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Options assessment of smart transport technology options for Perth

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Abstract

Smart transport technologies have the potential to effectively address problems in the transport network. The *Smart Transport Technology Roadmap for Perth* Project developed and assessed smart transport technology options that can effectively address transport problems (Chi et al., 2022). The Project first undertook a comprehensive review of smart transport technologies that have been deployed worldwide. The technology options were then developed to address key problems in the city's transport network, including congested road corridors, unreliable bus corridors, and intersections with performance and safety issues. A Multi-Criteria Assessment (MCA) was used to evaluate the performance of the options against the project objectives and associated criteria. Option E, which aims to provide improved safety outcomes for active transport users through the application of sensors, detectors, and Hold The Red (HTR) technology, was found to be the preferred option through the MCA. The Project's outcomes present a crucial step towards improving the transport network and can support wise decision-making of public investment.

1. Introduction

The Planning and Transport Research Centre (PATREC) at the University of Western Australia (UWA) delivered the Project entitled, *"A Smart Transport Technology Roadmap for Perth"* (the Project), in collaboration with the Royal Automobile Club of Western Australia (RAC) (Chi et al., 2022). The Project developed and assessed smart transport technology options that can effectively address the transport problems in Perth.

The Project first identified challenges including poor transport network efficiency, unreliable travel times, road safety concerns, low walkability and environmental impacts. The Project then assessed the feasibility of various smart transport technologies that have been deployed around the world and their suitability to address the identified challenges. The outcome of the Project is a preferred option that provides the best societal benefits based on the MCA outcomes.

This paper is an extract of the Project that presents a summary of the transport challenges in Perth, followed by an analysis of the transport technologies and the evaluation process used to determine the preferred option.

2. Literature review

Despite restrictions, lockdowns, and a growing trend of working from home since the COVID-19 pandemic outbreak, there has been an increase in demand for private vehicles (PV) (Marra et al., 2022; Bucsky, 2020). As travel demand for PV increases, traffic congestion intensifies (Das et al., 2021). On average, drivers in Perth spend up to 40% of their

travel time in congestion (Infrastructure Australia (IA), 2019a). Further, conflicts in land use exacerbate traffic congestion and reduce the effectiveness of urban supply chains (IA, 2019b). The high demand for PVs following the COVID-19 pandemic has come at the expense of public transport (PT) with significant falls in patronage (Biermann et al., 2020; Hass et al., 2020). Although the pandemic is the primary cause of reduced patronage, poor serviceability has also contributed to longer travel times using PT and thus lower mode share (IA, 2019b).

In contrast, there was increasing demand for cycling following the pandemic, mainly due to the reduced demand for work-related commuting trips and health concerns from travelling on PT (Department of Transport (DoT), 2020; Beck & Hensher, 2022).

Road safety is an ongoing challenge with road-related incidents being the second highest cause of injury-related hospitalisations and deaths in Australia (Beck et al., 2017). The outcome of the National Road Safety Strategy is found to be not on track (Statement by Infrastructure and Transport Ministers, 2021). Perth's road safety has been suboptimal, as evidenced by the annual road fatalities per 100,000 population in WA have exceeded the national average since 2008 (Road Safety Commission, 2017).

More broadly, Perth has faced transport issues, relying on infrastructure investment and network expansion as the primary solutions. However, the ongoing and unsustainable urban sprawl demands other ways to manage the underlying issues of population growth and continuing PV ownership. Innovation to determine feasible options and pathways is needed to address the problems and ensure that public funds are invested wisely.

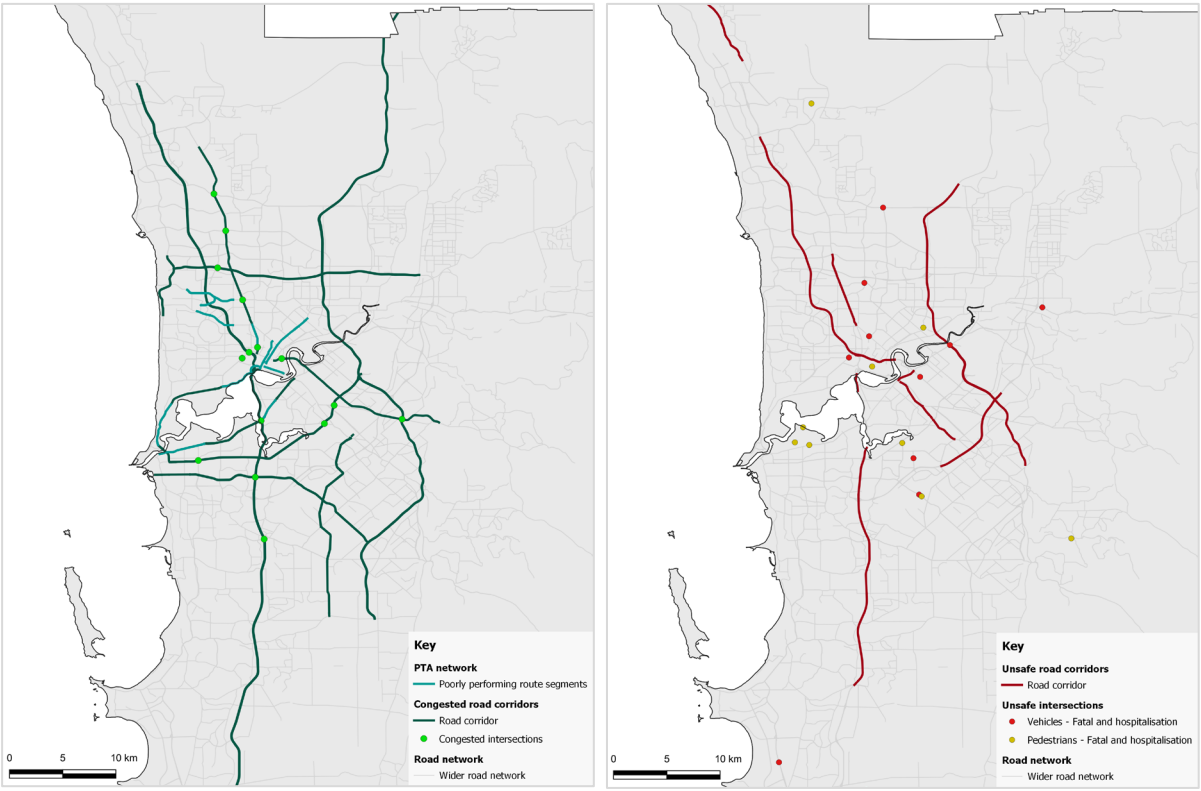
3. Identifying strategic priority locations for improvement

The Project undertook a review of Perth’s transport network, identifying corridors that experienced congestion, poor travel times and high crash rates. This formed the basis for the options development.

The first round of analysis focused on private vehicles and freight movements, nominating 16 congested corridors identified by IA and 15 congested intersections identified by Main Roads Western Australia (MRWA). This was followed by the Public Transport Authority (PTA)’s PT corridor review study which identified 10 poorly performing bus corridors based on the performance of slow speeds and travel time reliability. Lastly, the crash data was reviewed to identify intersections that experienced the poorest safety record.

Figure 1 illustrates the location of the congested road corridors, poor-performing bus routes and intersections with congestion (left) and road corridors and intersections with safety issues (right).

Figure 1: Location of identified corridors and intersections – congestion (left) and safety right)



4. Identifying smart transport technologies

A review of detection technologies and road network management applications (see Boussaid et al., 2020) was undertaken to understand the suitability for addressing the identified problems in the priority locations. The data gathered from these detection technologies can be applied in different contexts to address a variety of transport problems. Table 1 summarises how the collected data can be applied in various contexts and case studies.

Table 1: Summary of smart transport technologies and case studies (adapted from Chi et al., 2022)

Intervention	Technologies and applications	Purpose	Case study
Signal optimisation and intersection safety improvement	Integrates data from various detectors with Sydney Coordinated Adaptive Traffic System (SCATS) to generate information on volume, speed, and headway on road sections.	Improve the efficiency of signal phasing. Can interface with other sensors to better understand interactions of all transport users at intersections.	Smarter Road Program (VIC) Hold the Red (HTR) Trial (QLD) (VicRoads, 2021; TMR, 2021)
	Vehicle sensors and detectors (e.g. magnetometers; passive infrared; microwave presence radar; passive acoustic and video image processors)	Enhance safety at intersections (e.g. extending green lights for cyclists, warning connected cars of jaywalkers, priority for emergency vehicles, identifying near-miss incidents).	

Intervention	Technologies and applications	Purpose	Case study
Pedestrian and cyclist prioritisation at intersections	Data from sensors and detection can be used to detect pedestrians and cyclists waiting at a crossing.	Improve the phasing of traffic lights and prioritise vulnerable road users and prevent empty crossings.	Green Man Authority Trial (London, UK) (Transport for London, 2018)
	Image recognition and machine learning technologies can be used to detect pedestrian and cyclist movements at intersections.		
PT prioritisation	Vehicle location data from sensors or GPS can be integrated with the traffic management system.	Optimise the PT priority.	NextGen Bus Signal Priority System (Los Angeles, US) (LA Metro, 2022; Norman, 2022)
	Can interface with other priority methods (e.g., green time extension, early green, always green for bus, phase re-ordering and a green wave of lights).		
Smart Freeways	Use a centralised control system to interpret data from various sources such as automatic incident detection systems, CCTV, vehicle detectors, and the integrated ramp meter system along freeways.	Improve efficiency, productivity, reliability, safety, driver experience, sustainability and resilience.	Smart Freeways (WA) (MRWA, 2020b; MRWA, 2020a)
Vision analytics-based enforcement	Sensors can be used for enforcing bus-only, clearway lanes and parking management systems (e.g. detect free bays within the car park and direct drivers to a free bay)	Improve efficiency and safety benefits by enforcing speed limits, lane management and parking management.	Safe-T-Cam system (NSW and SA); Mobile phone and seatbelt cameras (QLD) (TMR, 2021)
Real-time network management and longer-term planning	Management and operation systems can use data gathered by detection systems to detect historical volumes and speeds on road networks, cyclist volumes or pedestrian volumes and intersection wait times.	Better monitor traffic, manage congestion, improve efficiency and improve safety outcomes	Australian Integrated Multimodal EcoSystem (AIMES) (The University of Melbourne, 2021)

5. Options development and assessment approach

Based on the literature review and stakeholder feedback, five technology options were developed to address transport problems, considering practicality, feasibility and potential impacts on the existing transport network. A summary of the options, the transport problems they aim to address and the applications of the smart technologies are outlined in Table 2.

Table 2: Summary of smart transport technology options (adapted from Chi et al., 2022)

Option	Targeted transport problems	Application
A: Efficiency improvement of traffic on the freeway and major arterials	Capacity and traffic efficiency issues along freeways and major arterials	Smart freeway technologies can be used to better manage the flow of vehicles and respond to crashes on the road network. The technology is a cost effective and less disruptive approach to providing additional network capacity.
B: Optimisation and efficiency improvement of traffic at intersections	Capacity and traffic efficiency issues at intersections	A variety of sensors and detectors are used to identify vehicles that are approaching a signalised intersection, including volume, direction and speed. This information improves operational efficiency (e.g. extend the green time during high demand and shorten it during low demand). Bus prioritisation will also be supported by giving them earlier and longer green time.
C: Intersection vehicle safety improvement & PT prioritisation	Vehicle safety at intersections and PT prioritisation	A variety of sensors and detectors are used to enhance the safety of the intersection. The inclusion of the HTR system supports enhanced safety by providing additional red time if a vehicle is likely to run the light. The better detection of buses will also support prioritisation by giving them earlier and longer green time.
D: Pedestrian and cyclist prioritisation and safety improvement at intersections	Intersection safety (pedestrian and cyclists)	The safety of pedestrians and cyclists is enhanced by alerting other road users of immanent crossings (e.g. flashing lights, signage indicating mixed road use etc). The better detection of buses will also support prioritisation by giving them earlier and longer green time.
E: Combination option - Option D combined with the HTR system	Intersection safety (vehicles, pedestrians and cyclists)	Combination of the various sensors, detectors and HTR described in Option C with the intersection safety enhancements described in Option D.

A Multi-Criteria Assessment (MCA) was used to select the preferred option. MCA is a well-established framework and decision-making technique for evaluating transport initiatives and projects (IA, 2021a, 2021b). MCA also provides a systematic process to consider an investment proposal from various perspectives and allows both non-monetary and monetary attributes to be assessed within the same framework (Chi & Bunker, 2021).

In general, a MCA process involves four key steps (Sierra et al., 2018). Initially, the objectives of the projects are clearly outlined. Following this, specific criteria are established for each objective, along with relevant measures for these criteria. Then weightings are assigned to each criterion based on its relative significance (Gühnemann et al., 2012). Finally, the options are assessed in light of their respective criterion weights.

Based on the identified transport problems in Table 2, the objectives of the MCA were defined. A set of criteria is developed to adequately assess the impacts that correspond to each objective. Appropriate measures for each criterion are also considered. Table 3 summarises the Project objectives and criteria included in the MCA. Since each objective has different criteria, weights are applied to ensure that each objective weighs the same. The rationale for each weighting is summarised as follows:

- **Efficient road network:** PT users, pedestrians and cyclists should be prioritised over motorists.

- **Sustainable transport modes:** Both PT and AT provide sustainable outcomes and should weigh equally.
- **Improving road safety:** The safety of all road users is equally important.
- **Strategic fit:** Equal weight is given to the criteria under strategic fit as they are equally important

Table 3: Project objectives and MCA criteria (adapted from Chi et al., 2022)

Objective	Criteria	Weight
Efficient road network	Reduce delays and travel time and improve travel time reliability for motorists.	20%
	Reduce delays and travel time and improve travel time reliability for PT users.	40%
	Reduce delays and travel time and improve travel time reliability for pedestrians and cyclists.	40%
Sustainable transport modes	Prioritising PT over other vehicles within the road network.	50%
	Prioritising pedestrians and cyclists over vehicles within the road network.	50%
Improving road safety	Reducing fatal and serious crashes involving motorists.	50%
	Reducing fatal and serious crashes involving pedestrians and/or cyclists.	50%
Strategic fit	The underlying causes and effects of the problems and opportunities make a clear case.	33%
	The option aligns with relevant national, state and local government goals, objectives, policies and strategic plans.	33%
	The option is compatible with the existing and future infrastructure network, system or place in where it is situated.	33%
Deliverability	The option offers deliverable solutions for responding to the problems and opportunities, concerning ease of implementation, capability and capacity, and other risks.	100%

The performance of each option against the criteria was ranked from one (positive impact) to three (negative impact) and weightings were applied so that each objective was accounted for equally. The summary results of the MCA demonstrated that Option E which addresses safety outcomes of vehicles, pedestrians and cyclists, performed the best (see Table 4). The option includes the identified sensors and detectors, the bus priority system, the pedestrian and cyclist priority system and the HTR system.

Table 4: Summary results (Chi et al., 2022)

Option	A	B	C	D	E
Efficient road network	2.2	2.2	1.8	2.6	2.6
Sustainable transport modes	2.0	2.0	2.5	3.0	3.0
Improving road safety	2.0	2.0	2.5	2.5	3.0
Strategic fit	3.0	3.0	2.7	2.7	2.7
Deliverability	3.0	2.0	2.0	2.0	2.0
Total score	**12.2**	**11.2**	**11.5**	**12.8**	**13.3**

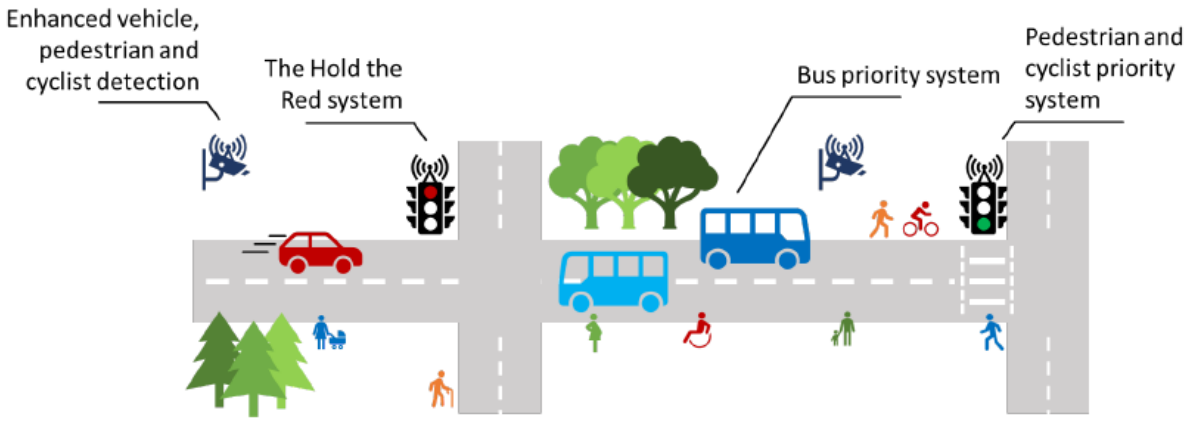
6. Conclusion and Practical Implication

The Project found that Option E (pedestrian and cyclist prioritisation and road safety improvement) is the preferred option. The option is expected to provide benefits to all road users including motorists, PT users, pedestrians and cyclists, including:

- Reduced delays and travel time, and improved travel time reliability for PT users, pedestrians and cyclists;
- Prioritised bus, pedestrian and cyclist movement over vehicles; and
- Improved safety outcomes for motorists, pedestrians and cyclists.

Figure 2 illustrates the key elements of the option.

Figure 2: Elements of the Option E (preferred) (Chi et al., 2022)



A bus priority system is currently being trialled in Perth, thus, the delivery risk of the system is relatively low. However, the stakeholder feedback revealed that there is still some SCATS integration risk associated with the HTR system and bus, pedestrian and cyclist priority system. Further trials are needed to minimise the deliverability risks.

This Project provided a summary of key transport challenges facing the Perth transport network and the strategic priority locations to address. It provided a comprehensive review of currently available smart transport technologies, their effectiveness based on broader Australian and international operational experience, their potential to be deployed in Perth, and the potential scale of outcomes that could be achieved.

The evaluation framework used an MCA analysis and offered practical examples of how this evaluative method can be used to assess new and existing technologies and their effectiveness in addressing identified transport problems. A preferred option (pedestrian and cyclist prioritisation and road safety improvement) that reflected the identified opportunities and challenges was found.

The Project supported RAC's role to advocate for ITS investment both in WA and nationally, including work towards an ITS architecture framework to assist in the deployment of consistent and interoperable technologies that facilitate safe, connected and sustainable mobility.

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