



# ANNUAL REPORT 2019

## Planning and Transport Research Centre

March 2020



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### **Version control**

FINAL

### **About PATREC**

The Planning and Transport Research Centre (PATREC) is a collaboration between the Government of Western Australia and local universities, constituted to conduct collaborative, applied research and teaching in support of policy in the connected spaces of transport and land use planning. The collaborating parties are: The University of Western Australia, Curtin University, Edith Cowan University, Department of Transport, Main Roads Western Australia, Western Australian Planning Commission and the Western Australian Local Government Association.

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# 1. INTRODUCTION

## 1.1. Purpose

The primary purpose of this report is to provide an update of activities conducted in 2019 with a focus on outputs and outcomes achieved.

## 1.2. 2019 in Focus

- Two substantive, two-year PATREC-iMOVE CRC projects, completed
  - Enhanced short- and longer-term network performance prediction capabilities through data-driven analytics and simulation
  - Planning intermodal and general logistics infrastructure for the future needs of Perth
- The substantive 18-month Smart Cities and Suburbs program project: RailSmart Planning Wanneroo, completed and awarded the Best “Integration of an Individual Technology Award, 2019” in the Smart Cities Awards Programme
- Three-year, Australian Transport Research Cloud project, Australian Research Data Commons (ARDC), awarded
- Nine new PATREC core projects (2019-2021), approved
- Connection events
  - Over 250 attendees benefitted from six seminars which PATREC hosted or co-hosted
  - Cost-Benefit Analysis Seminar Series attended by 191 participants
- Publication of nine peer-reviewed academic papers and eight technical reports and presentation of ten conference papers, two of which were published in proceedings
- Stakeholder satisfaction rate increased to 89.5%

# 2. RESEARCH PROJECT ACTIVITY

## 2.1. Projects completed

Two major two-year PATREC/iMOVE CRC projects were **completed**, each with three substantive components:

- Planning intermodal and general logistics infrastructure for the future needs of Perth
- Enhanced short- and longer-term network performance prediction capabilities through data-driven analytics and simulation

Seven external projects, not using any PATREC core funds, were conducted as follows:

- The substantive 18-month Smart Cities and Suburbs program project: RailSmart Planning Wanneroo, was completed.
- Two smaller external projects completed:
  - Pulse of Perth Visualising Public Transport Data Study, RAC
  - Incident Prediction, Main Roads WA
- Three projects in progress:
  - Drone Video Analytics, Main Roads WA
  - Multi-Objective Genetic Algorithm Optimisation for Network Widening and Maintenance Scheduling, Main Roads WA
  - iMOVE ITS Supplementary Research, Main Roads WA

- Three-year, Australian Transport Research Cloud project, Australian Research Data Commons (ARDC), awarded

Nine new PATREC core projects (201 9-2021) were **approved**, packaged into three PATREC/iMOVE CRC projects and two PATREC-only core projects.

These projects are summarised below.

### Planning intermodal and general logistics infrastructure for the future needs of Perth (Completed)

PATREC-iMOVE CRC Project 2-001 (\$320,000; January 2018-December 2019; UWA, ECU, MRWA, DOT)

#### Intermodal Systems for Perth


(especially in the context of the state government's Westport program)

#### Intermodal System Options

**Research question:** *What are the pertinent issues and an overview of some successful national (Sydney) and international intermodal operations?*

**Key findings**

- Smaller ports such as Prince Rupert (Canada) and Tauranga (NZ) demonstrate the simplicity of design that is possible when setting up a new port terminal primarily as an intermodal gateway.
- Moorebank in Sydney warrants close attention over the coming years particularly the benefits of integration and control along the intermodal supply chain.
- Port authorities or owners in smaller single terminal ports, often have some incentive to be involved in the management of container logistics function, especially intermodal functions. Australian ports generally fall into that category, and yet the landlord model is currently the dominant paradigm.



*Simple layout of Tauranga, Auckland, NZ container berth (Source: Google)*

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#### Intermodal Systems Structures

**Research question:** *What types of intermodal system exist around the world in terms of the scale of rail transport task, governance, ownership and infrastructure layout and what are the implications for Perth?*

**Key findings**

- The intermodal system in Perth lacks some of the advantages that successful systems have elsewhere due to:
  - Not having the problem of heavy road congestion around the port, to the extent that road freight charges are affected.
  - Competitive pressure on road freight operators making cost recovery difficult if there are delays or system inefficiencies.
  - Not having a public sector freight track operator to provide capital improvements and/or subsidise access costs.
- It is thus critical that some of the other factors of success are present (both for the existing Inner Harbour system and the potential new system at an Outer Harbour location):

Tauranga, NZ		Component		Aspect		Characteristics	
intermodal demand	market type	domestic	domestic	domestic	domestic	domestic	domestic
	market class	domestic	domestic	domestic	domestic	domestic	domestic
IMT	ownership	private (Common user)	private (Common user)	private (Common user)	private (Common user)	private (Common user)	private (Common user)
	location	regional	regional	regional	regional	regional	regional
trails	ownership	private	private	private	private	private	private
	operation	private	private	private	private	private	private
track network	ownership	private (Common user)	private (Common user)	private (Common user)	private (Common user)	private (Common user)	private (Common user)
	operation	private	private	private	private	private	private
port terminal	ownership	private	private	private	private	private	private
	operation	private	private	private	private	private	private
port management	ownership	public	public	public	public	public	public
	operation	public	public	public	public	public	public
intermodal system performance	operational	price	price	price	price	price	price
	operational	time	time	time	time	time	time
intermodal system performance	distance	distance	distance	distance	distance	distance	distance
	operational	operational	operational	operational	operational	operational	operational
intermodal system performance	operational	operational	operational	operational	operational	operational	operational
	operational	operational	operational	operational	operational	operational	operational

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- High level of integration along the chain between eg. the rail terminal and customers, the wharf and the rail terminal (port operator, stevedore lessees) and between the port and terminal management, in order to minimize cost and inconvenience to intermodal services
- Strong alignment of commercial interests and infrastructure design at the port – this is more important than joint ownership at distant intermodal terminals
- A truly aligned port intermodal interface needs to be created, following an integrated model, borrowing from some features of the systems that operate in Sydney and at Tauranga, but accounting for Perth’s local geographical, commercial and administrative conditions.

### Intermodal Demand Projections

**Research question:** *What is the likely growth in container trade volumes over the short to medium term, and how will this translate into demand growth for intermodal services, both at the existing Inner Harbour container berths, and any new berths at the Outer Harbour?*

**Key findings:**

- Estimated trade volumes 2027/28 (full containers) based on commodity-specific indicative growth rates suggest a total full container trade (exports plus imports) of 756,000 TEU by 2028.
- Total port trade by 2028 could amount to around 950,000 TEU (including empty containers: empty imports estimated at 25,000 TEU; empty export estimated at 164,000 TEU)
- It appears that the largest volumes available to a new IMT will be in the eastern area north of the Forrestfield IMT.
- The volumes available in more inner areas eg from Kenwick to Jandakot would appear to be lower, and more susceptible to the import/export imbalance issue (due to the lesser distance to port).
- The availability of export volumes may well be the catalyst for new IMT development, and these volumes could come to the rail system at many different points within and outside the metropolitan area.
- Export growth is most likely to be in agricultural commodities or new niche mineral volumes, originating well outside the metropolitan area.

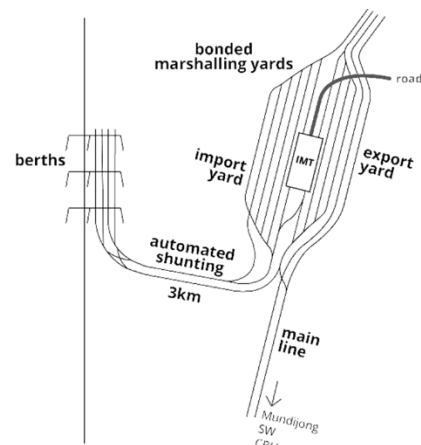


### Intermodal Structures – Options and Cost-benefit outcomes

**Research question:** *What is the commercial and operational potential of intermodal rail services for key future port options, and what is an appropriate methodology for determining the costs and benefits of intermodal rail systems investment?*

**Key findings:**

- The modal share of containerised rail freight under the range of container port design and location options will be a function of many factors, including:
  - Trade annual growth rate to 2068
  - Port terminal infrastructure design
  - Duplication of rail corridors
  - Development of outer metro industrial areas and IMTs
  - Integration of rail freight operations



- Depending on how these factors take shape, intermodal rail services have very strong potential to be substantially cheaper than road transport services for a large percentage of importers and exporters.
- Based on an agreed set of assumptions about trade growth patterns and infrastructure development, a methodology has been developed enabling the assessment of future intermodal market share and the modelling of the cost savings to the economy (direct freight cost savings to industry) of alternative port development options.
- A critical data source required for applying the methodology is the Land Use and Employment Survey, 2017 (Department of Planning, Lands and Heritage), providing lot-level detail of the nature and scale of economic activity across Perth. The geographical specificity provides the basis for a comparative road vs intermodal rail cost assessment to estimate the economic benefits of a new efficient intermodal rail network to all importers and exporters.

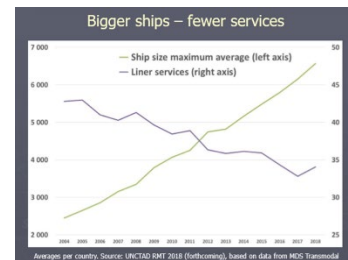
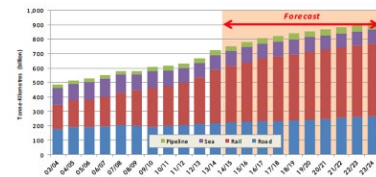
## Global Supply Chain Trends and Local Perspectives

(especially in the context of the state government's Westport program)

**Research question:** *What are some of the major global changes in supply chain systems and control, including blockchain technologies, and what are the potential impacts in Perth and WA?*

### Key findings

- Global trends
  - Container terminals, warehouses and distribution functions are increasingly becoming automated, using machine learning to accelerate processes
  - 'Big data' and IT investments are changing the ways in which firms relate to each other with high levels of control over long sections of the value chain by those who own and manage the data best
  - IT developments including blockchain will bring about cost savings for individual companies. Main impact - reductions in back-office cost, greater speed of regulatory approvals and potential to eliminate wasteful handling and transport tasks. Unlikely to impact significantly on the fundamental tasks of container handling and logistics functions in the port city.
  - GPS fleet management systems give transport companies better real-time information on freight activity, assisting with cost-competitiveness. The most significant changes from the routine use of GPS tracking data will likely come from roads authorities, in compliance and road user charging.
- Local perspectives on global trends
  - Freight activity may decrease due to an increase in local manufacturing supported by technological developments such as 3D printing
  - High productivity vehicles (HPVs) could reduce the number of trucks on the road but could equally reduce the rail task due to increased cost differentials
  - Air freight, including drones, could increase due to transport of small packages and lightweight goods associated with the growth of online shopping
  - Consolidation of shipping lines, vertical integration of large logistics companies and a reduction in road transport owner/operators are expected to continue and will impact on the structure of freight and logistics in Australia
  - Automation will continue to be used for repetitive, heavy work and increasingly reduce the number and size of the human workforce. Robotics and automated warehousing will displace manual workers and a larger workforce with technical knowledge and skills will be required. Union resistance could slow these changes
  - Shared freight deliveries will become more evident as companies try to "uberise" freight
  - Government policy was a concern in relation to imposing constraints on innovation
  - Greater collaboration between the private and government sectors is a priority.
  - The government role is seen as regulating access to infrastructure, providing policy certainty, facilitating data sharing

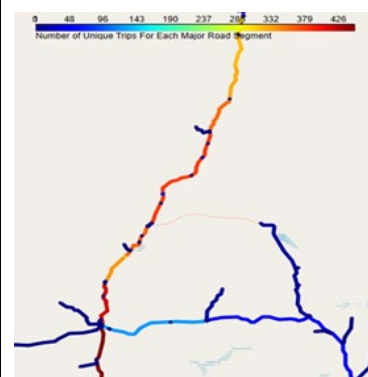


## Telemetry Systems for Tracking Road Freight Activity

**Research question:** Can BITRE's YULO software be adapted to monitor trucking activity in short-haul urban environments to supplement major commercial vehicle surveys and inform local and state transport planning and policy?

### Key findings

- BITRE's YULO framework is viable for application in analysing short-haul, urban freight activity
- YULO is able to succinctly analyse and visualise aggregated and single trip information for use in policy and planning.
- As part of the adoption of the framework from regional activity analysis to urban / short-haul freight analysis the following adaptation were implemented and shared with BITRE:
  - Re-implementation of most of the existing front-end into Python to facilitate faster prototyping
  - Creation of a directed road network 'mini-segments' shapefile for better visualisation of urban routes
  - Implementation of the directionality of travel on road segments in the Neo4j back-end
  - The ability to save interactive maps as stand-alone files for sharing with stakeholders
  - Development of a weighted routing algorithm
  - Initiated shapefile merge, periodicity mining and top-k paths of length-p algorithms
- The adapted YULO software was tested using GPS data for Oversize-Overmass (OSOM) escort vehicles made available by Main Roads WA, Heavy Vehicle Services.
  - Demonstrated the power of GPS telemetry databases for future governmental use in the management of the road network, vehicle registration system and administration of the freight transport industry
  - Specifically for MRWA, this analysis provides pointers as to how the OSOM escort fleet management data routinely produced and stored, might be useful for other purposes, both within the narrow management interest, and into the realm of highway planning.
  - Escort vehicle data is significant, as it provides proxy information on routes taken by a subset of heavy freight vehicles in Perth and WA, as well as details on the performance of vehicles under escort, and the average speeds achievable by freight vehicles on all sections of the highway network.

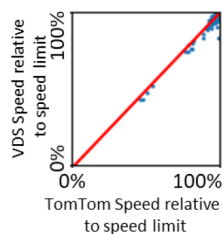


## Enhanced short- and longer-term network performance prediction capabilities through data-driven analytics and simulation (Completed)

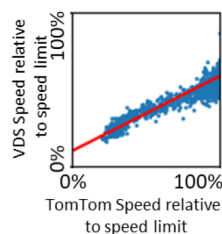
PATREC-iMOVE CRC Project 1-003 (\$280,000; January 2018-December 2019; UWA/MRWA)

### Short-term Traffic Speed Prediction for Perth Roads Using Machine Learning

**Purpose:** This project focused on short-term prediction of average speed for individual road sections in the Perth metropolitan road network up to a horizon of 75 minutes in advance. Good short-term predictions enable a pro-active approach to network operations, such as stopping gridlock before it appears, preventing queue spillbacks and also enable faster incident detection and recovery. This investigation used machine learning techniques that learn from the past to predict the future. The hypothesis was that machine learning could extract hidden value from the existing datasets that would improve prediction performance over naïve and traditional approaches.

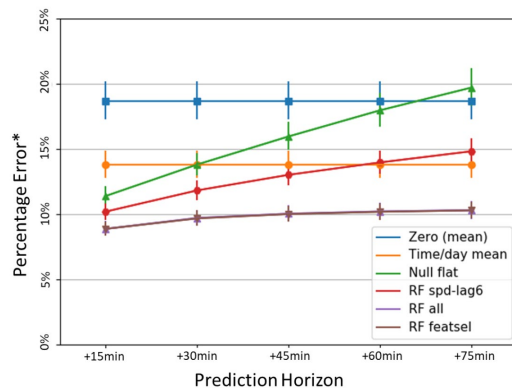


a.) An example of good alignment between VDS and GPS1 data points (M-Link 201)



b.) An example of good alignment between VDS and GPS1 but with some systematic error (M-Link 339)

**Key findings:** This project successfully applied machine learning techniques to short-term prediction of average speed for road sections. The proposed Random Forest (RF) models can extract hidden value from existing datasets and have been shown to be robust and perform well against the benchmarks (naïve and traditional approaches). Their advantage becomes obvious with an increasing prediction horizon. Accuracy does not substantially decrease with an increasing prediction horizon: during the AM and PM peaks, predicting 15 minutes ahead will produce an average percentage error of about 9% while for 75 minutes it is just above 10%.



### Implementing Multi-Zone Perimeter Controls on Perth's Road Network

**Purpose:** Ramp metering is one of the cornerstone solutions of Smart Freeways and is used to regulate traffic inflow at on-ramps to prevent flow breakdowns so it can remain reliable while delivering higher throughput. This project investigates the possibility of applying perimeter control that is based on a similar idea but expands it to the whole network. Perimeter control (also known as gating) works by dividing the network into multiple zones and regulating their flow exchange at the boundaries. It aims at load-balancing between zones across the network to achieve a stable and optimum operation at the global level. Macroscopic Fundamental Diagrams (MFDs) are used in this research to understand the behaviour of each zone in terms of the

**Key findings:**

- The four metropolitan network performance sub-areas (quadrants) have clear MFDs which do not ever reach critical density (the maximum vehicles/lane-km before congestion happens). It is primarily because these large regions seldom enter a congested state as a whole. Therefore, they needed to be subdivided into smaller zones for perimeter control.
- We adopted a top-down approach by bisecting the four network performance sub-areas until desired MFDs with low scatter and clearly defined critical density were found. The end result is 38 zones across the metro network. Zones with high

relationship between speed, flow and density. The accurate measurement of MFDs has become possible with the advent of 'big data'. If successful, it can maximise the productivity and reliability of the whole network by utilising spare capacity in zones with low demand-to-capacity ratio to alleviate stress for those under high demand.

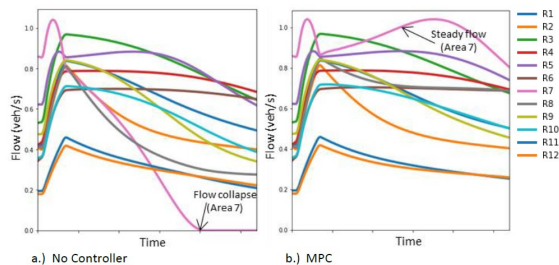


Figure 11 Results of the twelve-zone simulation\*

traffic demand tend to have more usable and well-behaved MFDs that indicate a critical density or 'tipping point' while still having low scatter. Conversely, zones with low traffic demand tend to have less-than-ideal MFDs with higher scatter and no clear indication of critical density, these zones would derive less benefit from the implementation of perimeter control

- We simulated the performance of MFD-based perimeter control using mathematical models. The results show the control strategy, regulating traffic flows at boundaries using signalling, can avoid flow breakdown of the congested zones. Although the traffic was slowed in zones that act as the buffer, the whole network performed substantially better. Travel time for completed trips decreased by 12% in the twelve-zone model.

## Simulating the Traffic Impact of AVs and CAVs on Perth's Freeways and Arterial Roads

**Purpose:** This project marks the first step towards understanding the potential traffic impact of AVs and CAVs on Perth's freeways and arterial roads.

The aim is not to predict the precise future but to estimate the range of possibilities by establishing the upper and the lower bounds that form the best and worst-case scenarios.

The purpose was to quantify the impact on Perth's road network if CAVs and AVs are mixed in with human-driven vehicles (HDVs) considering current levels of demand and infrastructure.

Detailed microsimulation experiments were used as this is the most cost-effective method to test future traffic scenarios whilst still producing realistic results. Unlike some more abstract models, each vehicle's movement is explicitly simulated at every time step. Utilising real demand data, road infrastructure and driving models derived from the literature, the predicted effects on traffic performance were analysed.

Three Aimsun models were used for testing - Mitchell Freeway, Stirling Highway and Canning Highway. They are representative of typical freeways and arterial roads so the results are assumed to be generalizable across the Perth

### Key findings:

- Both AVs and CAVs could improve the operations of both freeways and arterials but more so, freeways. This is despite being tested using a wider (than HDVs) range of performance parameters (eg. lower acceleration and deceleration rates to improve comfort). The results imply increased road capacity when AVs and CAVs are prevalent but the disproportionate increase between freeways and arterials could cause a mismatch between their performance which could cause bottlenecks at places where they connect ie. ramps.
- The best-case scenarios were produced by CAVs at 100% market penetration with significant improvement. The average delay (the difference between actual travel time and free-flow travel time) on the Mitchell Freeway was reduced from the current value of about 28 sec/km to just 1 sec/km. For Canning Highway, it was the difference between 89 sec/km and 41 sec/km, less dramatic but still a 54% reduction from the base case of 100% human driven-vehicles (HDVs).

road network. By analysing changes in traffic performance, we can understand their impacts and better plan for when these technologies are employed. The broader demand-side uncertainties such as consumer adoption rates, vehicle ownership, demand changes were outside of the scope of this project.

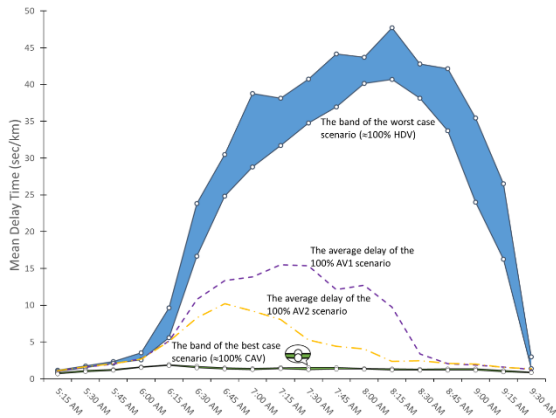


Figure 4: Time series of mean delay times for different scenarios (Mitchell Freeway, southbound, AM peak)

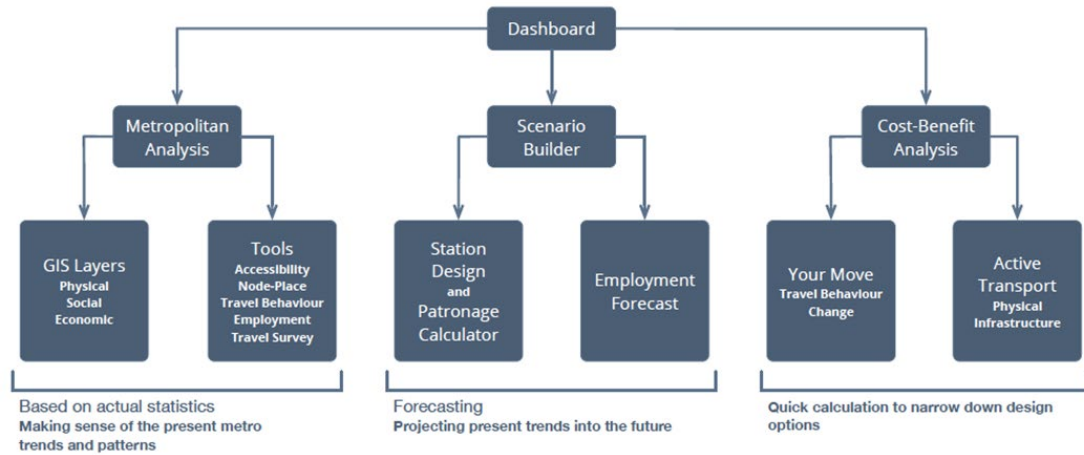
- 100% CAVs not only significantly improved the traffic operations but also travel time reliability, leading to more predictable journey times.
- The best cases were dominated by CAVs even without 100% market penetration. Average delay time decreases with increasing CAV market share as expected. However, although the 80% CAV scenario has a close average performance to the 100% CAV scenario, only the latter avoided any significant peak all together and produced much more constant traffic condition throughout the morning rush hour for the Canning Highway model.
- Reaction time appears to be the most significant factor affecting performance among all simulated variables. CAVs benefited largely from having zero reaction time in the simulations.
- There might be unintended consequences such as high-density flow achieved by a platoon of CAVs which could create difficulties in merging and lane changing.

## External Projects (not using PATREC core funds)

### RailSmart Wanneroo Planning Support System [www.railsmart.patrec.org](http://www.railsmart.patrec.org)

*Smart Cities and Suburbs Grant (\$1 million; Jan 2018 – June 2019; City of Wanneroo, DOT, UWA)*

**Completed**



**Purpose:** To assemble, adapt and apply a suite of innovative, evidence-based Planning Support Tools utilising smart city data integrated from multiple sources to better enable local government to maximise the opportunities generated by significant public transport infrastructure investment for the achievement of desired land use and transport outcomes in fast-growing, outer metropolitan areas.

Integrating and analysing data from multiple sources and sensor networks, this suite of Planning Support Tools provides more sophisticated information and capabilities for evaluation and monitoring of the development impacts of alternative land use and transport planning solutions to support decision making and improve governance at local and state level.

To this end, the open-source, **RailSmart Dashboard** was developed as a proof-of-concept planning support system to provide evidence to support decision making relating to development around three new railway stations in the local government area of Wanneroo in the Perth. It was developed specifically to forecast public transport patronage and potential job creation facilitated by the extension of the northern heavy rail line from Butler Station to Yanchep; including three new stations: Alkimos, Eglington and Yanchep.

**Key components:** The dashboard comprises three sections:

- Metropolitan Analysis - five tools and GIS layers
  - Tool 1: Activity centre node-place analysis and activation tool - a detailed analysis of all train station precincts with respect to their Place, Node, and Background Traffic characteristics
  - Tool 2: Railway Usage Analysis and Travel Behaviour - analysis of SmartRider data
  - Tool 3: Enhanced Employment Self Sufficiency Tool – based on numbers and ratios of strategic-driven or population-driven jobs
  - Tool 4: Dynamic Accessibility Planning Tool – accessibility (travel time), by both private transport and public transport, of jobs, dwellings and population
  - Tool 5: Last Mile Tool - based on a survey to identify propensity of households to adopt sharing economy transport options
- Scenario Builder – allows what-if selection of desired station typology, returning design requirements (including employment and density) and estimated patronage impacts.
- Cost-Benefit Analysis - quantifies anticipated economic benefits of travel behaviour change programs and projects – impacts of 1) mode shift from car and 2) provision of physical infrastructure to aid active travel

Project title and status	Description
<p><b>Completed</b></p> <p>Pulse of Perth Visualising Public Transport Data Study RAC; 2018-2019)</p>	<p>Complex public transport (PT) datasets, including the SmartRider transactional dataset, are visualised and summarised in order to better understand PT travel patterns and network constraints within the Perth metropolitan and Peel regions including:</p> <ul style="list-style-type: none"> <li>• How demand varies across the PT networks (bus, train and ferry) during a typical weekday;</li> <li>• Where demand is approaching or is at capacity of the line, route or service (“patronage congestion hotspots”)</li> <li>• Where there are constraints on the bus network, where bus-bunching, delays or reliability issues are occurring and bus priority measures may be beneficial</li> </ul>
<p><b>Completed</b></p> <p>Incident prediction (\$32,000; Main Roads WA)</p>	<p>Traffic accident modelling based on historical data using observed traffic data (an advance on using speed limit data as per current practice)</p>
<p><b>In progress</b></p> <p>Drone Video Analytics (\$85,000; Main Roads WA; 1 May 2019 – 31 March 2020)</p>	<ul style="list-style-type: none"> <li>• Explore new techniques for automated camera calibration - automated camera calibration is necessary to make the system operational. The feasibility of a few new techniques will be explored</li> <li>• Video analytics from drone footage at signalised intersections</li> <li>• Video analytics from drone footage at roundabouts</li> </ul>
<p><b>In progress</b></p> <p>Multi-Objective Genetic Algorithm Optimisation for Network Widening and Maintenance Scheduling (\$120,000, Main Roads WA; 1 Nov 2019 – 31 Aug 2020)</p>	<p>The objective of the project is to incorporate the use of MOGA to optimise locality and timing of integrated works between road widening and maintenance. Specifically, outcomes of the MOGA will minimise costs by integrating work while improving road user experience and safety by targeting the highest benefit roads. The outcomes of the MOGA will reflect the MRWA perspective on decision making allowing for consistency with ISO55000.</p>
<p><b>In progress</b></p> <p>iMOVE ITS Supplementary research (\$200,000; Main Roads WA; January 2019 - September 2020)</p>	<ul style="list-style-type: none"> <li>• Data fusion – software package delivered but validation required using alternate on-the-ground data as a next stage</li> <li>• SILO – agent-based simulation - waiting for ABS 5% data software environment to be set-up to enable interrogation of the 5% microdata sample for creating a better synthetic population (at moment have a synthetic dataset but based on 1% sample).</li> </ul>
<p><b>Awarded</b></p> <p>Australian Research Data Commons (ARDC), Australian Transport Research Cloud (\$450,000; Lead: AURIN; 2020-2022)</p>	<p>Will provide a common platform (data, storage, compute and tools) to support the needs of the Australian transport research community, providing access to key datasets and open-source, analysis and modelling tools:</p> <ul style="list-style-type: none"> <li>• Datasets including: ABS Census and Journey to Work datasets; State Household Travel Surveys; National Road network datasets; real-time traffic and public transport data; people flow data (e.g., Telstra Location Insights data); public transport timetable data; and de-identified smart travel card datasets</li> <li>• Tools (Open Trip Planner (OTP) and gtfspy), transport accessibility tools, urban mobility simulation (SUMO) and transport network modelling tools (MATSim)</li> </ul>

## 2.2. New PATREC core projects approved

At the Board meeting held on 28 November 2019, the Board approved a suite of projects to be conducted using core funding, with some being run through the iMOVE CRC, during 2020-2021.

Project title	Components and Objectives
<p>iMOVE 3: Managing transport system investment risk: enhancing patronage predictions and adapting strategic asset management and appraisal processes to account for emerging trends and uncertainty</p> <p><i>For transport planners and government transport agencies, the uncertainties of emerging technologies and changing trends challenge conventional transportation decision-making, both for long- and short-term planning. The purpose of this project is to adapt key existing planning tools, guidelines and frameworks to account for the uncertainty of changing trends and emerging technologies. This will enable the Transport Portfolio of WA to better manage transport infrastructure investment risks</i></p>	<p><b>Understanding systematic factors driving patronage shifts:</b> To determine the systemic factors driving patronage shifts (including long term labour market characteristics, the post-GFC demographic shifts, increased capacity in road infrastructure, CBD parking costs and transport trends such as: ridesharing, licenses, fuel prices, vehicle ownership), to (i) enhance the public transport patronage forecasting model for the improved prediction of fare revenues, operating subsidy requirements, levels of service provision and service innovations and (ii) facilitate the development of a range of customer-centric initiatives to optimise (public transport-related) travel behaviour.</p> <p><b>Determining digital journey planning app impacts on patronage:</b> To understand customer experiences of digital journey planning services and influence on mode share for all routine trip purposes (work, school, shopping, recreation, etc) and identify potential improvements to journey planning services in order to ultimately inform the development of a range of customer-centric initiatives to optimise (non-car based) travel behaviour.</p> <p><b>Adapting strategic asset management practice to account for uncertainty:</b> To identify specific impacts of specifically, CAV, disruptive technologies on road (and road/rail interface) asset management practice as well as response actions and opportunities for innovation in order to adapt templates and guidelines</p> <p><b>Adapting the Portfolio's infrastructure project assessment and prioritisation framework to account for uncertainty:</b> To propose adaptation strategies to appraise the uncertainties of emerging technologies within the project assessment and prioritisation framework to ensure that advice to decision-makers explicitly considers potential future changes to the transport systems.</p>
<p>iMOVE 4: Enhanced Vehicle Detection</p>	<p>To investigate alternative vehicle detection technologies for traffic signal control and smart freeway operations through a comparative desktop analysis and field trials of shortlisted technologies at two locations (intersection and freeway) in order to inform the future enhanced detection installation business case and delivery strategy</p>
<p>iMOVE 5: ITS phase 2, modelling support</p>	<p><b>iMOVE ITS Phase 2:</b> To undertake agent-based simulation of land use and transport scenarios during the transition to CAV to determine impacts on land use and transport systems</p>

	<b>LU-T modelling – CubeLand support:</b> To provide customised econometrics training and international best practice review of bid-rent parameters to support the deployment of CubeLand
Public confidence in use and roll-out of shared, automated and electric – retirement village shuttle bus trial	To provide unique experimental data on the effects of exposure to and trial of a SAEV on older people’s attitudes, intentions, and behaviours relating to SAEV use. Specific research objectives are to: <ul style="list-style-type: none"> <li>• Assess older people’s receptiveness to using SAEVs.</li> <li>• Measure whether access to a SAEV increases mobility around a retirement village site.</li> <li>• Determine whether exposure to and/or use of the SAEV on retirement village premises changes attitudes to SAEVs and intentions to use SAEVs in other contexts.</li> <li>• Assess the potential for older people to interact with a SAEV by using hand/arm gestures to flag down the vehicle.</li> </ul>
Industrial land analysis – freight demand forecasting	To further our understanding of Fremantle container trade and its relationship to freight transport usage across Perth and Western Australia. A particular focus of the project is to assist in the analysis of intermodal freight activity and to inform government policy aimed at improving intermodal usage into the future. The project includes an analysis of the following aspects of the issue: <ul style="list-style-type: none"> <li>• Identification and analysis of recent container trade growth trends</li> <li>• Short term container trade growth forecasts</li> <li>• Comparison of trade data with business enterprise data for Perth to link trade with land use and freight activity</li> <li>• Description of the industrial landscape of Perth in the context of intermodal terminal planning</li> <li>• Implications of findings for intermodal strategy and policy</li> </ul>

## 3. KNOWLEDGE TRANSFER

### 3.1. PATREC Connection Events

- Seminar held on 21 February 2019 - Public Confidence in Shared, Autonomous, and Electric Vehicles: Australian and WA Research Findings - more than 80 attended. Presentations:
  - Carey Curtis & Doina Olaru: Planning for Disruptive Transport Technologies: How Prepared are Australian Transport Agencies?
  - Simone Pettigrew: How Australians think and feel about AVs
  - Doina Olaru & Brett Smith: Autonomous Vehicles Down Under: An Empirical Investigation of Consumer Sentiment
- iMOVE-PATREC seminar held on 26 February – invitation only – 50 attended including iMOVE Board members. Presentations:
  - Enhanced short- and longer-term network performance prediction capabilities through data-driven analytics and simulation: Dr Chao Sun, Project Leader
  - Planning intermodal and general logistics infrastructure for the future needs of Perth: Tim Hoffman, Project Leader

- PATREC summary and future directions: Professor Sharon Biermann, PATREC
- Seminar held on 14 June 2019: Simona Mihaita, Future Transport Mobility Lab at the University of Technology in Sydney in the School of Computer Science. Her main research focus is how to engage traffic simulation and optimization using machine learning and artificial intelligence to improve traffic congestion, predicting the duration of traffic accidents and estimating their urban impact, while also leveraging smart analytics for connected and autonomous vehicles in a smart city environment.
- Seminar held: Smart Cities, Smart Planning Tools: RailSmart Planning Dashboard – held on Tuesday, 29 October 2019 at the Australian Urban Design Research Centre (AUDRC). The purpose of the seminar was to provide a high-level overview of the dashboard and present more detail on the individual tools which make up the system (43 attendees)
- Seminar held on 4 December 2019: Joint UWA School of Population and Global Health and PATREC Seminar: Cities, cars and health: what road shall we travel? Presentation by Prof Mark Stevenson, Professor of Urban Transport and Public Health, The University of Melbourne, at AUDRC (65 attendees).
- Seminar held on 12 December 2019: Urban Transport Inequalities: the case of Malta, Presentation by Maria Attard, Professor in Geography, Director of the Institute for Climate Change and Sustainable Development, University of Malta, at AUDRC (10 attendees).
- The Director participated as an invited panel speaker in the session Transport and Mobility as part of the Climate Change Symposium held at UWA on 11 November 2019. The title of her presentation was: Congestion busting, Emission lowering? Highlighting some recent WA planning and transport policy research findings with implications for a State Climate Policy. The purpose of the symposium was to inform better discussion of and submissions to the State's Climate Policy process. A "Climate Change issues paper" was released in early September to launch a period of consultation, which closes on 29 November. <https://ccs19.com.au/>
- Dr Sae Chi presented as an invited panellist (costs paid) on the Perth USAsia Centre Panel: "Building bridges: Indonesia and the infrastructure 'cold war'", convened as part of the Conference on Indonesian Foreign Policy (CIFP) November, 2019: Cooling Off the Hot Peace: Strategic Opportunities and Economic Remedies for a Distressful World <https://perthusasia.edu.au/events/upcoming-events/conference-on-indonesian-foreign-policy>
- Cost-Benefit Analysis Seminar Series 2019: With the support of the DoT's Portfolio Investment Coordination team and DPLG's CubeLand modelling group, PATREC's Dr Sae Chi delivered a series of CBA seminars with a particular focus on transport infrastructure over the course of 3 weeks in August 2019. Comprising six, 2-hour sessions in all (two sessions each for three levels of complexity - Introduction, Intermediate and Advanced), almost 200 attendees from transport portfolio agencies including DoT, MRWA and PTA, and other agencies such as DPLH and Treasury, participated.

Level	Date	Attendance numbers
Introduction	August 7	47
	August 8	32
Intermediate	August 12	42
	August 13	25
Advanced	August 21	33
	August 22	12
<b>TOTAL</b>		<b>191</b>

## 3.2. Research Outputs

The focus of PATREC's research outputs in 2019 was on the publication of final reports for the iMOVE CRC and Smart Cities and Suburbs RailSmart Planning Wanneroo projects, with seven substantive technical report produced amongst them, as well as the RAC Pulse of Perth final report (Table 3). Nine peer-reviewed journal papers were published in 2019. A total of ten conference papers were presented with two published in proceedings. Twelve journal papers were submitted, re-submitted or accepted for publication (Table 4).

**Table 3: Research Outputs in 2019**

Publication Title	Authors	Date
<b>RESEARCH PROJECT TECHNICAL REPORTS COMPLETED</b>		
Enhanced short- and longer-term network performance prediction capabilities through data-driven analytics and simulation: <b>Implementing Multi-Area Perimeter Controls on Perth's Road Network</b> (iMOVE 1-003)	Noah Lester, Sergio Matias Banchemo, Thomas Stemler, Chao Sun & Sharon Biermann	Dec. 2019
Enhanced short- and longer-term network performance prediction capabilities through data-driven analytics and simulation: <b>Short term traffic prediction using data-driven analytics and machine learning</b> (iMOVE 1-003)	Chris Bartley, Chao Sun, Mark Reynolds, Wei Liu & Sharon Biermann	Dec. 2019
Enhanced short- and longer-term network performance prediction capabilities through data-driven analytics and simulation: <b>Simulating the traffic impact of AVs and CAVs on Perth's freeways</b> (iMOVE 1-003)	Liam Cummins, Yan Ji, Chao Sun, Thomas Stemler, Doina Olaru & Sharon Biermann	Dec. 2019
Planning intermodal and general logistics infrastructure for the future needs of Perth: <b>Intermodal Systems – Options, Structures and Demand</b> (iMOVE 2-001)	Tim Hoffman, Sae Chi & Sharon Biermann	Dec. 2019
Planning intermodal and general logistics infrastructure for the future needs of Perth: <b>Supply Chain Trends - Global Trends and Applicability to Perth and WA</b> (iMOVE 2-001)	Craig Standing, Susan Standing, Ferry Jie, Tim Hoffman & Sharon Biermann	Dec. 2019
Planning intermodal and general logistics infrastructure for the future needs of Perth: <b>Telemetry Systems for Tracking Road Freight Activity</b> (iMOVE 2-001)	Tim Hoffman, Daniel Cowen, Rachel Cardell-Oliver & Sharon Biermann	Dec. 2019
RailSmart Planning Support System (Smart Cities and Suburbs)	Linda Robson, Sharon Biermann, Tristan Reed, Doina Olaru, Brett Smith, Kirsten Martinus, Sae Chi, Rachel Cardell-Oliver, Chao Sun, Craig Standing, Susan Standing, Ferry Jie & Candice Parsons	June 2019
Pulse of Perth SmartRider Data Visualisation (RAC)	Tristan Reed, Yan Ji, Chao Sun & Sharon Biermann	Mar. 2019
<b>PEER-REVIEWED JOURNAL PAPERS AND BOOK CHAPTERS PUBLISHED</b>		
McLeod S, Schapper, J.S.M, Curtis, C & Graham, G (2019) Conceptualizing freight generation for transport and land use planning: A review and synthesis of the literature, <i>Transport Policy</i> , 74, Feb, 24-34. <a href="https://doi.org/10.1016/j.tranpol.2018.11.007">oi.org/10.1016/j.tranpol.2018.11.007</a>		
Olaru, O, Moncrieff, S, McCarney G, Reed, T, Sun, Y, Pattison, C, Smith, B and Biermann, S (2019). Extending the Node-Place Model and Policy Implications, <i>Sustainability</i> 11(2), 477. <a href="https://doi.org/10.3390/su11020477">doi.org/10.3390/su11020477</a>		

Taplin, J. and Sun, Y (2019) Optimizing bus stop locations for walking access: stops-first design of a feeder route to enhance a residential plan". *Environment and Planning B: Urban Analytics and City Science*. doi.org/10.1177/2399808318824108

McLeod, S & Curtis, C (2020): Understanding and Planning for Freight Movement in *Cities: Practices and Challenges, Planning Practice & Research*, DOI:10.1080/02697459.2020.1732660

Pettigrew, S, Worrall, C, Talati, Z, Fritschi, L & Norman, R (2019) Dimensions of attitudes to autonomous vehicles, *Urban, Planning and Transport Research*, 7:1, 19-33  
doi.org/10.1080/21650020.2019.1604155

Pettigrew, S, Mitiku Dana, L, & Norman, R (2019) Clusters of potential autonomous vehicles users according to propensity to use individual versus shared vehicles, *Transport Policy*, 76, 13-20.  
doi.org/10.1016/j.tranpol.2019.01.010

Pettigrew, S & Cronin, S.L (2019) Stakeholder views on the social issues relating to the introduction of autonomous vehicles, *Transport Policy*, 81, 64-67.  
doi.org/10.1016/j.tranpol.2019.06.004

Booth, L, Norman, R & Pettigrew, S (2019) The potential implications of autonomous vehicles for active transport *Journal of Transport & Health*, 15, 100623. doi.org/10.1016/j.jth.2019.100623

Owaidah, A., Olaru, D., Bennamoun, M., Sohel, F., Khan, N. (2019) Review of Modelling and Simulating Crowds at Mass Gathering Events: Hajj as a Case Study, *Journal of Artificial Societies and Social Simulation*, 22(2),9 <http://jasss.soc.surrey.ac.uk/22/2/9.html>.

#### CONFERENCE PAPERS PRESENTED AND PUBLISHED IN PROCEEDINGS

Cardell-Oliver, R. & Sangam, P. (2019) Tracking the Evolution of Public Transport Demand using Spatial-Social-Temporal Contexts, In Proceedings of the 6th ACM International Conference on Systems for Energy-Efficient Buildings, Cities, and Transportation (BuildSys '19). ACM, New York, NY, USA, 179-182. doi.org/10.1145/3360322.3360870.

Reed, T. W., & Robson, L. (2019). Transport Planning with a Web Planning Support System. ATRF, Canberra, 30 Sep-2 Oct.  
[https://www.australasiantransportresearchforum.org.au/sites/default/files/papers/ATRF2019\\_resubmission\\_40.pdf](https://www.australasiantransportresearchforum.org.au/sites/default/files/papers/ATRF2019_resubmission_40.pdf)

#### CONFERENCE PAPERS PRESENTED

Smith, B., Olaru, D., and Tang, X. (2019) Identifying Customer Segments for Autonomous Shuttles: A Quick On Board Survey, ATRF, Canberra, 30 Sep-2 Oct.

Harms, T., Olaru, D., and Pattison, C (2019) Using wearable technology to analyse daily travel behaviour, ATRF, Canberra, 30 Sep-2 Oct.

Olaru, D., Smith, B., Boruff, B., Biermann, S. (2019) Localised and global effects of urban transport networks on residential and commercial properties. *Urban Networks Symposium 17-19 July 2019, Perth*.

Jie, F, Standing C, Biermann, S, Robson, L & Standing S (2019). Analysis of the Use and Perception of Transport Sharing in Western Australia, *17th ANZAM Operations, Supply Chain and Services Management Symposium*.

Kiani Mavi, R, Standing, S, Jie, F, Biermann, S and Standing, C (2019) Future Trends in Supply Chains and Freight Logistics: Growth of International Business and e-Commerce, paper presented at the ANZAM Operations and SCM Symposium, July 2019, Melbourne.

Reed, T. W. & Robson, L. (2019). Dynamic Geographic Layer Generation for RailSmart PSS. Extended abstract, *State of Australian Cities Conference*, December 2019.

Martinus, K, Biermann S & Nunez Picardo, A. (2019) Debunking Self-Sufficiency, Self-Containment and the Jobs-Housing Balance: Strategic Employment to Population Driven Employment as a Target Measure. Extended abstract. *State of Australian Cities Conference*, December 2019.

Chi, S. (2019) Economic Benefits of Travel Behaviour Change Initiatives. Extended abstract, *State of Australian Cities Conference*, December 2019.

**Table 4: Journal Papers/Book Chapters Submitted, Re-submitted or Accepted for Publication in 2019**

Paper
Pettit, C, Biermann, S, Pelizaro, C & Bakelmun, A (2020). A data driven approach to exploring future land use and transport scenarios: the Online What If? Tool. <i>Journal of Urban Technology</i> . <b>Accepted for publication</b> doi.org/10.1080/10630732.2020.1739503
Sangka, B., Rahman, S., Yadlapalli, A., & Jie, F. Managerial Competencies of 3PL Providers: A Comparative Analysis of Indonesian Firms and Multinational Companies. <i>The International Journal of Logistics Management</i> . <b>Accepted</b>
Clements, K. W., Lan, Y. & Liu, H. Understanding Alcohol Consumption across Countries. <i>Applied Economics</i> . <b>Accepted</b>
Liu, C., Huynh, D., Sun, Y., Reynolds, M., & Atkinson, S., A Novel Vision-based Pipeline for Vehicle Counting, Speed Estimation, and Classification, <i>Intelligent Transportation Systems Transactions</i> . <b>Under review</b>
Clements, S., Olaru, D., Smith, B., & Boruff, B. Understanding the impact of agglomeration economies on commercial property prices, <i>Journal of Transport Geography</i> . <b>Under review</b>
Jie, F, Standing, C, Biermann S & Standing S. Factors affecting the adoption of transport sharing systems: Evidence from Australia, <i>Transportation Research Part F: Psychology and Behaviour</i> . <b>Under review</b>
Jie, F, Standing, C, Biermann, S, Standing, S & Robson L. Analysis of the Use and Perception of Transport Sharing in Western Australia, <i>Asia-Pacific Journal of Business Administration</i> . <b>Under review</b>
Chi, S. & Bunker, J. Bridging the Gap Between Theory, Research and Practice in Cost-Benefit Analysis for Road Infrastructure Investments. <i>Research in Transportation Economics</i> . <b>Under review</b>
Standing, C, Standing, S, Hoffman, T, Jie, F, Kiani Mavi, R & Biermann, S Future Trends in Freight Transport and Logistics: A Literature and Expert Analysis. <i>Transport Reviews</i> . <b>Under review</b>
Smith, B, Goods, C, Barret, T & Veen, A. Consumer 'App-etite' for Workers' Rights in the Australian 'Gig-Economy' <i>Journal of Choice Modelling</i> . <b>Under review</b>
Biermann, S & Martinus, K 2019. Reducing the need to travel: the challenge of employment self-containment, in Carey Curtis (ed) <i>Handbook of Sustainable Transport</i> . Edward Elgar. <b>Under review</b>
Cervigni, E., Renton, M., Haslam-Mckenzie, F., Hickling, S., Olaru, D. (2019) Quantifying the urban food environment in Perth, Western Australia using multivariate methods and clustering, <i>Applied Geography</i> <b>Under review</b>

### 3.3. Research Impact

#### 3.3.1. Research Project Outcomes

The close collaboration between researchers and Main Roads WA official throughout the project lifespan results in a high degree of satisfaction in the final products.

*“Enhanced short- and longer-term network performance prediction capabilities through data-driven analytics and simulation” research project, we undertook through iMOVE CRC/PATREC collaboration explored new frontiers for us and provided valuable insights into how we could use machine learning to predict traffic conditions up to a horizon of 1.5 hours to aid our real-time traffic operations. It also explored how we could use perimeter control or gating to balance traffic load across multiple sub-areas to achieve optimum performance at the network level, using macroscopic fundamental diagrams. Although much more research work is needed before we can operationalise it, we could see the real potential of this technique to make a paradigm change in how we operate our road networks. The project also investigated and*

*enhanced our understanding of the potential impacts of automated vehicles, and connected and automated vehicles on Perth's freeways and arterial roads using simulation. The project benefitted from the great team of researchers assembled by PATREC and delivered some excellent outcomes for us, which would be valuable in realising Network Operation's vision of "Predict for 20 (minutes), act in 5 (minutes) and change the future" (Kamal Weeratunga, Manager Network Performance (acting), 6 March 2020*

*"The results are very encouraging and the report reads well. You should be proud of your work. Great job, well done!" (Graham Jacoby, Network Operations Analysis Manager, Main Roads WA, 20 November 2019)*

The City of Wanneroo entered the RailSmart project in the Smart Cities Awards Programme for which it won the Best "Integration of an Individual Technology Award, 2019" which was presented on 30 March 2019 at an awards ceremony that was held as part of the Smart Cities 2019 conference. Citation: "RailSmart draws upon available travel data and modelling of trends and patterns evidenced across the Perth metropolitan area and applies them to the City of Wanneroo to showcase detailed transport modelling, employment and land use trends and enables scenario modelling of potential outcomes at activity centres in the City of Wanneroo".

<https://smart-cities.com.au/awards/2019-winners/best-integration-of-an-individual-technology/>

A press release by the City of Wanneroo:

*On the 30th of May 2019, the RailSmart project won the Best Integration of an Individual Technology award at the 2019 Smart Cities Awards in Melbourne. The RailSmart Planning Support System is a digital dashboard built by a large group of PATREC researchers and was based on applying detailed academic models to forecast future transport patronage and employment trends.*

*The RailSmart project was a collaborative project between PATREC, the City of Wanneroo and the Department of Transport (WA). The RailSmart web dashboard provides information to support decision making for transport and land use planners. This information has been developed out of the work of many PATREC researchers.*

*This information was used in the context of informing land development in the station precincts within the Yanchep Rail Extension area in the north-eastern corridor of the City of Wanneroo. As part of METRONET, three stations will be built in Alkimos, Eglinton and Yanchep, past the existing terminus at Butler.*

*Mayor Tracey Roberts accepted the award on behalf of the City. The RailSmart project was supported by the Australian Government through the Smart Cities and Suburbs Program.*

Further, the RailSmart project has been shortlisted as a finalist in the Royal Town Planning Institute's International Award for Planning Excellence <https://www.rtpi.org.uk/events-training-and-awards/awards/rtpi-awards-for-planning-excellence/finalists-2020/> to be announced on 30 April 2020.

The RAC's Pulse of Perth Visualisation of SmartRider data received excellent media attention:

- RAC's web page:
  - <https://rac.com.au/about-rac/advocating-change/getting-around/pulse-of-perth>
- Links to the original videos:
  - <https://www.youtube.com/watch?v=1gUpJeA3968>

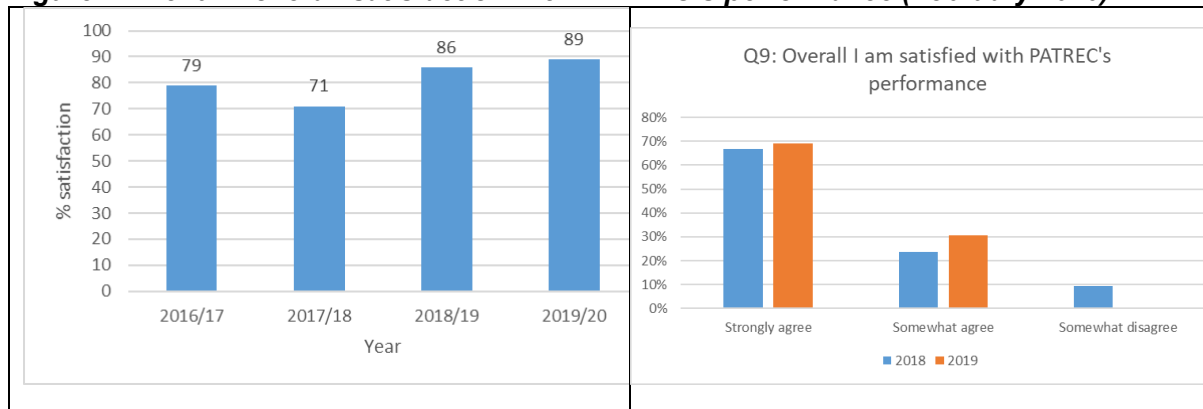
- [https://www.youtube.com/watch?time\\_continue=1&v=-g4Rt72vuK0](https://www.youtube.com/watch?time_continue=1&v=-g4Rt72vuK0)
- LinkedIn post  
<https://www.linkedin.com/feed/update/urn:li:ugcPost:6554910160337408000>
- Reported by news outlets
  - <https://www.watoday.com.au/national/western-australia/how-we-travel-in-real-time-perth-s-public-transport-hotspots-revealed-20190709-p525la.html>
  - <https://www.theage.com.au/national/western-australia/how-we-travel-in-real-time-perth-s-public-transport-hotspots-revealed-20190709-p525la.html>
  - <https://www.smh.com.au/national/western-australia/how-we-travel-in-real-time-perth-s-public-transport-hotspots-revealed-20190709-p525la.html>
  - <https://theworldnews.net/au-news/how-we-travel-in-real-time-perth-s-public-transport-hot-spots-revealed>

The CBA seminar series was very well-received with participants describing the seminar in feedback evaluation forms as, amongst others, “very informative”, “insightful”, “excellent”, “great presentation” “highly recommended”. There were several requests for additional sessions and there was strong interest in having a 2-day short course, containing more in-depth guidance and full CBA calculation of a real-life example, as well as CBA for various types of transport projects.

### 3.3.2. Stakeholder Satisfaction Survey Results

An on-line survey, comprising nine questions, was developed using Qualtrics to provide feedback to the Director and Board on the level of satisfaction of PATREC partners with the performance of PATREC on an annual basis. The 2019 survey, conducted in February 2020, circulated to over 120 stakeholders directly involved in PATREC research (n=26), returned a percentage satisfaction rate of 89.5%. This is the highest satisfaction rate of the four years in which the survey has been run (Figure 1). Government partners had the highest response rate (n=15), with ten university respondents and one “other”. All respondents agreed that overall, they are satisfied with PATREC's performance, 69% strongly agreeing and 31% somewhat agreeing. “Strongly agree” dominates replies to questions relating to usefulness of outcomes, value for money, good interactions and extending the knowledge base and networks. “Somewhat agree” dominates the responses to two questions: understanding each other's needs and bridging the gap between research and policy.

**Figure 1: Trend in overall satisfaction with PATREC's performance (February 2020)**



### 3.4. New PATREC website and logo (www.patrec.org)

A new PATREC website has been built and launched. It is hosted externally using cloud computing with flexible updating and design capabilities. The website aims to be far more contemporary than the last and to be dynamic in nature with regular news updates. The strength of the old site was as a source of PATREC published papers and reports, the new site has sought to further enhance this strength by clearly structuring the publications, seeking out all relevant publications and attaching them for download and adding a search engine to allow for more rapid information retrieval.

Whilst redesigning the website it was felt that the present PATREC logo emphasised the transportation aspect but did not acknowledge the land use aspect of the PATREC mandate and as such a new logo is proposed, for which we seek board approval. The new logo is an evolution of the old logo, also inspired by the RailSmart website logo.

## 4. PEOPLE AND RESOURCES

### 4.1. Staffing

The iMOVE CRC and Smart Cities projects enabled some human resourcing stability to be ensured for the core PATREC team.

#### **Research Project Manager**

- Dr Linda Robson was appointed in the role of PATREC Research Project Manager primarily for the RailSmart Planning Wanneroo project
- Appointed on a two-year fixed-term contract (1 April 2018 – 31 March 2020), in 2019 for 0.6 FTE with the other 0.4FTE to cover her teaching responsibilities being paid by UWA
- Reverting back to teaching-only position with UWA from 1 April 2020.

#### **PATREC Research Fellows**

Dr Chao Sun's current fixed term contract extended to June 2020, with an ongoing contingent position being pursued

- iMOVE ITS and RAC Pulse of Perth project lead
- New iMOVE ITS project lead
- Project lead for a number of Main Roads WA external projects
- Salary paid 100% by research project funding with some funding provided by UWA Engineering for his transport engineering teaching

Dr Sae Chi – fixed-term contract extended to 31 December 2020

- Transport Engineer/Economist, commenced 24 September 2018, from Brisbane) – iMOVE Freight, RailSmart, new iMOVE Managing Risk project sub-project lead
- Salary paid 100% by research project funding (iMOVE, Smart Cities)

#### **Research Assistants**

- Software Engineers (mostly on a casual basis) working on RAC Pulse of Perth, iMOVE CRC ITS, Main Roads WA external projects
  - Yan Ji
  - Rui Wang
  - Chris Bartley
  - Martin Porebski
  - Jacquie Soon

- Robert Pennefather
- Noah Lester
- Anna Taleb-Bendiab
- Hao Xue
- Sergio Banchemo
- Sonja Stemler, Civil Engineer
- Liam Cummins, Mechanical Engineer
- Tristan Reed (Computer Scientist, Curtin) – RAC Pulse of Perth, RailSmart Wanneroo, iMOVE CRC Freight (truck tracking, new iMOVE Managing Risk project )
- Daniel Cowan (Computer Scientist, UWA) - iMOVE CRC Freight (truck tracking)
- Cate Patterson (Smart Cities support, UWA)
- Subha Parida (ECU, new iMOVE Managing Risk project)
- Dr Leon Booth (Curtin, new PATREC Acceptance of SAEV project)

PATREC involved a number of academics who are employed full time by partner universities but who participate on an in-kind basis to conceptualise and manage projects, direct research assistants, undertake research and identify opportunities (Table 5). Limited use is also made of consultants where relevant expertise is not available within the partner universities.

**Table 5: PATREC Project Research Associates**

<b>PATREC Research Associates</b>	<b>Faculty/School/Centre</b>	<b>University</b>
A/Prof Doina Olaru	Business School	UWA
Dr Brett Smith	Business School	UWA
A/Prof Paul Bergey	Business School	UWA
Dr Kirsten Martinus	School of Ag. and Environment	UWA
A/Prof Rachel Cardell-Oliver	Computer Science	UWA
Dr Wei Liu	Computer Science	UWA
Dr Jianxin Li	Computer Science	UWA
A/Prof Mark Reynolds	Computer Science	UWA
Prof Simone Pettigrew	Psychology	Curtin
A/Prof Richard Norman	Economist	Curtin
Prof Tele Tan	Mechatronics engineering	Curtin
Dr David McMeekin	Spatial Sciences	Curtin
Prof Craig Standing	Business and Law	ECU
Dr Susan Standing	Business and Law	ECU
A/Prof Ferry Jie	Business and Law	ECU
Prof Kerry Brown	Business and Law	ECU
A/Prof Hadrian Djajadikerta	Business and Law	ECU
Tim Hoffman	THAdvisory	Consultant

**Table 6: Project Steering Committee Participation**

Agency	iMOVE Freight	iMOVE ITS	RailSmart	iMOVE Risk	Accepting SAEV
DPLH	John Chortis		Matt Selby		
DoT	Steve Beyer Tim Collins (Westport) Anne Marie Brits		Brett Hughes Zarin Salter Trevor Buckenara Liam Heitson	Steve Beyer Claire Thompson Jane Millar Trevor Buckenara Liam Heitson Martin White Martin Keen Graham O'Neil Brendan Lumbers Andrew Wilkinson Beth Beere	Alizanne Cheetham Simon Grieve
MRWA	Gary Player	Kamal Weeratunga Steve Atkinson Graham Jacoby		Flori Mihai	
City of Wanneroo			Ian Martinus Steve Marmion Michelle Tovey		

## 4.2. Finances

As at the end of 2019, the closing balance of \$113,245 was \$45K under budget. Income was under budget by \$141,675 largely as a result of iMOVE Commonwealth income lagging behind budget due to delays in submission of final milestone reports for the ITS project (90K) and the last Freight milestone report (\$43,382). These outstanding reports have now been completed and income included in 2020. Expenditure came in almost \$100K under budget due mainly to savings on administrative support.

**Table 7: Financial Summary for 2019**

<b>PATREC Income and Expenditure 2019</b>	<b>YTD Actual 31 Dec 2019</b>	<b>Budget 2019</b>
<b>INCOME</b>		
WA Government Grants	240,000	240,000
Universities Sponsorship	180,000	180,000
iMOVE Commonwealth	207,560	341,000
iMOVE UWA	70,000	70,000
iMOVE additional gov/industry	182,100	135,000
Smart Cities and Suburbs	563,500	563,000
Other Research Grants & Contracts	172,482	231,000
Accrued Interest	4,183	1,500
<b>Total Income</b>	<b>1,619,825</b>	<b>1,761,500</b>
<b>EXPENDITURE</b>		
<b>PATREC OFFICE</b>	<b>123,201</b>	<b>203,320</b>
<b>RESEARCH PROJECTS</b>	<b>1,490,584</b>	<b>1,506,928</b>
<b>Total Expenditure</b>	<b>1,613,785</b>	<b>1,710,248</b>
<b>YTD BALANCE</b>	6,040	51,252
<b>Balance Brought Forward from 2018</b>	<b>107,205</b>	<b>107,205</b>
<b>CLOSING BALANCE (incl Balance B/F)</b>	<b>113,245</b>	<b>158,457</b>

## 5. GOVERNANCE

### 5.1. Board Members

The PATREC Advisory Board comprises a senior representative of each of the collaborating Parties and a Chair who is independent of all Parties. Reece Waldock continued as the Independent Chair of the Board. Prof Alan Dench replaced Prof Keith Hampson as the member for Curtin University while Prof Tim Colmer replaced Prof Matthew Tonts as the UWA member (Table 9). The PATREC Director is an ex officio member of the Board. The PRAC Chair and PTA are also invited to Board meetings.

**Table 9: PATREC Board Members**

2018	2019
Adjunct Prof Reece Waldock, Independent Chair	Adjunct Prof Reece Waldock, Independent Chair
Mr David Caddy, Chair, Western Australian Planning Commission	Mr David Caddy, Chair, Western Australian Planning Commission
Mr Peter Woronzow, Acting Managing Director, Main Roads Western Australia	Mr Peter Woronzow, Managing Director, Main Roads Western Australia
Mr Steve Beyer, Acting Managing Director, Policy Planning and Investment, Department of Transport	Mr Steve Beyer, Director, Portfolio Strategic Projects Office, Department of Transport
Prof Keith Hampson, Chief Executive Officer, SBEnc, Curtin University	Prof Alan Dench, Pro Vice-Chancellor Humanities, Curtin University
Prof Margaret Jones, Director, Office of Research and Innovation, Edith Cowan University	Prof Kerry Brown, Director of the Centre for Innovative Practice, Edith Cowan University
Prof Matthew Tonts, Pro Vice-Chancellor/Executive Dean, Faculty of Arts, Business, Law and Education, The University of Western Australia	Prof Tim Colmer, Acting Pro Vice-Chancellor (Research), The University of Western Australia
Mr Ian Duncan, Executive Manager, Infrastructure, WALGA	Mr Ian Duncan, Executive Manager, Infrastructure, WALGA

## 5.2. PATREC Research Advisory Committee Members

Comprising one to two senior representatives from each partner organisation, chaired by a nominated representative of one of the government partners, elected by the Board, the objectives of PRAC are to:

- introduce an element of formality and rigour to the research project identification, selection, support, monitoring and dissemination process;
- enhance communication amongst partners; and
- advise the Board on project level matters, allowing the Board to focus on strategic matters.

Steve Atkinson took over as Chair of the PRAC on the retirement of Brett Hughes and Damien Martin, elected during 2018, continued as Deputy Chair in 2019 (Table 10).

**Table 10: PATREC Research Advisory Committee Members**

<b>Name</b>	<b>Organisation</b>
Steve Atkinson (Chair)	Main Roads WA
Catherine Wallace	Department of Transport
Justin McKirdy	Department of Transport
Douglas Morgan	Main Roads WA
Kamal Weeratunga	Main Roads WA
Damien Martin (Deputy Chair)	Department of Planning, Land & Heritage
John Chortis	Department of Planning, Land & Heritage
Martin White	Public Transport Authority
Rebecca Lange	Curtin University
David McMeekin	Curtin University
Hadrian Djajadikerta	Edith Cowan University
Ferry Jie	Edith Cowan University
Doina Olaru	The University of Western Australia
Brett Smith	The University of Western Australia
Sharon Biermann	PATREC

## 6. PERFORMANCE AGAINST KPIS AND TARGETS

Broad key performance indicators set for PATREC relate directly to the value-add role or purpose for which PATREC was established. The university collaborators require an increase in research profile and performance while the government partners require better evidence on which to base policy and investment and development spending decisions. The number of performance indicators has been reduced to essential academic and policy impact indicators with a focus on outputs and outcomes rather than inputs. Performance to date against 2019 targets as set in the Annual Business Plan 2019, is summarised in Table 11.

**Table 11: Key Performance Indicator Targets (2019) and Achievements as at 31 December 2019**

Performance Indicator	Target 2019	Achieved as at 31 December 2019
<b>Academic Performance Indicators</b>		
Number of journal papers published	5	6
Number of peer-reviewed book chapters published	1	1 submitted
Number of peer-reviewed conference papers published in proceedings	10	2
Number of peer-reviewed books published		
Number of top-up sponsored PhD graduated		
Value (\$) of [direct] external research funding (over and above subscriptions), secured (through PATREC account)	\$1,183K	\$1,196K
Value (\$) of [indirect] external research funding (over and above subscriptions), secured (through individual partner university account)		ECU iMOVE freight income=\$33,558
<b>Policy Impact Performance Indicators</b>		
Number of high impact, policy-informing projects/sub-projects completed (2-year projects)	3	3 (RailSmart, iMOVE ITS and Freight)
Number of substantive Technical Reports/Working Papers published	3	8 (RailSmart 1, 3 iMOVE Freight, 3 ITS, 1 RAC)
Number of PATREC Perspectives published on PATREC website	3	0
Number of presentations at PATREC and other connection events*	10	16
Number of connection events arranged and held	6	5
Number of short courses, unit contributions presented by PATREC staff	4	2 unit contributions; 6 CBA seminars
<b>Stakeholder (academic and policy) satisfaction indicator (qualitative)</b>	80%	89.5%

\*Including conference presentations with no published paper