Problem Statement

Network optimisation with connected and automated vehicles

TD 18-11

Technological Drivers of Change

Problem Description

Question	Response
Description of the problem and purpose of the proposed research	Congestion is a growing problem, particularly in urban areas. There are impacts to the economy, environment and social wellbeing of the community. Commuters suffer slow unreliable journeys in peak and off-peak periods. Connected and automated vehicles (CAVs)[1] are often proposed as a solution to congestion through more efficient use of road space. However, as the use of CAVs is expected to increase, there are circumstances/scenarios that could arise where CAVs could increase rather than lessen congestion. An issue of potential significance is that CAVs may exacerbate the problem that individual vehicles increasingly rely on navigation systems that independently optimise journeys for that vehicle's journey. Individualised optimal trip routing can be at the expense of overall network performance. This issue is likely to become more acute in the future as vehicles become increasingly connected and automated, and vehicles are able to respond and re-optimise due to network conditions in real-time. Such a future state could prove detrimental to the needs of other network users, and the broader community. This would challenge the Government's future mobility goals as described by *Future Transport 2056 Strategy*. This research project is seeking to undertake a proactive exploration of the extent of this problem. This exploration is proposed to be done through examining the extent to which a centralised network optimisation function, and associated use of social optimisation algorithms, may be required. The concept is that these would replace individualised prioritisation algorithms and technologies in favour of socially-optimal network optimisation.

[1] https://future.transport.nsw.gov.au/plans/future-transport-strategy

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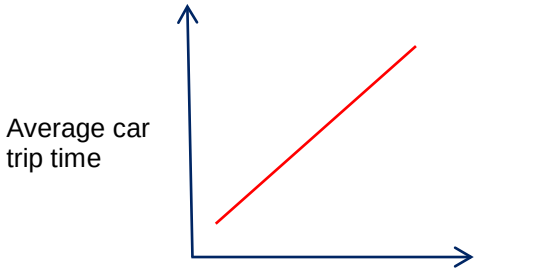
Hypothesis & Variables

Question	Response
For explanatory research, please describe a clear hypothesis with variables for testing **For exploratory research,** please describe how the proposed research will contribute to future explanatory research	Today, navigation systems direct drivers to their destination based on a limited knowledge of the network and travel times. Current navigation technologies make route decisions based on the prioritisation of individual trips. These routing choices are not based on optimal performance of the entire road network, resulting in a non-optimised network. To address this in the future, a possible response will be that a traveller will be required to enter their destination when they use highly or fully automated vehicles. The information would then be transmitted to the Transport Management Centre (TMC) (or simular function). The TMC systems would analyse the origin and destination information and model the impact of this journey on the network, and either accept the route or 'program' another route. The hypothesis is that this would improve overall network performance. To test the hypothesis, a modelling process is proposed that will look at the positive (or negative) impacts of a centralised routing process for road vehicles. The modelling will examine how vehicles could be optimally routed through the network to avoid congestion, checking a range of factors, such as demand, available capacity, environmental factors, incidents and planned events (such as road occupancies, events).  The assumption tested will be that the more centralised the CAV routing function is, the better the average car trip time. With these assumptions, the research will demonstrate: • the reliability of the network. • the improvement of journey times. • the opportunity to manage congestion. The intent is to develop and test resulting optimisation algorithms focussing on a 100% CAV market penetration.

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Strategic Criteria & Alignment

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Alignment with strategic theme	This Problem Statement is aligned with the Transport for NSW (TfNSW) Strategic Research Theme of 'Technological Drivers of Change'. This theme is based on exploring how new technologies will impact transport planning, management and delivery. TfNSW needs to be able to anticipate and understand change, and be proactive in its response. The aim of this problem statement is to enhance the benefit of CAV platforms and learn how to create intelligent transport networks (data/predictive modelling). The Problem Statement aligns with the Future Transport Technology Roadmap[2] and addresses Strategies 4 and 5 in facilitating key concept development around the below: • Real-time traffic management. • Develop a blueprint and operating model for CAVs on the network. Widespread automated network management using real-time data and analytics.
External driver of change analysis **Outline how the research will better position TfNSW to respond proactively to macro drivers of change**	We use PESTLE analysis to identify and describe the external drivers of change that this research would help TfNSW be in a better position to respond to. **Political** CAVs are a worldwide trend and present a number of challenges and opportunities for political and policy processes. This has seen a number of parliamentary inquires occur both in Australia and overseas to prepare the political landscape. These reflect a growing awareness that CAVs will impact on the role and responsibility of the government in terms of transport network management as well as big data information management. **Economic** The performance of cities is seen increasingly as a key factor in addressing national productivity in an information-based economy. CAVs offer significant potential to improve urban performance and alleviate congestion. However, they also offer significant challenges under certain scenarios. **Environmental** CAVs offer the prospect of improved environmental sustainability if associated with car sharing and an uptake of electric vehicles. **Technology** CAVs are reflective of a number of key technology drivers of change including machine learning and artificial intelligence. **Legal** Future legal decisions will be a key determinant of CAV take-up, particularly in the area of insurance liability.
Forward looking	The research focuses on future opportunities that have not yet been explored. It looks at the role of data collection and the privacy context of CAVs as well as the opportunity to predict and manage the network better, optimising CAV use and management to benefit public transport and people movement.
Potential research impact	The outcomes of the research can result in a fundamental shift in how people move through the road network, and the governance options for facilitating optimal network performance.

[2] https://future.transport.nsw.gov.au/technology/roadmap

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Technical Criteria

Question	Response
Innovation **Outline how the proposed research will result in new knowledge**	The research undertakes preliminary analysis of the need and extent of a centralised routing control mechanism to optimise the future road network in Sydney. It is therefore an important input into TfNSW's future advice and decision-making on network governance options. This type of analysis has not been undertaken in the Sydney context before.
Basis in completed research and/or observed practice	This concept of optimising the transport network through CAV management is based on the existing practice of automatically optimising an IT network. It seeks to apply the established practices of how packets[3] are optimally routed through an IT network by routers and switches to a road network. Emerging practices in this area include the smart/managed motorway concept used in Victoria. The approach there follows the principle of restricting entry onto the motorways if the motorway performance will significantly degrade.
Feasible data requirements	• Road network model (this already exists to a certain extent). • Current CAV data collected. • Other (to be defined by universities).

Level of Collaboration & Resource Requirements

Question	Response
Level of collaboration **Please select the level of collaboration required to complete the proposed research**	**1. 'Quick-Fire' Research** ☐ Intense bursts of research activity (e.g. under 8 weeks). Intended to make use of 'hackathon'-type environments, where students/researchers work collaboratively and intensely on particular problems involving data interrogation and visualisation.
	2. Undergraduate Final-Year Research ☐ Suitable for final-year undergraduate students (e.g. capstone, Honours) as part of the research requirements for their undergraduate degree (i.e. 1 to 2 semesters).
	3. Higher Degree Research ☐ Project may form whole or part of a postgraduate research degree (i.e. Masters, PhD), and contribute to new knowledge (i.e. 1 to 3 years).
	4. Major Collaborations and Funded Research ☒ Project may form the basis for a significant collaboration agreement between TfNSW and the relevant research institution, including major competitive grant funding (e.g. Australian Research Council funding with TfNSW as an industry partner).
Comments	This problem statement may form the basis for a major collaboration agreement between TfNSW and the relevant research institution.
Supporting TfNSW resources	Access to data and subject matter experts in the NSW Transport cluster.

[3] Unit of data routed between an origin and a destination on the Internet or any other packet-switched network.

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