Ipswich Connected Vehicle Pilot

C-ITS component of the Cooperative and Automated Vehicle Initiative

Preliminary Findings for Safety Evaluation and User Perception

Dr Michael Pascale and Dr Mohammed Elhenawy, Queensland University of Technology

Dr Merle Wood and Jack Pinnow, Department of Transport and Main Roads (Queensland)

David Alderson, WSP

MAIC Motor Accident Insurance Commission

iMOVE

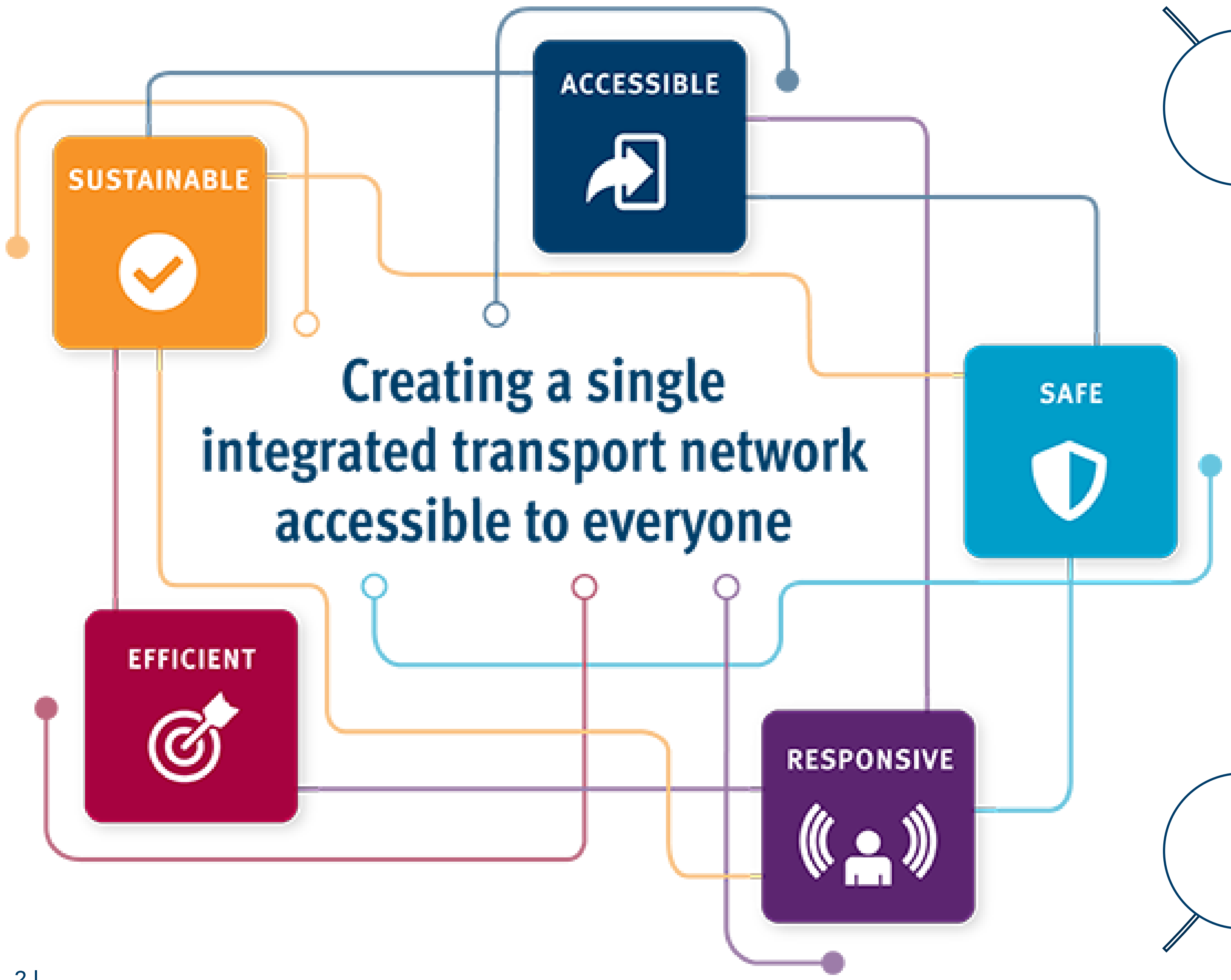
QUT

City of Ipswich

Australian Government
Department of Infrastructure, Transport, Regional Development and Communications

Queensland Government

Overview



- 3.33 million face-to-face transactions in our Customer Service Centres
- 5.45 million Queensland registered vehicles
- 2.48 million go cards used in South East Queensland
- 356.8 million tonnes of cargo moved through 21 declared ports
- 1.7 million passenger trips provided through the Taxi Subsidy Scheme.

Cooperative and Automated Vehicle Initiative (CAVI)

Make **roads safer** and contribute towards the Queensland Government's vision of **zero road deaths and serious injuries** on Queensland roads

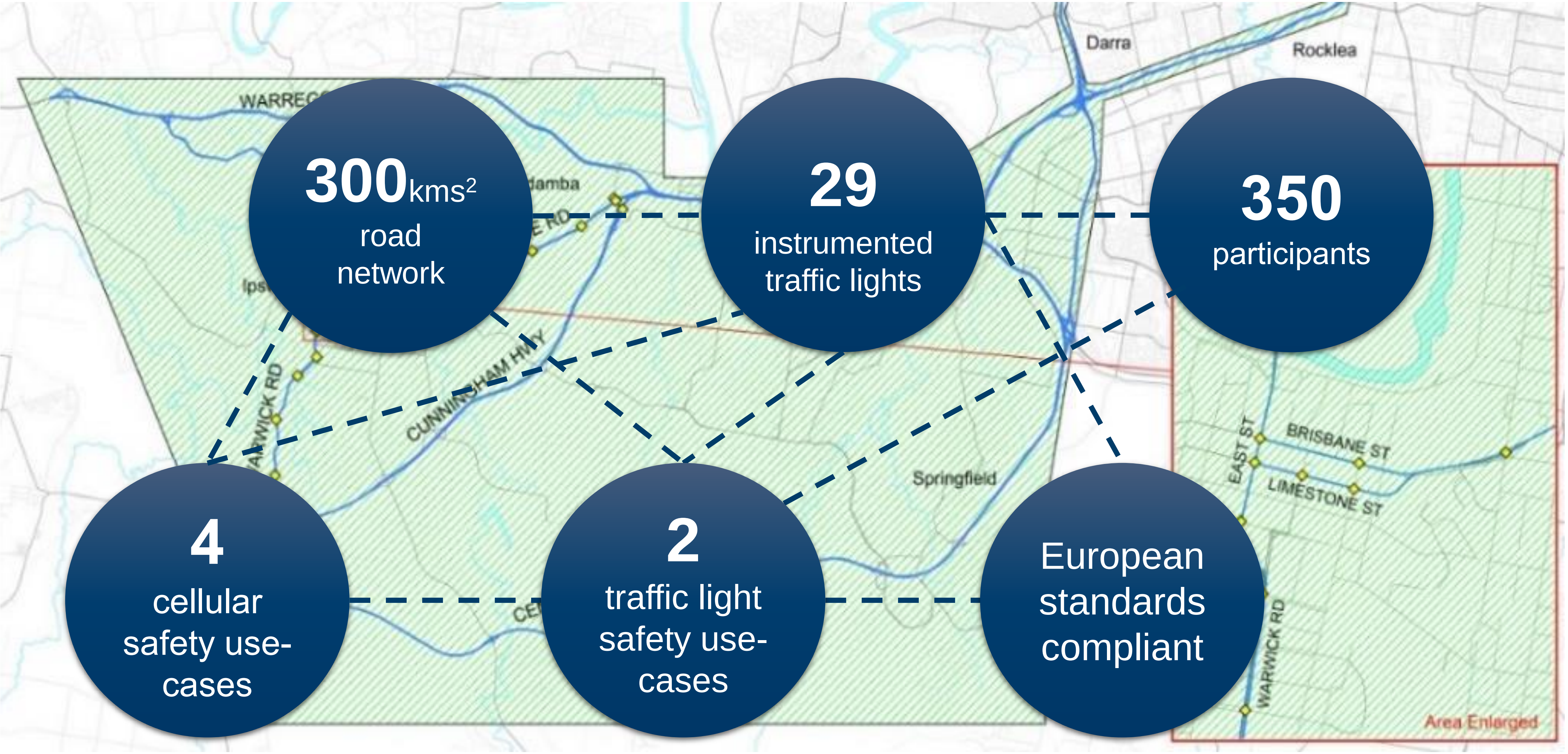
Validate the safety impacts and benefits

Demonstrate technologies and build public awareness

Encourage partnerships and build capability

Grow the department's readiness

Ipswich Connected Vehicle Pilot (ICVP)



300kms^2 road network

29 instrumented traffic lights

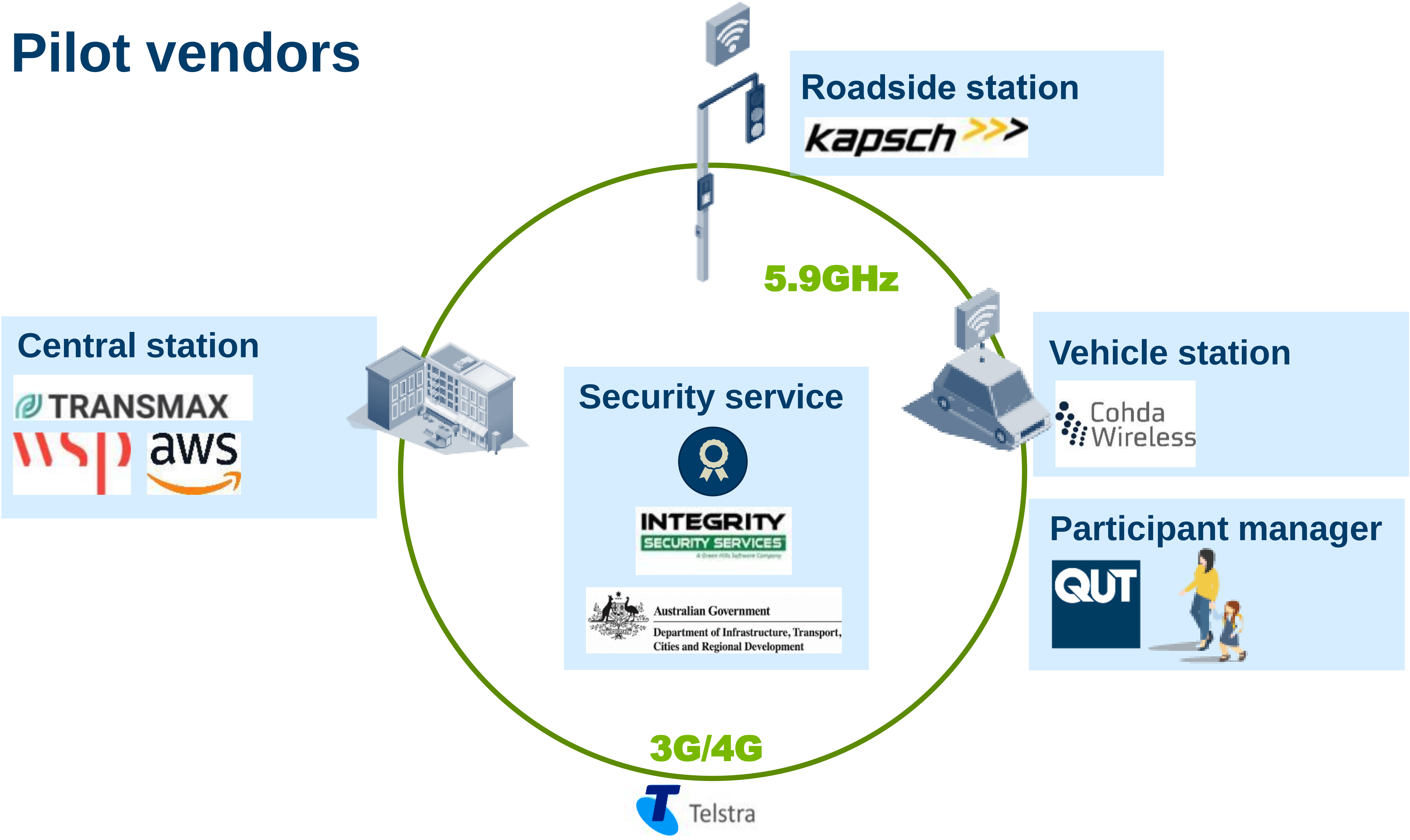
350 participants

4 cellular safety use-cases

2 traffic light safety use-cases

European standards compliant

Pilot vendors



Pilot safety use cases

Advanced Red Light Warning

Road Hazard Warning

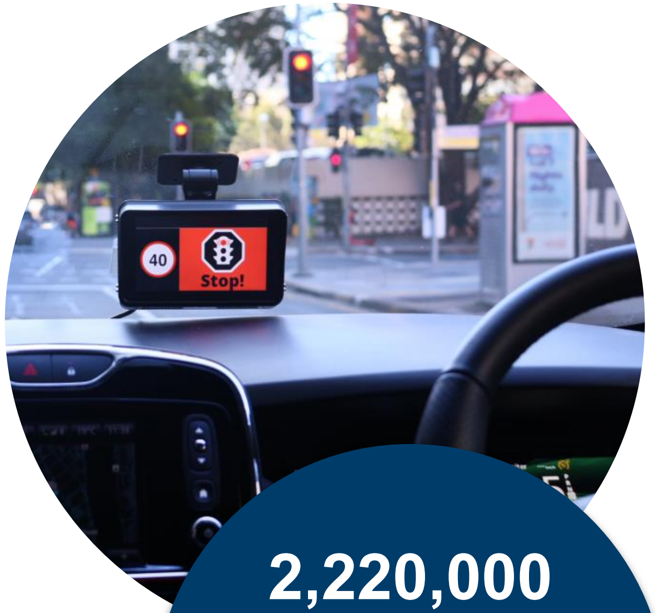
Back of Queue

Turning Warning Vulnerable User

In-Vehicle Speed

Road Works Warning

Pilot statistics



2,220,000
kms travelled
48,000
hours
Ave 3 hrs/wk

Messages published*

*by Transport and Main Roads (TMR)

Messages published*	Message	"heads up"	"take action"	Action
≈10Hz	Red Light	51800	5500	Stop!
≈10Hz	Turning Warning Vulnerable User	12900		
2500	Road Works	5800	13900	Reduce Speed
2000	Road Hazard	500		
45800	Motorway Back of Queue	5000		

User perceptions and safety evaluation

Research questions:

1. Does the system improve road safety?
2. Is the system acceptable to drivers?

Safety impact	**User acceptance**
Central, roadside and vehicle stations (12 months)	Questionnaires (4) Interviews (3 rounds of *n*=15-20)
Driving data and messages	User ratings

Participant conditions

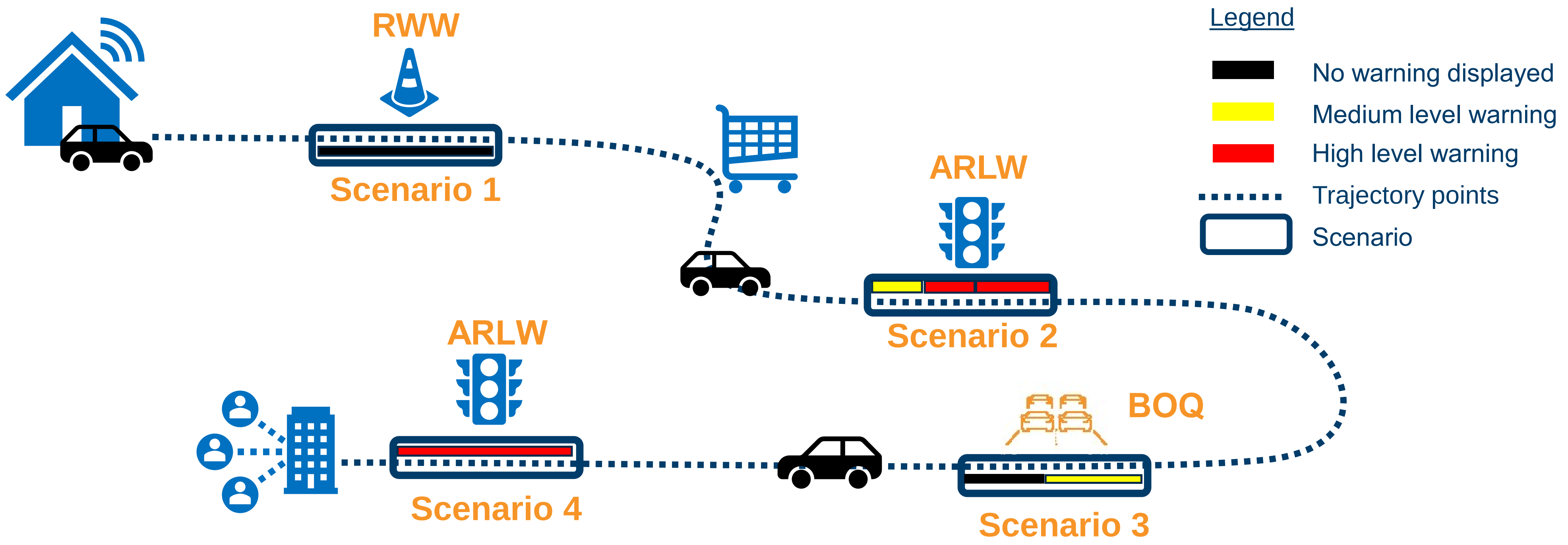
Control – Equipment installed, but warnings never active
***n* = 35** (excluding optional 2 active weeks at the end of participation)

TreatmentFirst - Equipment *active for 180 days* and then *inactive for 90 days*
***n* = 160**

BaselineFirst – Equipment *inactive for 90 days* and then *active for 180 days*
***n* = 154**

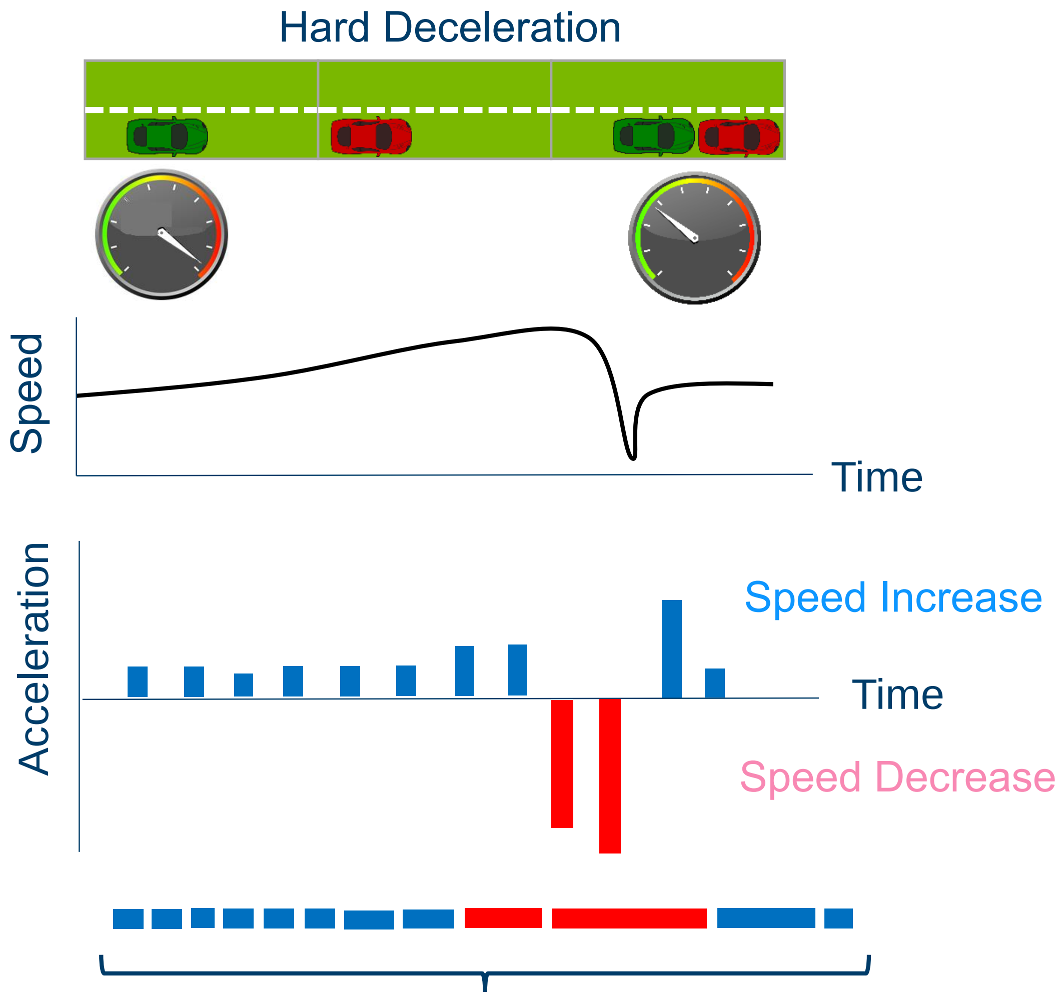
Data preparation

- Trim data to “safety scenarios” for each use case warning
  - Actual display to Treatment participants
  - “Would have been displayed” to Control/ Baseline participants



Safety evaluation

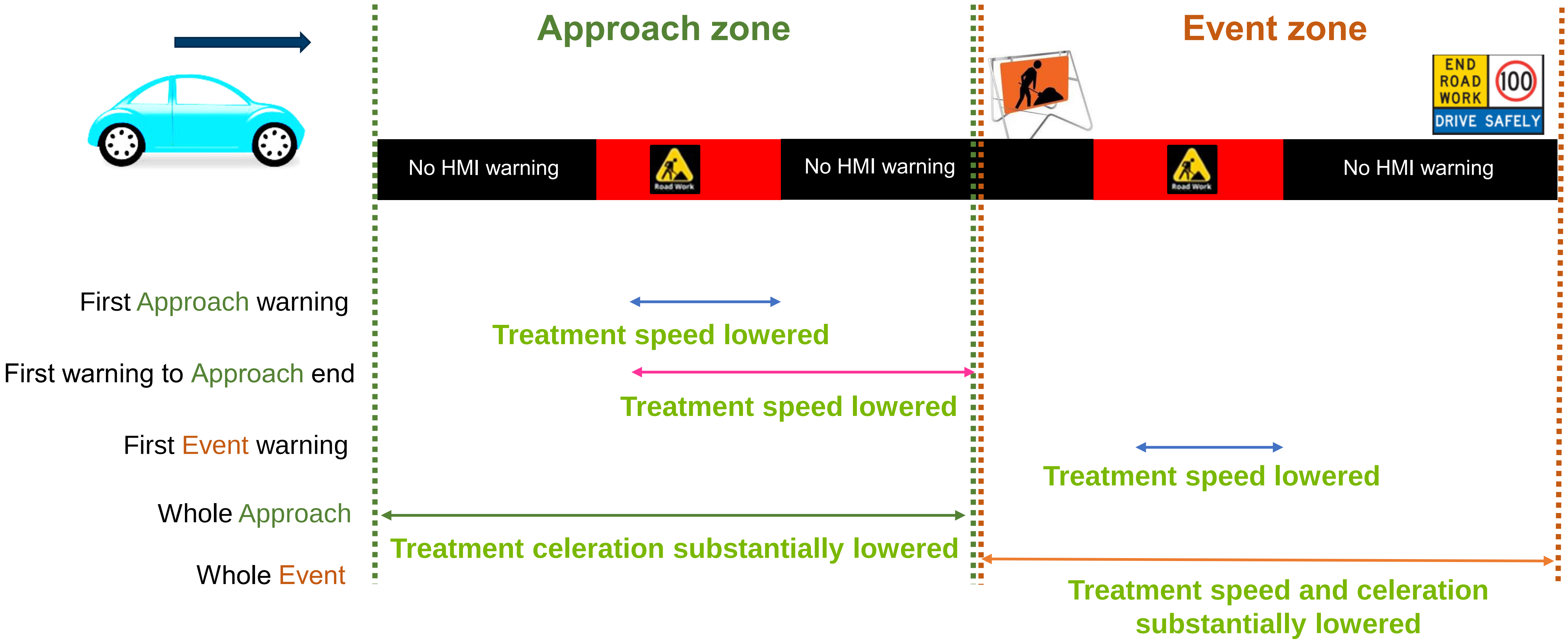
- Safety hypotheses/ surrogate measures:
  1. Lower mean speed (normalised with speed limit)
  2. Lower celeration
  3. Lower near crash
- Convert to crash reduction
- Scalable to 100% market penetration



Celeration = Sum of the absolute value of all speed changes (i.e. accelerations + decelerations)

Road Works Warning

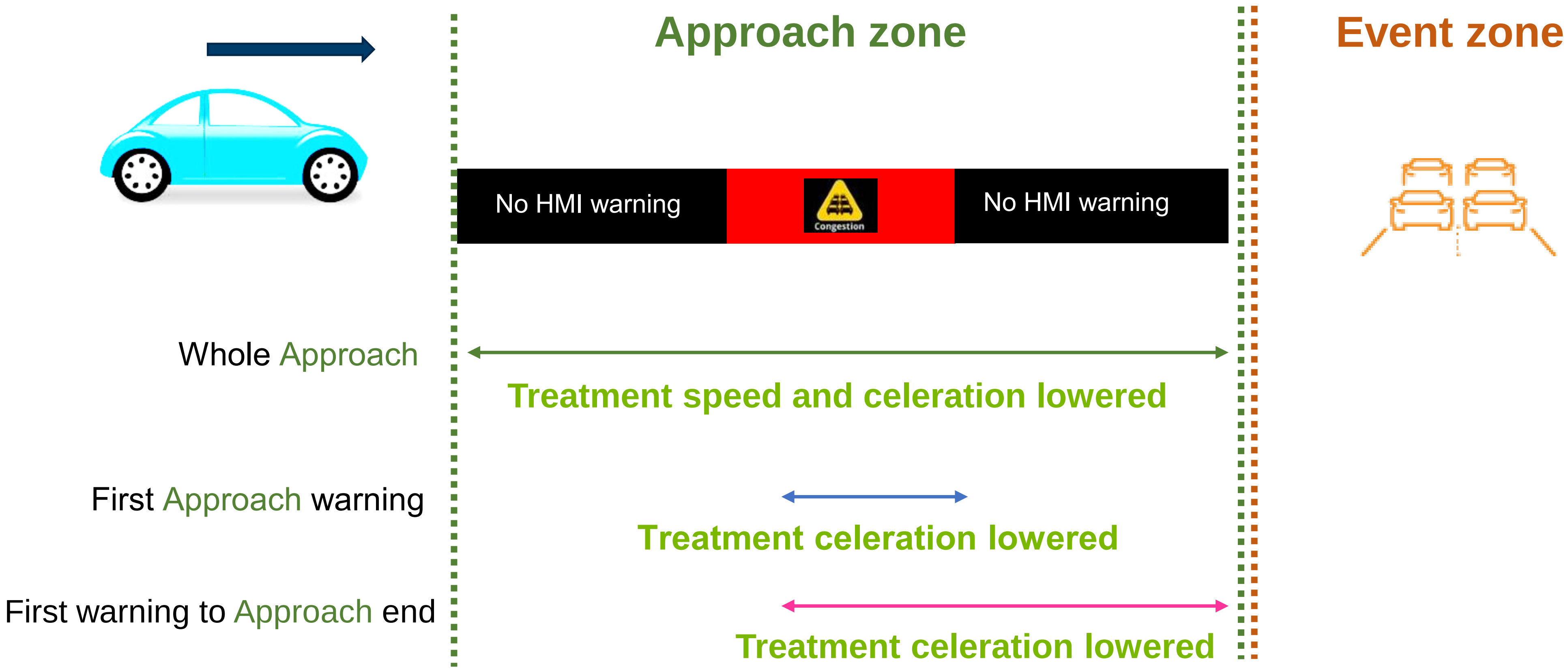
Significant mean speed and celeration reduction of treatment group compared to control group:



Preliminary findings – subject to change

Back-of-Queue

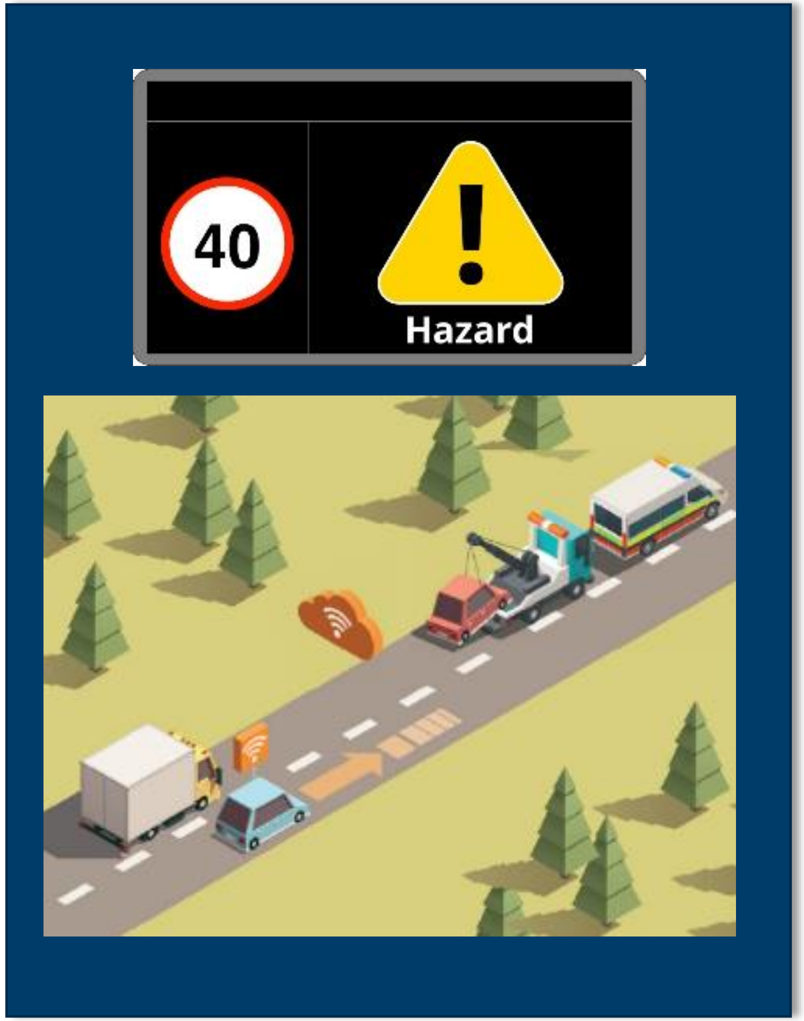
Significant mean speed and celeration reduction of treatment group compared to control group:



 *HMI = Human Machine Interface

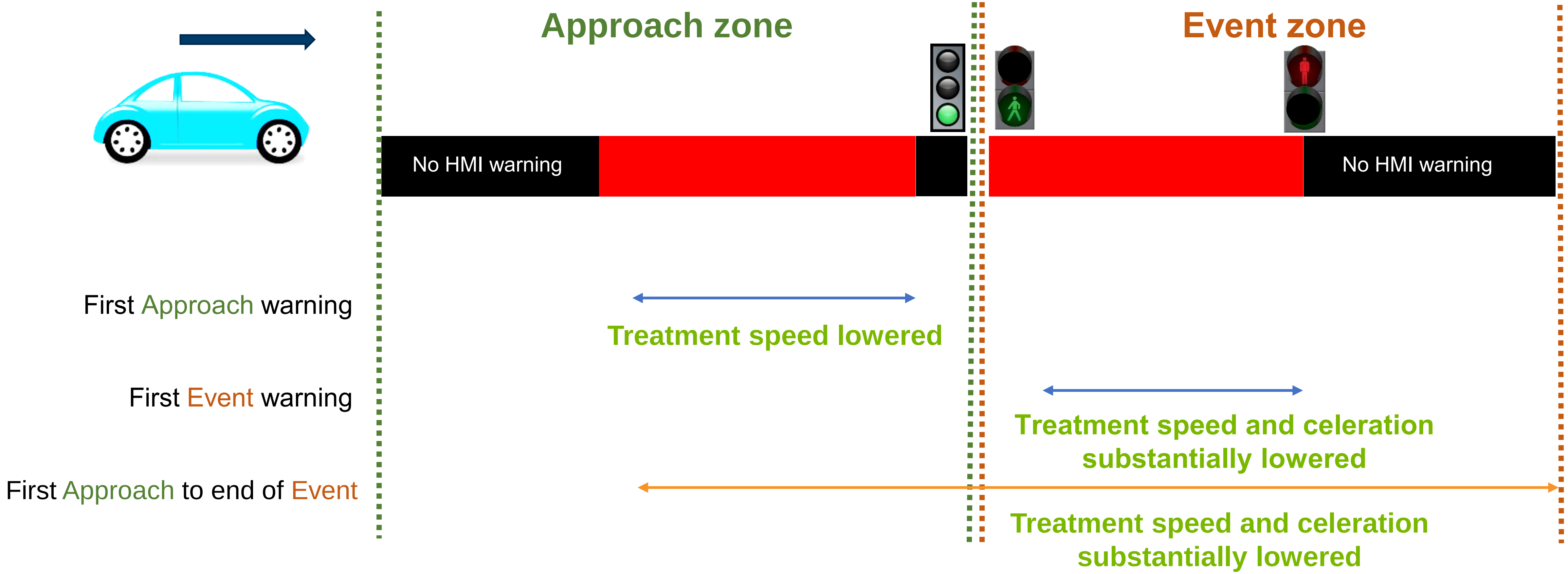
Road Hazard Warning Analysis

- Speed and celeration analyses did not show any significant differences between HMI enabled and HMI disabled participants
- Limited sample size due to low occurrence of hazard events
- Different behaviour expected for a wide range of hazard types



Turning Warning for Vulnerable Road Users

Significant mean speed and celeration reduction of treatment group compared to control group:



 **HMI = Human Machine Interface*

Preliminary findings – subject to change

Advanced Red-Light Warning Analysis

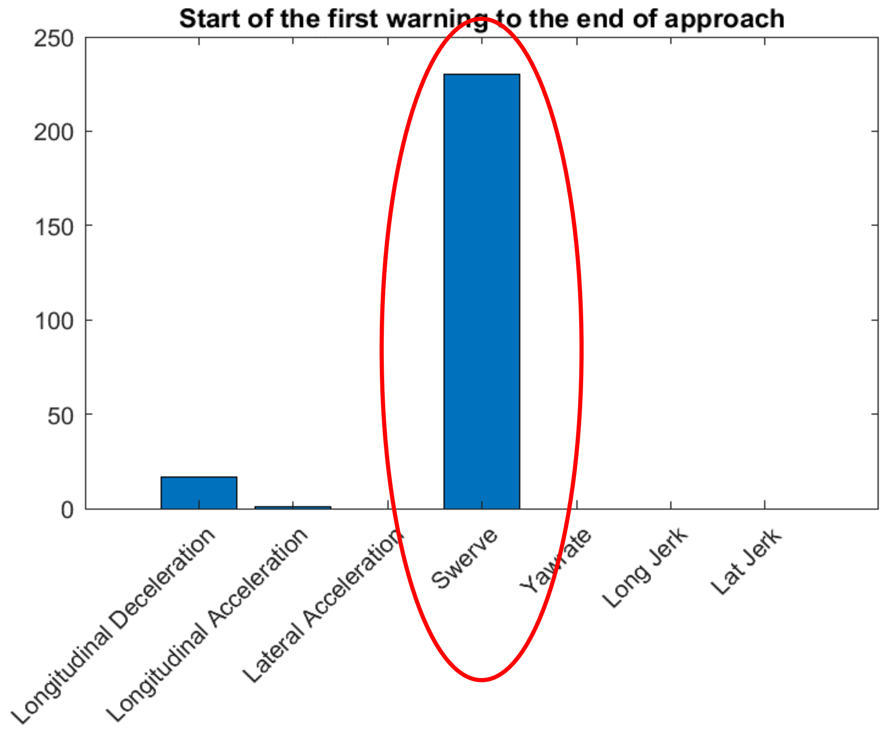
- First round of analysis based on generic situations did not find any significant results

- Analysis extended to:
  - Focus on 1st vehicle in queue
  - Escalation (from Medium to High warning)
  - Red light running likelihood

- The likelihood of escalation reduced:
  - When HMI is on, drivers would be more likely to comply with the medium warning and hence these scenarios did not receive the high warning
  - Speed reduction was significant when focused on a subset of escalated scenarios

Near crash/ crash determination methods

- **Observed kinematics data**
  - Triggers recommended by overseas studies
  - Only BoQ showed significant difference in near crash rate between treatment and control participants



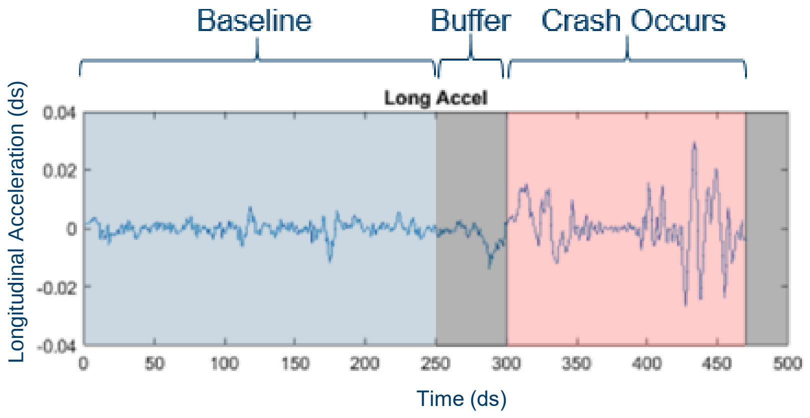
- **Driving volatility measures**
  - Alternative indicators to detect jerky driving, leading to unsafe situation

- **Machine learning**
  - Training models to predict near crashes

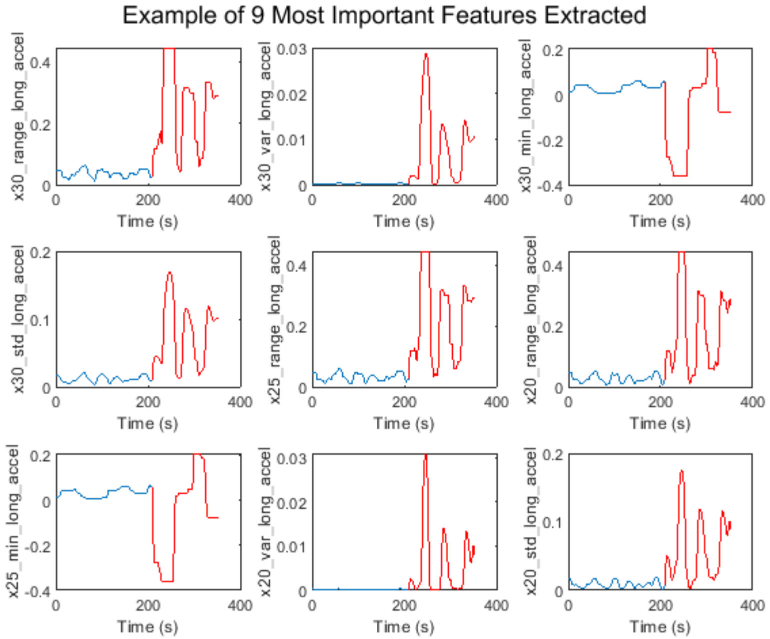
Driving volatility measures

Measure of driving volatility	Formula
Coefficient of variation	$C_v = \frac{std}{\lvert \bar{x} \rvert} * 100$
Mean absolute deviation	$MAD = \frac{\sum_{i=1}^{N} \lvert x_i - \bar{x} \rvert}{N}$
Quartile coefficient of variation	$Q_{cv} = \frac{Q_3 - Q_1}{Q_3 + Q_1} * 100$ where Q_1 and Q_3 are the sample 25th and 75th percentiles, respectively.
Percent of extreme values	$\frac{\sum_{i=1}^{N} I_{x_i > \bar{x} \pm z * std}}{N}$ $z \in \{1,2,3, \ldots\}$
Time-varying stochastic volatility	$v_f = \sqrt{\frac{\sum_{i=2}^{N} (r_i - \bar{r})^2}{N - 2}}$ $r_i = \ln\left(\frac{x_i}{x_{i-1}}\right) * 100$

Machine learning - Transformation Process



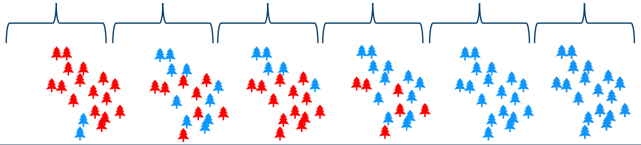
Create Features



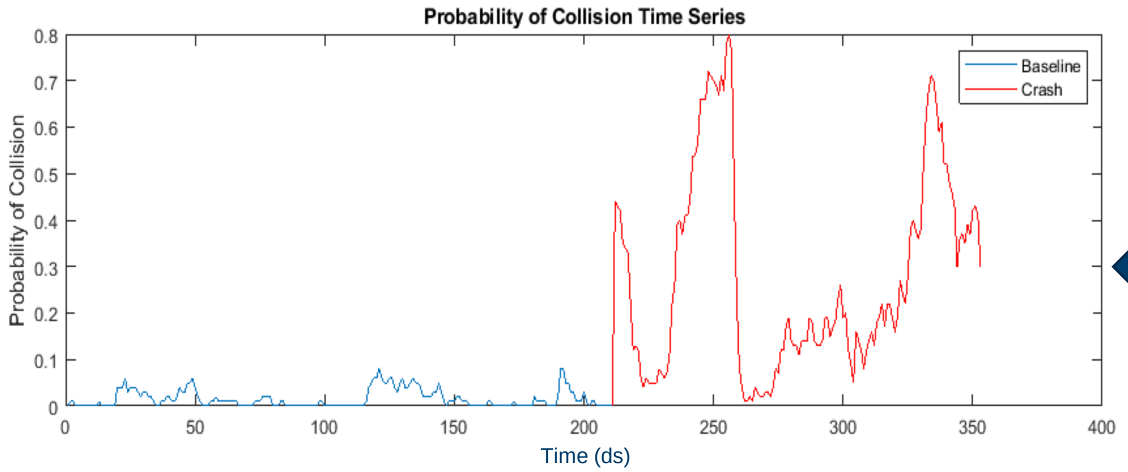
Machine Learning Model

Random Forest
100 Trees
Balanced subsample
~250 created features

t = 250 t = 220 t = 205 t = 15 t = 5 t = 0

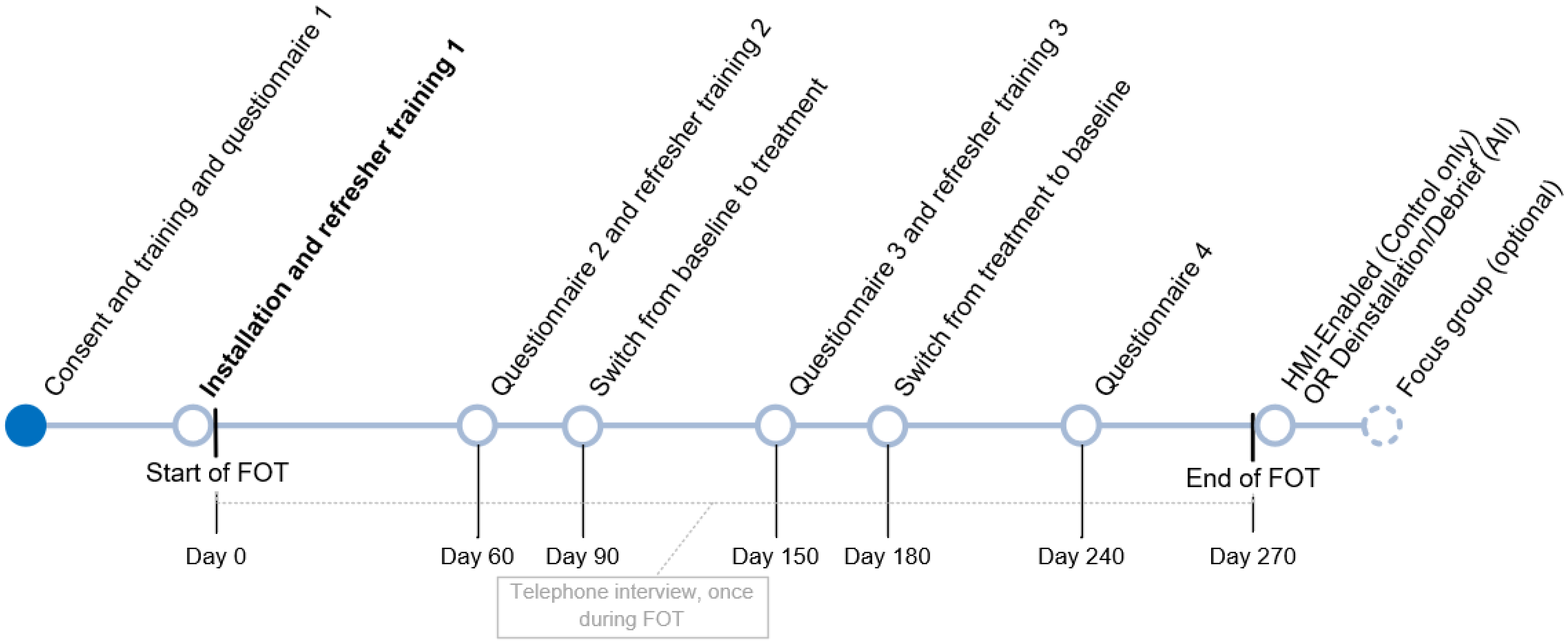


Transform to crash probability



Preliminary findings – subject to change

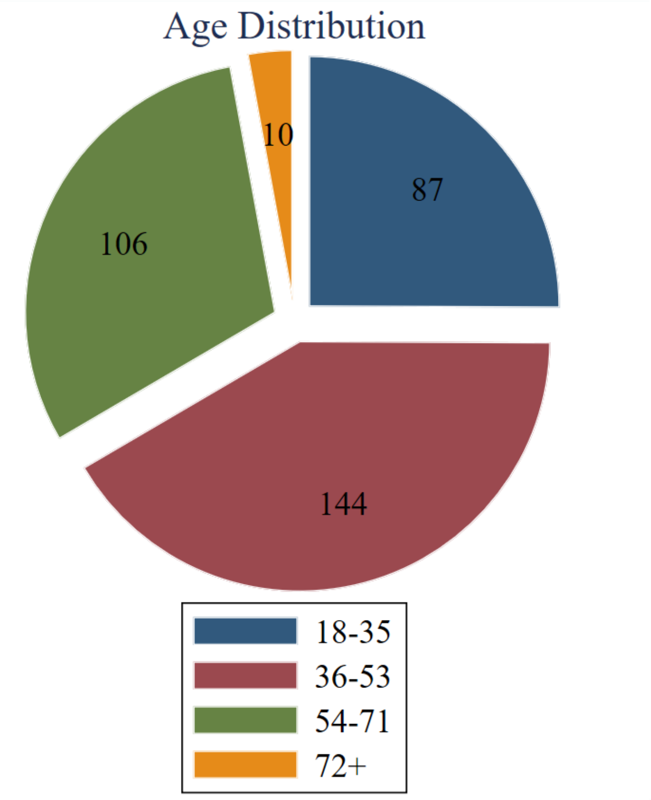
User Perceptions - Timeline

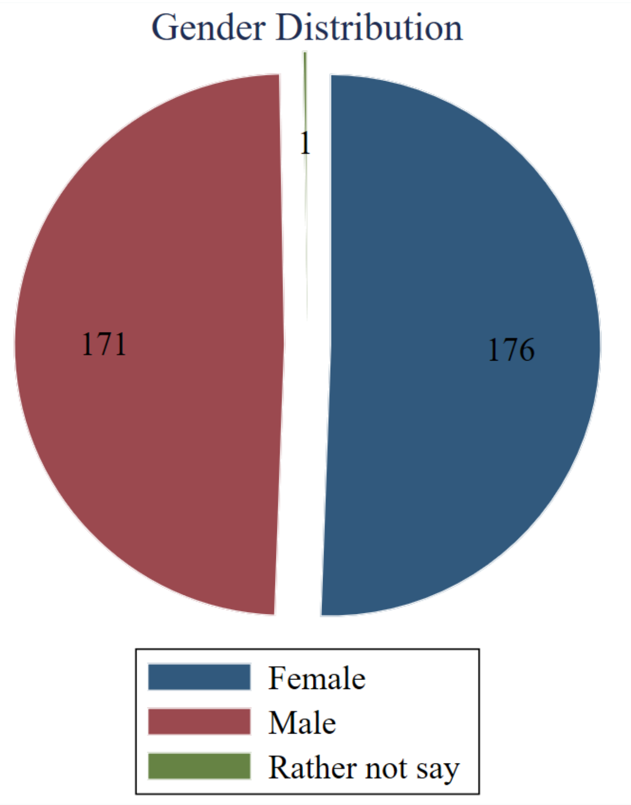


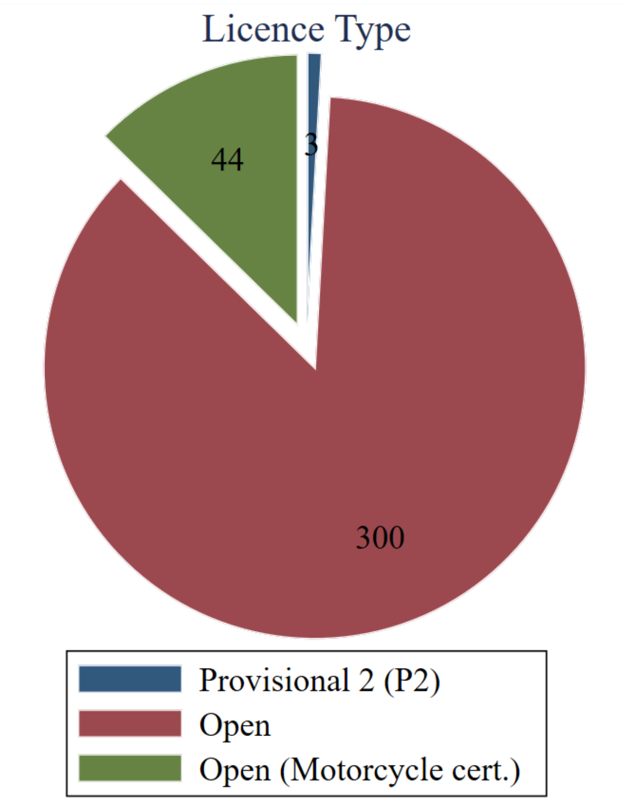
**FOT = Field Operational Test*
**HMI = Human Machine Interface*

User Perceptions – Demographics

n (Questionnaire 1) = 350
Age (mean) = 46; SD = 14; Min = 20; Max = 78







n (Questionnaire 4) = 326: participants withdrawing, missing data (incomplete questionnaires)

User Perceptions – Questionnaire and Interviews

- Acceptance (Unified Model of Driver Acceptance – derivative of TAM/TPB)

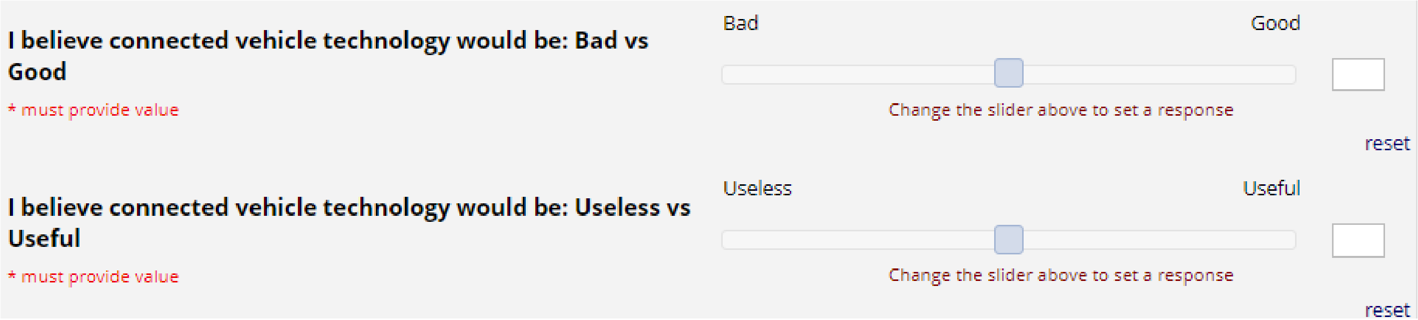
  Rahman, M. M., Strawderman, L., Lesch, M. F., Horrey, W. J., Babski-Reeves, K., & Garrison, T. (2018). Modelling driver acceptance of driver support systems. *Accid. Anal. Prev.*, *121*, 134–147. https://doi.org/10.1016/j.aap.2018.08.028

- Self-reported safety
- Differences in attention or perception
- Experiences related to the ICVP HMI and warnings
- Experiences related to the ICVP use-cases
- General experiences in the pilot

- Expectations of future C-ITS technology (most recent round of interviews)

User Perceptions – Acceptance

Sliding scale ratings from 0 to 100



Bad versus Good
Useless versus Useful
Undesirable versus Desirable
Ineffective versus Effective
Extremely Annoying versus Not at all Annoying
Irritating versus Likeable
Worthless versus Assisting

Disagree versus Agree

Improve driving performance
Increase safety
Useful for driving
Recommend to family and friends
Compatible with driving
Fits well with driving
Willingness to pay for feature in new car
Willingness to pay if retrofitted into existing car
Intend to purchase
Intend to use (if installed in vehicle)

Preliminary findings – subject to change

User Perceptions – Acceptance

(mixed effects regression)

Factors:

- Time (differences between questionnaires)
- Condition (Control vs TreatmentFirst vs BaselineFirst)
- Gender
- Age
- Technology readiness (Technology Readiness Index)
- Propensity for risk (BIG 5: drink driving, fatigue, without seatbelt, using phone, speeding)

Hypothesis: Participants who experienced the C-ITS would report greater acceptance.

Generally positive responses, maintained over time. Early models have detected effects associated with time, condition, age, and technology readiness. Fuller analyses still underway.

User Perceptions – Others
(mixed effects regressions)

Factors:

- Time (differences between questionnaires)
- Condition (Control vs TreatmentFirst vs BaselineFirst)
- Gender
- Age
- Technology readiness (Technology Readiness Index)
- Propensity for risk (BIG 5: drink driving, fatigue, without seatbelt, using phone, speeding)

Hypotheses:

Compared to the control group, participants who experienced the C-ITS would report…

- **Greater safety while driving.**
- **Positive effects on attention and perception, without the display being a distraction**
- **Greater effectiveness of warning presentation (timing, content, imagery)**
- **Greater usefulness for each of the use-cases.**

Initial analyses indicate mixed trends over time; however, responses were generally positive.

Summary

- Promising initial results for speed and celeration hypotheses with significant lower speed and celeration found in most use cases

- Near-crash estimation was not found significant between Treatment and Control/ Baseline groups; model needs further development

- Participants maintained high expectations of C-ITS over the course of their participation, however there was a slight reduction in their experience ratings following exposure to the active HMI

Thank you
and stay connected

TMRQld

@TMRQld

Department of Transport and Main Roads

TMRQld

https://www.qld.gov.au/transport/projects/cavi