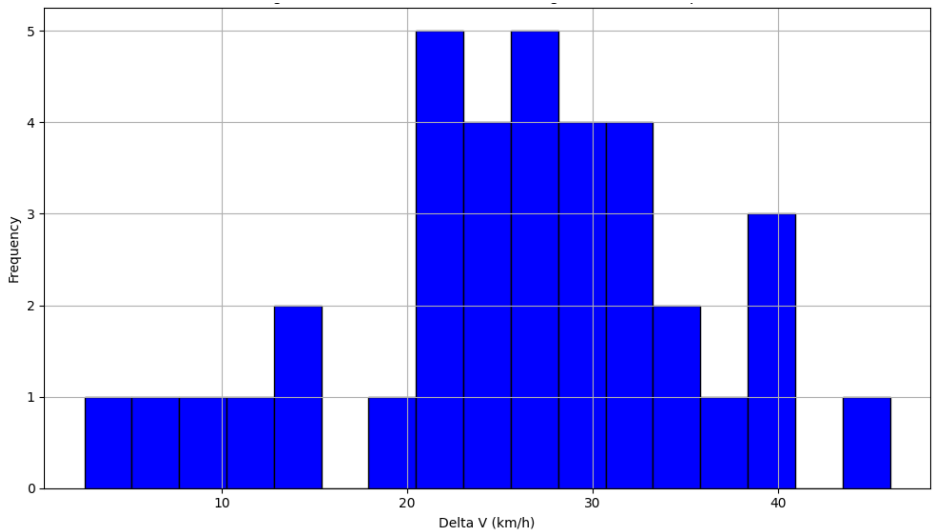


- PET v TTC provides indication of crash likelihood
- Delta-V indicates crash severity
  - higher delta-v = higher severity outcomes

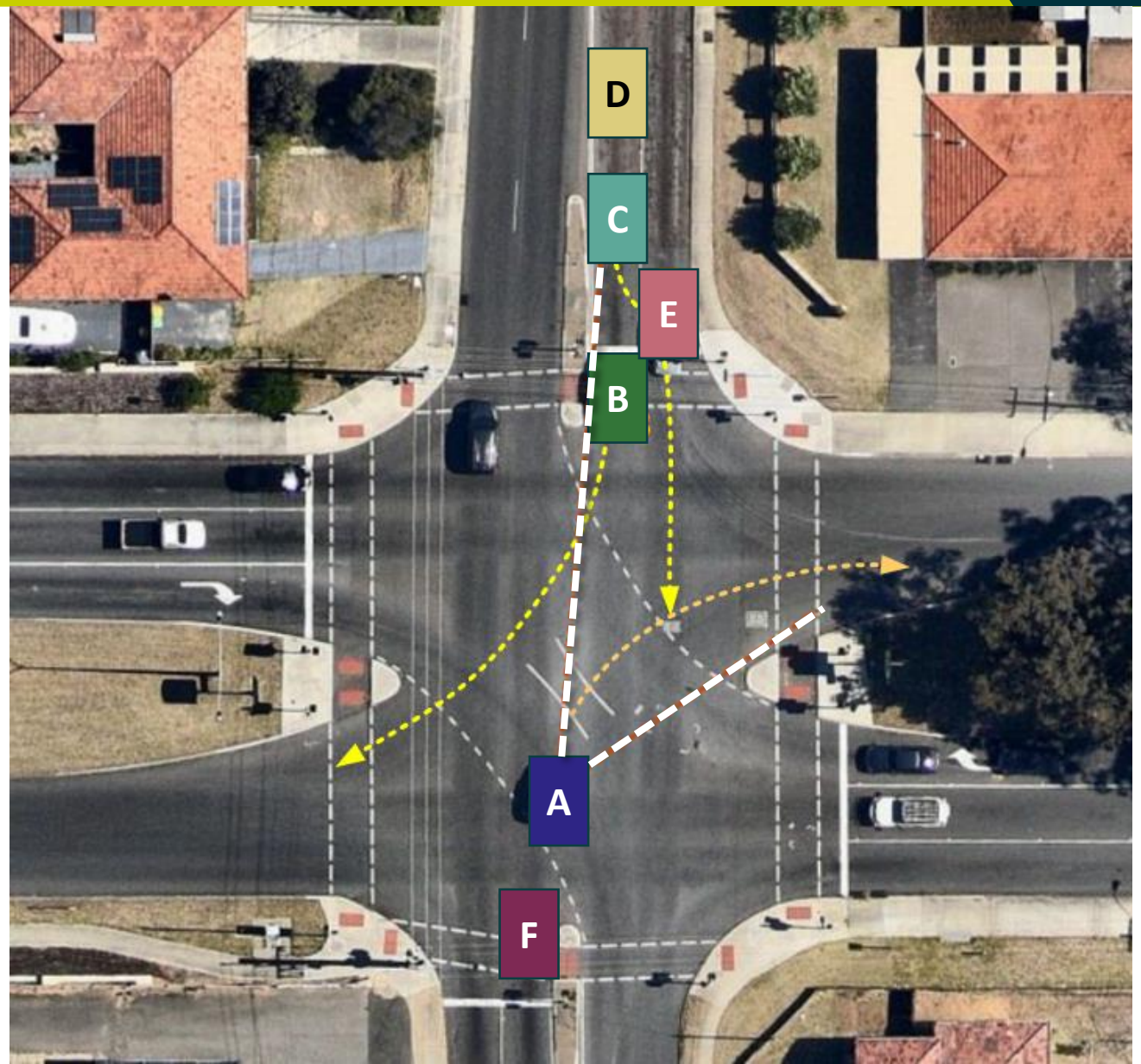
Key Analysis Observations

- Turning vehicles were slower, but through movements exceeded the accepted Safe System speed threshold of 50 km/h.
- A low number of near-miss incidents fall into the *'higher likelihood of a collision'* category range.
- Majority of all near-miss incidents had a delta-v value exceeding 30 km/h.

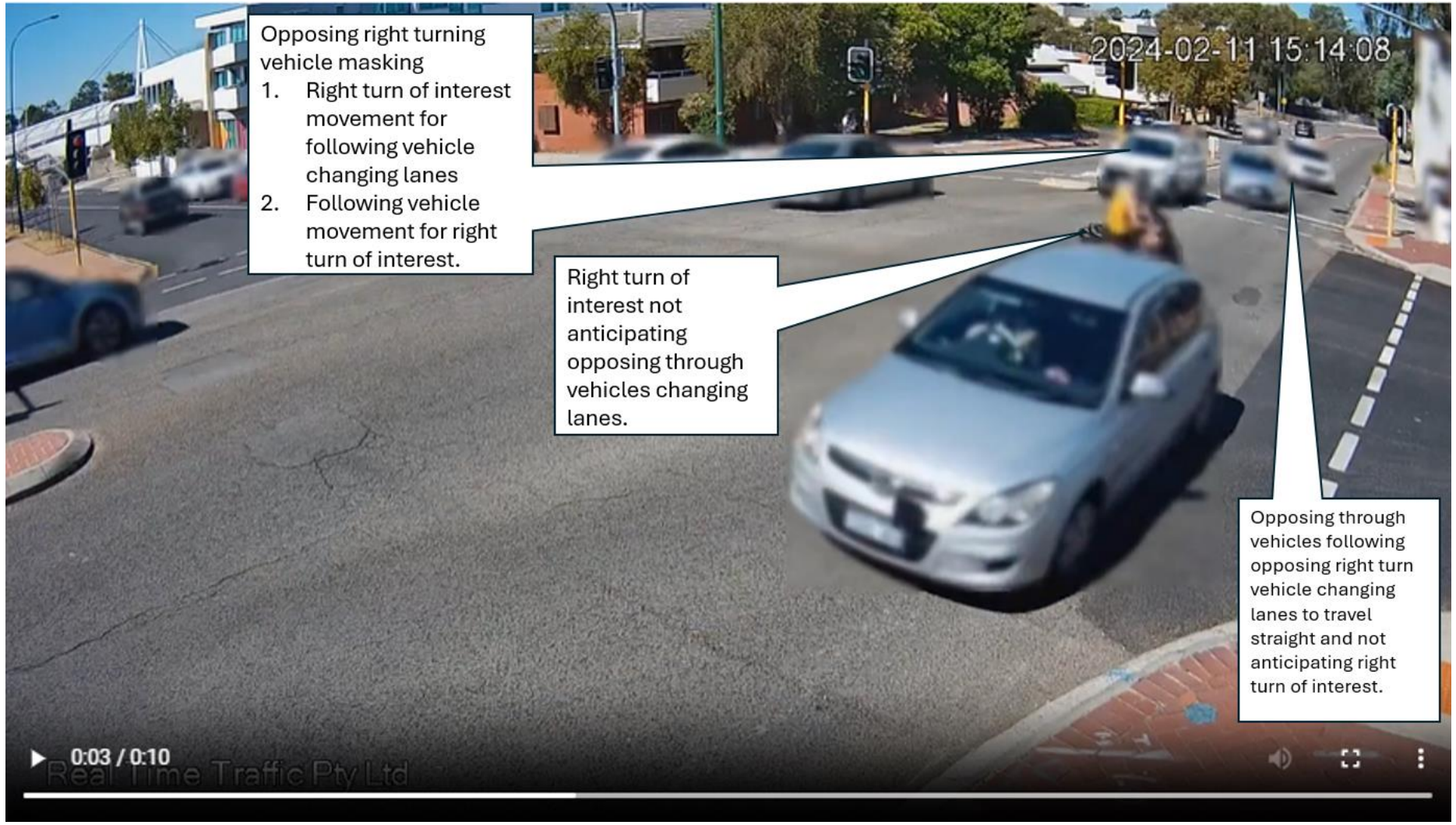




Dynamic Visual Obstruction (DVO)



Near-miss Observations - DVO



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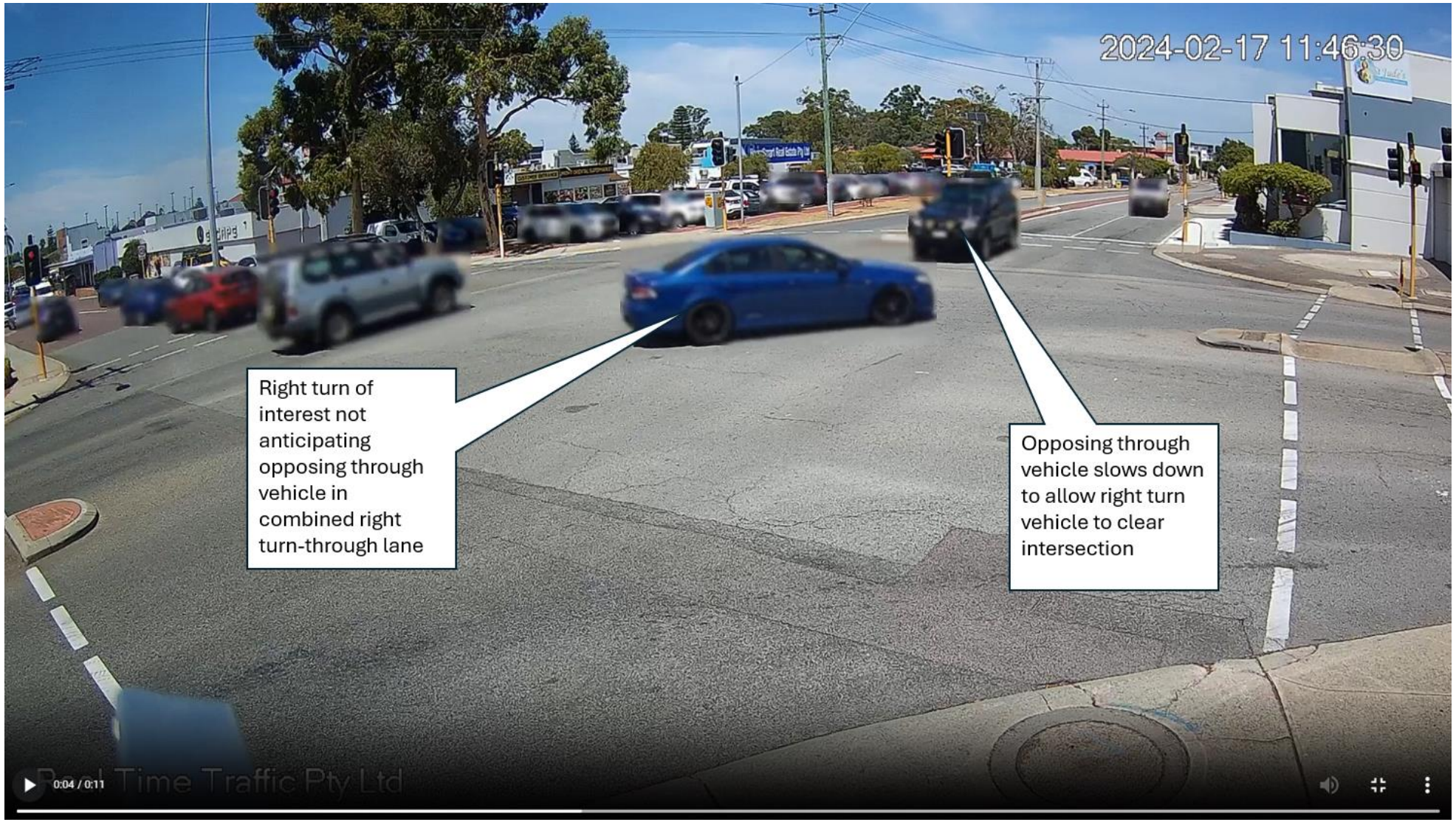

Conclusions

Overall Contributing Factors

- Permitting right-turns to occur by filtering through opposing traffic without a temporal separation.
- Permitting both right-turn and through movements from the one from lane since right-turn drivers waiting for a safe gap in the opposing through traffic create:
  - an obstruction to the lines of sight for opposing right-turn drivers
  - an obstruction to lines of sight to opposing through traffic following behind the opposing right-turn vehicles
  - a delay to following through traffic.

Suggested Risk Mitigation Measures

- Eliminating filter right-turn manoeuvres through re-phasing traffic signals
- Altering traffic arrangements at priority intersections
- Measures to improve lines of sight for drivers in stacked right-turn traffic
- Reducing speed in the through traffic stream

Suggested Risk Mitigation Measures

- Eliminating filter right-turn manoeuvres through re-phasing traffic signals
- Altering traffic arrangements at priority intersections
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- Reducing speed in the through traffic stream

Additional suggestions:

- Additional insights could be obtained using real-world crashes
- Adopt a Safe System Crash Review process

NOTE: THIS SLIDE IS A COMBINATION OF THE PREVIOUS AND NEXT AND WAS INTENDED TO BE PRESENTED AS SUMMARY BEFORE THE PROJECT BACKGROUND

Additional Suggestions (Next Steps)

- Additional insights could be obtained using real-world crashes
- Adopt a Safe System Crash Review process

Questions and Discussion