Reimagining urban movement

Research and policy must reimagine how we'll move through cities in 2030 and beyond

THE UNIVERSITY OF MELBOURNE

New research and technologies to solve old transport problems

For over half a century, cities worldwide have struggled to ease traffic congestion, improve road safety and reduce emissions. As populations surge and urbanisation accelerates, these challenges have become a global crisis, representing fundamental threats to economic prosperity, social wellbeing and sustainability.

The University of Melbourne's transport research recognises that the urgency surrounding transport challenges extends far beyond mere traffic jams or delayed commutes, requiring innovation that reimagines how we move through cities.

New technologies, particularly Co-operative Intelligent Transport Systems (C-ITS) and Artificial Intelligence (AI), coupled with forward-thinking policy frameworks, could revolutionise urban transport across the world over the next decade. C-ITS enables vehicles, roadside infrastructure and other nearby road users (such as pedestrians and cyclists) to connect with each other so they can be aware of each other's movements and be safer. And AI enables us to use this data to identify patterns and conflicts – with it, we could optimise the entire transport system, considering all travellers.

The Australian Integrated Multimodal EcoSystem (AIMES), founded by University of Melbourne Professor Majid Sarvi, is turning this theory into practice. A world-first, living transport laboratory on the streets of Melbourne, it is one of the world's most ambitious practical applications of highly integrated transport technologies in real time, creating a global blueprint for smart mobility.

> *Australia has the potential to be a world leader in AI and connected transport.*

Successful deployment of these technologies nationally and internationally requires co-ordinated action across government, industry and research institutions, to translate research innovations into commercially viable solutions. Research institutions provide the neutral ground where these diverse stakeholders including vehicle manufacturers, technology providers and infrastructure contractors each collaborate.

Australia has the potential to be a world leader in AI and connected transport. However, unless we seize this opportunity and act to change transport systems globally, transport challenges are likely to become more complex and more entrenched over the next decade.

Congestion crisis, safety threat to worsen

The current design of transport infrastructure predominantly prioritises order over safety. Intersections, where a significant number of serious injuries occur, are primarily designed to manage traffic flow rather than actively protect vulnerable road users.

The result is a system that inherently pays less attention to the dangers, particularly for pedestrians and cyclists, who are some of the most vulnerable users of transport networks.

This safety crisis extends to broader social equity concerns and deters many people from choosing active transport options such as walking and cycling, even when these modes offer substantial health and environmental benefits.

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This trend, observed globally before the COVID-19 pandemic and resuming as cities returned to normal activity, points towards significantly increased traffic volumes across urban centres.

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These transport problems are global, and Australia's major cities also face challenges due to their expansive geographical footprints. Unlike more compact European or Asian cities, Australian urban areas are car-dependent, making public transport economically challenging for governments.

Developing countries face an even more concerning future, with rapid economic growth and accelerated motorisation as more people live in cities and utilise the transport system. China offers a preview of this pattern – rapid industrialisation has led to widespread car ownership and accompanying congestion problems. This cycle is now repeating across South-East Asia, Africa and Latin America, often outstripping infrastructure development.

Improving transport safety over the next decade will be particularly challenging. As traffic congestion intensifies, the probability of accidents and serious injuries will also rise. Intersections, already responsible for a significant proportion of serious injuries, will face increased pressure as more vehicles, pedestrians and cyclists compete for space.

Current vehicle safety technologies, with features such as blind-spot warnings and collision avoidance systems, still struggle to address the complex nature of intersection conflicts where multiple road users interact simultaneously under time pressure. The overwhelming cognitive load on road users navigating these environments frequently will likely cause more errors that could be fatal.

Beyond CO_2: Transport's full footprint

Transport's environmental footprint continues to expand, with the sector accounting for approximately 22 per cent of Australia's total emissions. This contribution poses a fundamental challenge to the nation's climate commitments and environmental stewardship.

Vehicle emissions release not only greenhouse gases but also particulate matter and other pollutants that degrade air quality and contribute to respiratory illnesses, cardiovascular disease and premature deaths.

The environmental burden of transport extends beyond direct emissions. Traffic congestion increases fuel consumption and emissions per kilometre travelled. Road expansion to accommodate growing traffic volumes often also comes at the expense of green spaces. This compounds the environmental impact affecting biodiversity. It also creates urban heat islands and decreases cities' overall liveability.

Electric vehicles (EVs) represent the most visible approach to reducing transport emissions. With substantial government support and domestic manufacturing advantages, China has seen significant EV sales growth, reaching 11 million vehicles last year, almost half of new car sales. But this scale of growth in EVs hasn't occurred globally and while EV sales are growing in most markets, they still represent a minority share of new car sales.

EVs have less tangible environmental benefits where power grids rely heavily on coal or gas, the source of emissions simply shifting from vehicle tail pipes to power stations. In addition, even with increasing EV penetration, the total number of vehicles on the road and vehicle-kilometres travelled continues to grow. This means that overall energy consumption for transport rises even as individual vehicle efficiency improves. Without dramatic acceleration in both EV adoption and renewable energy generation, transport emissions will continue to increase in many countries.

Current trends suggest that without proactive government intervention, congestion, safety and emissions problems will worsen substantially worldwide over the next decade.

In Australia, most of the states have ambitious safety targets with the hope of achieving zero road deaths by 2050, while the goal of reducing emissions 42.7 per cent on 2005 levels by 2030 requires deep cuts in the number of petrol and diesel-powered vehicles. Already, all states are poised to achieve these goals by launching smart transport systems that embrace this technology.

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The cost of doing nothing

Transport challenges affect the economy. Traffic congestion makes it difficult to predict journey times. This creates stressful uncertainty, affecting everything from business operations to personal wellbeing. Businesses face increased operational costs – delayed deliveries, disrupted supply chains and higher fuel consumption that all contribute to reduced efficiency and competitiveness.

Traffic accidents create substantial economic costs through medical expenses, property damage, lost productivity due to injury or fatalities, and the administrative overhead of emergency services and insurance systems.

Traditional approaches to these challenges are insufficient. Physical infrastructure improvements, while valuable, are limited. Road barriers, traffic signals and conventional safety measures are not enough to address the systemic nature of these interconnected problems.

Modern transport systems are complex. Melbourne alone contains more than 300,000 streets and several thousands of intersections. This complexity requires sophisticated, data-driven solutions to process vast amounts of information in real time. The rapid evolution of AI is an unprecedented opportunity to tackle these long-standing challenges.

The University of Melbourne's transport technology research group is uniquely positioned to bridge the gap between technological possibility and practical implementation. Research conducted by the Australian Integrated Multimodal EcoSystem (AIMES) is already informing effective policymaking and ensuring transport solutions are not only theoretically sound but also practically viable, environmentally sustainable and socially beneficial.

AIMES is providing the evidence necessary for governments and industry to confidently invest in transformative technologies of the future.

Technological innovations offer the potential to address congestion, safety and emissions simultaneously while maximising the efficiency of existing infrastructure. The University of Melbourne is at the forefront of research in this area.

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Co-operative Intelligent Transport Systems (C-ITS) enable continuous communication between all elements of the transport network, creating a greater level of situational awareness and co-ordinated response capability.

The safety applications of C-ITS are particularly compelling. Current intersection design prioritises traffic flow management over active safety protection, leaving road users vulnerable to conflicts arising from limited visibility, driver distraction or simple human error. C-ITS provides drivers with dynamic insights and "extra cognition" drawn from the broader transport network. Vital information such as location, speed and direction of each vehicle is communicated to everybody else in that vicinity.

A typical scene is where a vehicle driver prepares to turn left while a cyclist approaches in their blind spot. With C-ITS, the infrastructure can detect the cyclist's presence and trajectory while simultaneously monitoring the vehicle's intentions, providing the driver with timely warnings to prevent collision. The system can alert drivers approaching intersections too quickly to slow down and to stop safely for red lights, preventing severe crashes.

AI: The new operating system for cities, streets that think

Artificial Intelligence now functions as the core transport intelligence, continuously learning from streams of network, vehicle and traveller data to predict risk, prioritise movement and optimise signals and routes in real time.

This is in sharp contrast to existing transport operation systems, which are not truly intelligent but largely reactive, siloed and constrained by static rules. They rely on many uncoordinated sensors that are costly to maintain and do not work together in an orchestrated fashion, leaving them unable to adapt dynamically to incidents, multimodal demands or changing conditions. Rather than business as usual, cities add intelligence: measurable cuts in delay, crashes, and emissions using the assets they already have.

We can access higher volumes of real-time data than ever before – from transport systems through already-deployed road sensors, travellers' mobile phone data and vehicle telematics.

Utilising AI enables us to identify traffic patterns and traffic congestion or potential conflicts in the networks.

For the first time in modern history – since the invention of car – we have a technology which could truly and precisely optimise in real time the entire transport system, considering all travelers.

This has significant economic value for cities. For example, only a one per cent reduction in traffic congestion, incidents and emissions in major cities like New York is valued at over $200 million annually.

AI algorithms can also analyse data to predict the likelihood of accidents at specific intersections and preemptively adjust signal timing, issue targeted warnings to drivers or implement other preventive measures. This can significantly reduce congestion, improve safety and minimise emissions.

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During major incidents, AI can rapidly assess the impacts and reroute traffic. Implementation could start with emergency services so they receive automatic priority and public transport, so that the most people can benefit. Buses and trams could receive analysis about real-time traffic conditions to change their routes and schedules and be aware of overall traffic conditions in the network.

AI's capability represents a crucial advantage for resource-constrained governments, as it acts as an intelligent overlay on existing systems, creating greater efficiency through better decision-making and co-ordination.

It can offer long-term analysis of traffic patterns to highlight infrastructure investment needs. It could also reduce the cost of digital infrastructure investment and maintenance by using data-driven, AI-generated patterns generated to replace fixed road sensing technologies currently being used widely by road authorities around the world.

The beauty of AI in mobility is its ability to extract greater efficiency from existing infrastructure without necessarily requiring massive new investments.

For developing countries, AI presents an opportunity to leapfrog traditional, expensive digital infrastructure investments, to provide traffic analysis potentially at orders of magnitude that lower costs, thereby democratising advanced transport management for cities experiencing explosive growth.

Theory into practice

The AIMES project in central Melbourne is operating in a complex, high-traffic environment, providing crucial insights into how AI and C-ITS performs under actual urban conditions rather than in a controlled testing scenario. AIMES researchers have installed a variety of advanced mobility sensing devices at many intersections on over 100 kilometers of road network, north of the Melbourne CBD.

This technology, integrated into a single system, allows researchers to detect, classify and register vehicle movements (including trams, buses and trucks) and that of other road users (pedestrians and cyclists crossing or waiting at intersections) with high precision in real time. The data underpins the development of a comprehensive modelling framework, using AI and machine-learning algorithms, to simulate and optimise the operation and control of smart intersections.

The results so far demonstrate remarkable potential for this technology.

The results so far demonstrate remarkable potential for this technology. If deployed comprehensively on a national scale, it could reduce traffic congestion and emissions as well as improving transport safety, with the potential to reduce accidents to near zero if all vehicles and infrastructure were connected and AI used effectively.

However, this leads to a “chicken and egg” dilemma as vehicle manufacturers wait for transport infrastructure to be ready for vehicles with C-ITS capabilities and infrastructure developers wait for there to be enough connected vehicles on the road.

Some car makers are already incorporating C-ITS capabilities into some of their new models, even when local transport infrastructure cannot yet support full functionality. Other manufacturers are poised to add C-ITS to their vehicles. AIMES is working with government, vehicle manufacturers and technology companies to make this happen.

Policy for transforming transport

To translate transport technological innovation into widespread benefit for society requires sophisticated policy frameworks. The next five to 10 years could see the creation of policy that will shape urban transport systems for decades to come.

AIMES is leading a major national project to create a unified framework for connected vehicles in Australia. This ensures that all systems across the country are harmonised and “speak the same language”, a critical step for a safe and effective rollout.

Current transport policy globally is often misaligned between stated objectives and operational priorities. While governments express commitments to safety and environmental sustainability, transport agencies continue to operate primarily with congestion reduction as their core performance metric.

Effective policy reform would establish congestion, safety and emissions as equally weighted for all transport decisions.

This would require fundamental changes to budget allocation processes, project evaluation criteria and performance management. Every major infrastructure project, technology deployment or operational modification would demonstrate quantifiable benefits across all three objectives.

This integrated approach would transform how transport agencies approach problems. Rather than simply adding traffic lanes to reduce congestion, they would consider how AI and smart infrastructure improves accident rates and emissions. Signal timing would balance traffic flow with pedestrian safety and stop-start emissions. Route planning would consider not just travel time but also safety exposure and environmental impact. The policy framework would establish clear accountability mechanisms and regular public reporting on progress.

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Strategic deployment of connected infrastructure and AI

Successful C-ITS and AI in mobility deployment requires decisive policy intervention to boost the cycle of mutual dependence between the smart capability of vehicles and cities' infrastructure readiness.

Government transport agencies are poised to use pilot programs in various cities to demonstrate the quantifiable benefits of AI and C-ITS to reduce congestion, improve safety and optimise emissions. If these pilots are in high-impact locations, such as intersections known for their safety issues and congestion, this could build public and political support, social proof for wider deployment.

To access these real-time data streams and analyse them with AI, transport agencies would also require policy frameworks that address data governance and ethics and the utilisation of effective AI. These policies would have clear frameworks for the collection, sharing and use of transport data, while protecting individual privacy and ensuring security.

Ethical AI policies would ensure AI algorithms were transparent, auditable and free from bias, and require testing and certification.

Transport agencies would also have to upskill their existing employees so they could effectively procure, deploy and maintain AI systems and recruit new experts in data science and machine learning.

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Implementation requires collaboration

During the next five to 10 years, the successful integration of connected transport systems and artificial intelligence could fundamentally reshape urban transport. Globally, cities that proactively invest in these technologies will gain significant advantages to improve safety and reduce emissions and traffic congestion.

Successful deployment of these technologies requires co-ordinated action across government, industry and research institutions to translate research innovations into commercially viable solutions. Research institutions provide the neutral ground where these diverse stakeholders including vehicle manufacturers, technology providers and infrastructure contractors each collaborate.

Australia has the potential to be a world leader in AI and connected transport. Harmonisation efforts under way across Australian states and territories should ensure that the implementation of C-ITS in Melbourne works seamlessly with existing systems in Sydney, Brisbane and other cities. This would maximise network efficiency while minimising deployment cost and complexity. If these C-ITS and AI systems are integrated internationally, we would see safer, more efficient transport systems worldwide, extending to all modes of travel including sea and air transport, too.

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