

ANNUAL SUMMARY REPORT

A50: Investigation into Innovative Methods to Inform Network Management of Skid Resistance (2020–21 – Year 1)

ARRB Project No.: 015709

Author/s: Cassandra Simpson, Brittany Croft

Prepared for: Queensland Department of Transport and Main Roads

June 2021

Final

Summary

This project investigated new methods of collecting skid resistance and surface texture data on road networks. The project examined the viability of using real-time 'friction/grip' data collected via crowdsourcing to assess the skid resistance of the road surface. The new method could be used in conjunction with, or to replace, traditional network skid resistance test methods.

The literature review showed the potential for road agencies to use harsh braking, traction control use, wiper speed use, regenerative braking, deceleration, speed/torque ratio, and vibrations measured using accelerometers, as surrogate measures to locate areas of the road network that may have low skid resistance and/or texture. These new data streams could be used to enhance the management of the road network and alert road agencies to both real-time issues such as oil spills and the long term issues of polishing. The review showed very little information was available regarding vehicle data for network skid resistance.

Although the report is believed to be correct at the time of publication, the Australian Road Research Board, to the extent lawful, excludes all liability for loss (whether arising under contract, tort, statute or otherwise) arising from the contents of the report or from its use. Where such liability cannot be excluded, it is reduced to the full extent lawful. Without limiting the foregoing, people should apply their own skill and judgement when using the information contained in the report.

This project found the vehicle data can be broken into two broad groups according to type:

- safety device data (anti-lock braking system and traction control, harsh acceleration and deceleration, hazard/emergency lights use, wiper use)
- movement data (location, direction of travel, speed, yaw, g-force, acceleration, deceleration).

The project did not find a source of the safety device data. The project found three sources of the movement data. The best data sources identified for Stage 2 of this project are:

- movement data obtained from the Queensland Department of Transport and Main Roads (TMR) Connected and Automated Vehicle Initiative (CAVI) project
- movement data obtained from third-party road analytics companies (RAC).

Both options have similar advantages for data availability for a road network. The CAVI project data is expected to be easily shared and available as the project is undertaken by TMR. The RAC data presents some unresolved issues of veracity and access by formal agreement.

Both options have similar advantages for identifying skid resistance events using a controlled experiment on a test track such as Mt Cotton. The CAVI project would include significant analysis to generate a reliable algorithm, and this could be limited by the number of vehicles available for the test track work. The RAC project could provide a shortcut by sharing the results of the test track exercise and information regarding the analysis and resulting algorithm.

The Movement Data using CAVI is recommended for Stage 2 of this project, given the advantages of partnering with CAVI. The test track exercise should be undertaken early to determine if a way of identifying skid resistance events can be achieved. Where the skid resistance events cannot be identified, the next best option is to investigate Stage 2 with the RAC.

Queensland Department of Transport and Main Roads Disclaimer

While every care has been taken in preparing this publication, the State of Queensland accepts no responsibility for decisions or actions taken as a result of any data, information, statement or advice, expressed or implied, contained within. To the best of our knowledge, the content was correct at the time of publishing.

Contents

1	Introduction	1
1.1	Objectives	1
1.2	Scope.....	2
1.2.1	Milestones	3
2	Literature Review	4
2.1	Literature Review Summary	4
2.1.1	Road Network Skid Resistance.....	4
2.1.2	Vehicle Sensor Data.....	5
2.1.3	Gaps in Knowledge	6
2.1.4	Literature Review Conclusion	7
2.2	New Information.....	7
3	Detailed Study Design	8
3.1	Options for the Detailed Study Design	8
3.1.1	Option 1: Safety Device Data.....	8
3.1.2	Option 2: Vehicle Movement Data	9
3.1.3	Options for Location of Trial	11
3.2	Discussion	12
3.3	Recommendation.....	13
	References	14
Appendix A	Literature Review.....	15

Tables

Table 2.1:	Examples of vehicle sensor data.....	6
Table 3.1:	Example of data from the CAVI C-ITS Pilot	10
Table 3.2:	Options for study design.....	12

Figures

Figure 1.1:	ARRB's skid resistance testing vehicle, iSSAVe	1
Figure 1.2:	Concept of the overall project.....	2
Figure 2.1:	Skid resistance of pavements becomes worse when wet	4
Figure 2.2:	Standard skid resistance testing equipment.....	5
Figure 2.3:	Vehicle data transfer to and from external sources.....	7
Figure 3.1:	The four components of CAVI	10

1 Introduction

Road agencies assess road pavement surface texture, friction and skid resistance to enhance the safety of the travelling public.

Typically, management of the skid resistance of road networks adopts a risk management approach where the network is cyclically tested using a standard test vehicle (see Figure 1.1). The road network is then benchmarked against investigatory levels which vary depending on the skid resistance and surface texture demand levels for different sections of road. The skid resistance of new road surfaces is managed through standards and specifications such as the properties of the aggregates used in road surfacings and the surface texture.

Although road networks are tested at intervals, the skid resistance varies constantly due to seasonal changes and transient items such as oil and water on the road surface.

A more contemporary approach would incorporate the cyclic skid resistance and surface texture test data with real-time 'friction/grip' data provided by modern vehicle technologies. This real-time information could include road surface condition and texture, friction, anti-lock braking system (ABS)/traction control events, brake pressure/deceleration rates, rain intensity, longitudinal and lateral forces, and steering input.

A motor vehicle manufacturer approached Queensland Department of Transport and Main Roads (TMR) to initiate a project to investigate the opportunities to leverage the real-time, crowd-sourced data being collected by sensors on their vehicles that could be used to assess the skid resistance of roads. In response to the approach the research project described in this report was created. Unfortunately, the motor vehicle company was subsequently unable to participate so alternative data sources were investigated. All alternative data options listed in this report are real-time and crowd-sourced, with the only differences being the method and number of data types available for collection.

The opportunities to use this real-time and crowd-sourced data remain the same regardless of the method of collection. One of the opportunities for real-time data, and the basis for this project, is to understand how accurate it is in measuring infrastructure condition and in particular the skid resistance of pavements. To do this, a collection trial and comparison of real-time data and standard test vehicle data is planned. The outcomes of the comparison would establish if the new real-time information can complement the typical cyclic network testing and fill in the gaps to create a constantly updated, relevant snapshot of the network condition to improve transport safety.

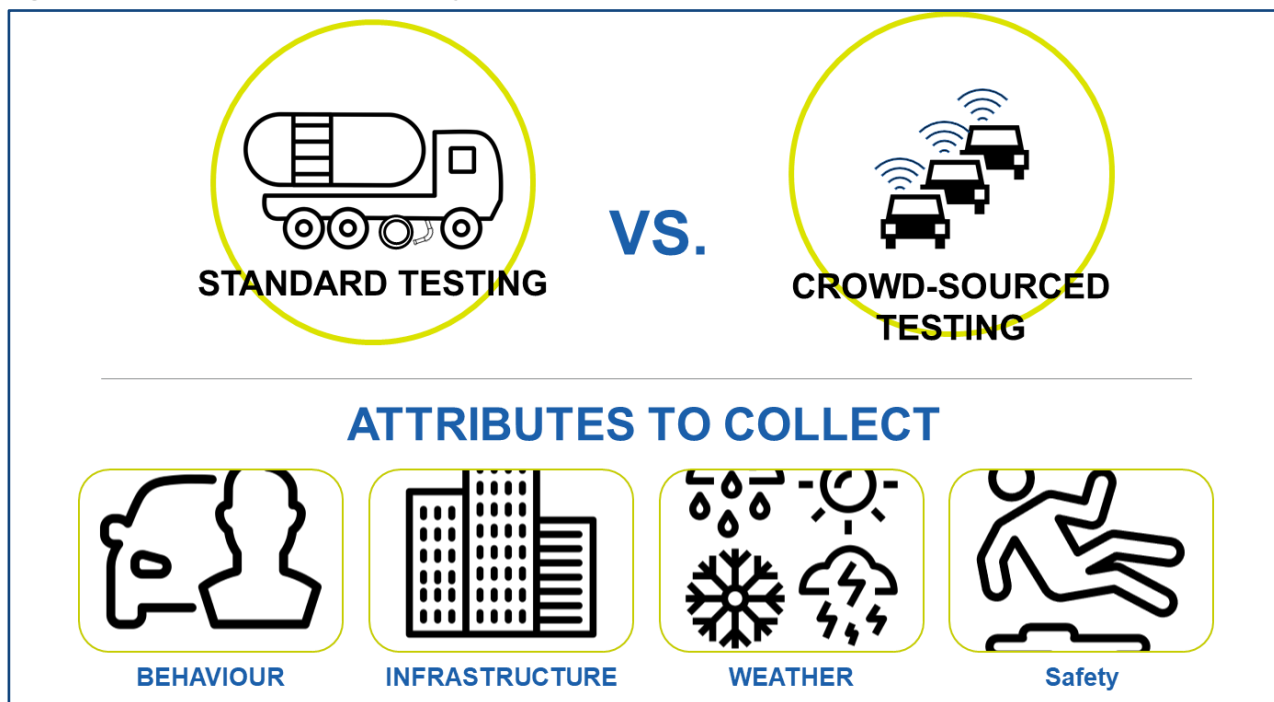
1.1 Objectives

Stage 1 of this project explored the viability of using real-time 'friction/grip' data collected via crowdsourcing to revolutionise the assessment and management of the skid resistance of road surfaces. It aimed to outline and recommend a detailed study design to be used in Stage 2 of the project to guide trials comparing the new real-time collection methods to the traditional skid resistance testing methods. Figure 1.2 provides a pictorial overview of the project's objective.

Figure 1.1: ARRB's skid resistance testing vehicle, iSSAVe



Figure 1.2: Concept of the overall project



This Stage 1 report focuses on the investigation which included:

- an initial literature review and analysis of existing information on skid resistance testing and vehicle data technologies
- a detailed study design including consideration of various sources of real-time data
- recommendations for Stage 2.

1.2 Scope

The full scope of the three year project was as follows:

Stage 1

1. Development of a literature review and gap analysis report covering:
 - a. road agency practices nationally and internationally for the use of skid resistance and surface texture data, including machine learning surveys and vehicle data that can inform road asset management and maintenance practices
 - b. future directions in the acquisition of and the use of skid resistance and surface texture data, including machine learning surveys and vehicle data
 - c. the availability and capabilities of relevant technologies, including cooperative intelligent transport systems (C-ITS) vehicle to anything/everything (V2X) use case/s
 - d. identification of relevant knowledge and possible technology performance gaps and limitations.
2. Preparation of a detailed study design and research plan for Stage 2, including the possible need for controlled trials. These trials will test responses and overall functionality of vehicle systems and a parallel comparison with established technologies for measuring surface texture and skid resistance. This will include the following considerations:
 - a. public network trials
 - b. study design to cover
 - i. the need for controlled trials on different surfaces as a pilot study to prove the availability and usefulness of vehicle transmitted data

- ii. the need for public network trials with data made available from a fleet of vehicles operated on the road system covering different operating conditions and for a time period sufficient to enable an adequate sample of time series data.

Stage 2

1. Implementation of the data collection trials
2. Collation and analysis of data
3. Reporting of findings
4. Overall assessment of the state of readiness of the technologies and recommendations for future data collection of road surface texture and skid resistance.

Stage 3

1. Develop draft action plan for implementation, including revisions to current management plans.

This report covers the results from Stage 1.

1.2.1 Milestones

The scope of the milestones for Stage 1 were as follows:

- Milestone 1: Literature Review and Gap Analysis Report
The literature review investigated the types of data ready for use and whether the data could be used for the purpose of indicating skid resistance of roads. The major topics covered included:
 - background information on skid resistance and vehicle data
 - the data types that are beneficial to indicate surrogate measures of skid resistance
 - what data is currently being collected by vehicles in Australia and internationally
 - who or what is able to collect this data
 - the accessibility of the data and barriers that could prevent the data being used
 - a conclusion on the status of this data in relation to its usefulness for this project.
- Milestone 2: Detailed Study Design for Stage 2
The study design was expected to provide consideration of:
 - the types of vehicle data available for a trial in Queensland
 - the coverage in time, location, and number of vehicles with data
 - the use of road network or test track experiments to correlate the vehicle data with network skid resistance testing.

2 Literature Review

A detailed literature review was undertaken for this project. The Summary from the literature review is shown in Appendix A. This section provides an overview of findings.

2.1 Literature Review Summary

The literature search showed the potential for road agencies to use harsh braking, traction control use, wiper speed use, regenerative braking, deceleration, speed/torque ratio, and vibrations measured using accelerometers, as surrogate measures to locate areas of the road network that may have low skid resistance and/or texture. The data would only be available from newer cars or phone applications and the data would have to be sourced from the motor companies or phone application owners. The data can be received by the motor companies in real time and could be shared in real time with the road agencies.

The review showed very little information was available regarding vehicle data for network skid resistance. Various road agencies claimed interest in this area of research but were not active.

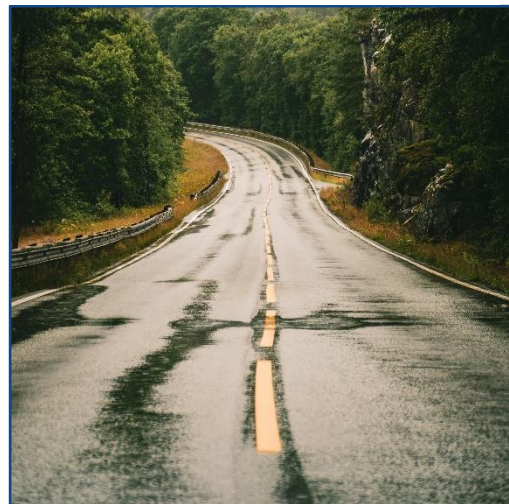
Skid Resistance

Skid resistance is defined by Austroads (2009) as:

Skid resistance is a measure of the friction between the vehicle tyre and the road surface. It will depend on both the microtexture of the aggregate in the surfacing and the macrotexture (surface texture) of the surfacing, as well as the presence of moisture and its film thickness.

Research has found inadequate skid resistance is associated with a higher incidence of wet skidding related crashes (see Figure 2.1). The available road surface skid resistance varies in real time depending on transient influences such as dust, grime and oil, and by seasonal variation such as rainfall patterns and traffic volumes.

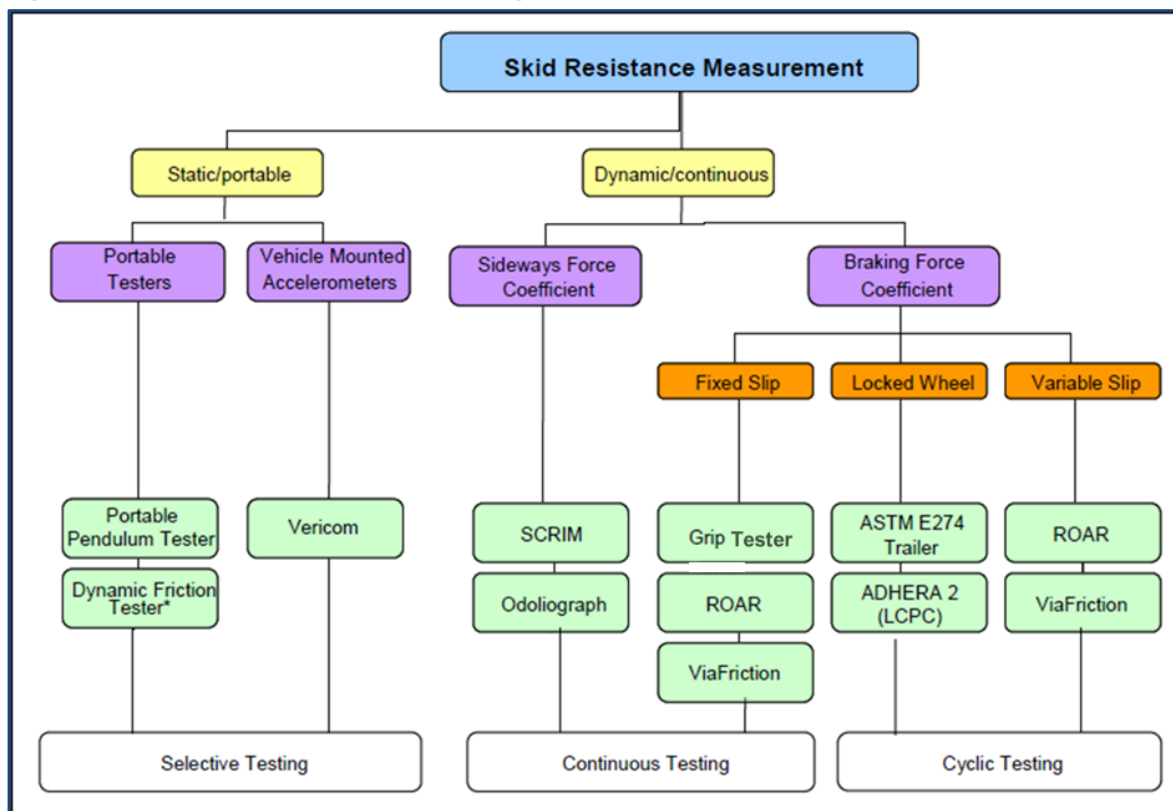
Figure 2.1: Skid resistance of pavements becomes worse when wet



2.1.1 Road Network Skid Resistance

Typical management by road agencies for skid resistance included a risk management approach where a selected network of roads is tested using standardised test equipment. Austroads (2011) classified types of test equipment as shown in Figure 2.2.

Figure 2.2: Standard skid resistance testing equipment



Existing road sections are benchmarked against investigatory levels which vary depending on an assessment of the skid resistance demand levels for each section of road. The results represent a ‘snapshot in time’, which is then used to determine maintenance requirements.

Australia and New Zealand Road Agency Testing

Sideways force co-efficient testing (SCRIM or iSSAVE) was used by New Zealand, four Australia states and two Australia territories. South Australia used a braking force co-efficient test (Grip Tester). Western Australia does not undertake network testing for skid resistance.

Skid resistance testing was undertaken on a frequency basis between one to three years and only part of the network was tested for seven road agencies.

The eight Australian road agencies also undertook testing for surface texture on a frequency basis (between one and two years).

The review showed the Australian and New Zealand road agencies typically used conventional skid resistance testing equipment for testing of the road networks.

2.1.2 Vehicle Sensor Data

Vehicle sensor data is collected using sensors to monitor the on-road performance of vehicle systems such as braking, traction control and engine management systems.

Most of the vehicle data refers to vehicle location, speed, temperature, and engine capabilities. Some of the vehicle data has the potential to be used to infer information about the road environment including congestion, heavy rain events, conditions for ice on roads, and instances of hard braking and use of traction control systems (that limits spinning of the drive wheels to enhance control of the vehicle).

The types of vehicle data fall into two groups:

1. data provided to the driver
2. data provided to the motor vehicle manufacturing company.

Table 2.1 lists examples of vehicle sensor data that fall into these two groups.

Table 2.1: Examples of vehicle sensor data

Data provided to the driver	Data provided to the motor company
By the vehicle	In addition to the data provided to the driver
Blind spot warnings	ABS and traction control – location and time
Calculated emissions for the trip	Accelerator pedal pressure
Condition of braking system	Brake pedal pressure
Congestion and reported crashes on the chosen route	Condition of the braking system
Distance for the trip	Fog light use – location and time
Engine revolutions	Harsh acceleration – location and time
Forecast weather (via smartphone)	Harsh braking – location and time
Fuel efficiency of driving technique based on acceleration and braking	Hazard/emergency light use – location and time
Fuel used and forecast distance to needing refill	Monitoring of driving behaviour including longitudinal and lateral acceleration and deceleration (and derived measures such as jerk or yaw)
Identified vehicle maintenance requirements such as oil and tyre pressure, engine temperature	Presence of potholes – under development using laser systems or feedback from suspension system
Lane deviation	Salinity (via weather sensors in the road)
Measures related to fatigue and distraction based on time or lane deviation	Steering wheel angle and wheel rotations
Presence of roadworks/lane closures/crashes	Vehicle maintenance requirements such as engine performance and efficiency
Real time vehicle speed and location	Windshield wiper use – location and time
Real-time safety warnings such as upcoming red traffic lights – under development	Wiper speed – location and time
Real-time warnings that ABS or traction control has been engaged	
Rear view and 360° camera information	
Snow and ice warnings based on temperature	
Speed signs	
Upcoming speed camera location.	
By Smartphones	
Location and speed	
Speed camera locations	
Speed limits	
Traffic congestion	
Weather conditions	

2.1.3 Gaps in Knowledge

The review identified several significant gaps in knowledge as follows:

- vehicle data being matched to conventional network skid resistance testing equipment
- vehicle data (harsh braking, traction control, wiper speed) being used in response to the condition of the road surface regarding surface condition not relating to snow/ice
- the frequency and quantity of data that may be available from motor companies to Australian road agencies
- evidence of vehicle data being used by international road agencies (outside of trials).

2.1.4 Literature Review Conclusion

The literature search showed the potential for road agencies to use harsh braking, traction control use, wiper speed use, regenerative braking, speed/torque ratio, and vibrations measured using accelerometers, as surrogate measures to locate areas of the road network that may have low skid resistance and/or texture. The review found the data would only be available from newer cars, mobile devices or phone applications and the data would have to be sourced from the relevant companies and owners.

The review found very little information was actually available regarding vehicle data for network skid resistance.

The search for road agencies using innovative sources of data revealed one promising project, the Danish Road Directorate is undertaking a major four-year project to develop models for relationships between vehicle data and road conditions. This is the LiRA project which was planned to start in 2021 and involved a fleet of vehicles collecting regenerative braking, ABS and speed/torque ratio data and high frequency vibrations from accelerometers, with the intention to correlate this data with the friction and texture of the pavement. Various international road agencies, including those in Australia, have claimed interest in this area of research but were not yet active.

2.2 New Information

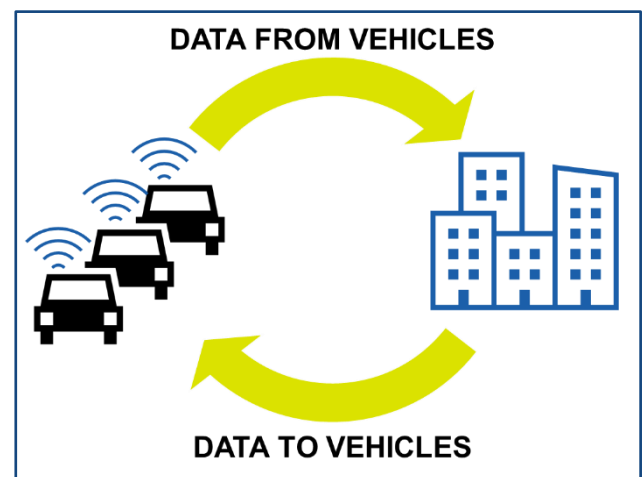
This area of research of new methods of road asset data collection is currently developing. New information has emerged after the completion of the literature review and is discussed in this section.

The Transport Research Laboratory (TRL 2020) undertook a stocktake on the current autonomous vehicle data in the United Kingdom (UK) and considered whether it could be used to measure skid resistance. The report identified areas for further development, namely the transfer of data sent from vehicles, and data sent to vehicles.

The TRL report concluded that road asset condition data cannot be collected by autonomous vehicles in the UK when the report was published in July 2020. The report explained road asset data could be collected after more work is undertaken in this area. The proposed additional work was:

- development of a method of aggregating vehicle data and translating this into road friction condition indicators
- undertaking a calibration exercise to enable road friction to be estimated
- development of a way to feed network skid resistance data to vehicles to share the skid resistance information.

Figure 2.3: Vehicle data transfer to and from external sources



3 Detailed Study Design

This section details the findings from this project to determine a detailed study design. The section includes the different data sources and test options that were considered in reaching the final recommended study design.

3.1 Options for the Detailed Study Design

Options for the detailed study included review of the various types of vehicle data and how the data could be made relevant to road network skid resistance testing. Vehicle data can be broken into two broad groups according to the type of information:

- safety device data
- movement data.

Safety device data included the use of the safety devices such as:

- ABS and traction control
- harsh acceleration and deceleration
- hazard/emergency lights use
- wiper use and speed.

This data was expected to provide the best indicator of skid resistance demand on the road network. This type of data was available only from the motor vehicle companies.

Movement data included:

- location
- direction of travel
- speed
- information such as yaw, g-force, acceleration, deceleration.

Typically, the movement data is not as comprehensive as the safety data since it does not have access to all the vehicle's internal systems and relies on movement. However, movement data can still be used to infer the skid resistance of the road. For instance, the movement data can report the vehicle rapidly moving sideways and this information can be overlaid with road geometry data to understand the intent of the movement. In this case, it could mean the vehicle is skidding sideways or the vehicle is changing lanes. Adding information from many vehicles at the same location and movement could indicate the road is slippery. The data could also be cross-referenced with weather data to see if the slippery event occurred during rain events. The movement data was expected to provide alternate information as a surrogate for skid resistance demand on the road network. This type of data was available from motor vehicle companies and other sources.

The original project plan included access to vehicle safety device data through a partnership with a motor vehicle company. Unfortunately, the motor company was unable to provide this data due to capacity limitations. Therefore, alternative data sources were investigated as the vehicle data was critical to the detailed study design and the research.

3.1.1 Option 1: Safety Device Data

As a result of the original motor company being unavailable for the project, other motor companies were considered. It was assumed that if one motor company was collecting this data, other companies would also be collecting this information. After approaching several companies, it was found that motor companies in Australia are either not collecting this data or were unwilling to share the data. In addition, the National Transport Commission (NTC) was developing policy on government access and use of vehicle data, and this significant change may have temporarily affected access to the information.

There were many barriers that need to be overcome prior to using the data, including:

- privacy, as data collected by a vehicle may be the property of the vehicle owner
- selection of communication devices to transfer data from vehicle to collection facilities
- installing collection facilities to store the data
- the cost associated with acquiring the communication and secure storage space facilities.

The investigation did not reveal any viable data sources from motor companies for this type of data.

3.1.2 Option 2: Vehicle Movement Data

Vehicle movement data is normally sourced using on board diagnostic systems devices that record the on-board diagnostics of a vehicle and vehicle movement data. The devices are 'plug and play' meaning they can be retrofitted by plugging them into an existing port in a vehicle. The current standardised vehicle port and communications protocol is called OBD2.

During the search for suitable OBD2 devices, it was found that there are various approaches to using these devices. The project revealed three ways to access movement data using OBD2 devices:

- accessing data from existing vehicle data projects in Queensland
- purchasing data from road analytics companies
- conduct an independent trial.

CAVI

Cooperative and Automated Vehicle Initiative (CAVI) was a set of four trials run by TMR from 2017 to 2021. The four trials were:

1. Cooperative Intelligent Transport Systems (C-ITS) Pilot
2. Cooperative and Highly Automated Driving (CHAD) Pilot
3. Vulnerable Road User Pilot
4. Change Management.

The concept of each of the trials is shown in Figure 3.1. The trial most applicable to this research study was the first trial, the C-ITS Pilot.

Figure 3.1: The four components of CAVI

			
1. Cooperative Intelligent Transport Systems (C-ITS) Pilot The largest on-road testing trial in Australia of cooperative vehicles and infrastructure	2. Cooperative and Highly Automated Driving (CHAD) Pilot Testing a small number of vehicles with cooperative and automated technologies.	3. Vulnerable Road User Pilot A project looking at how new technology applications can benefit vulnerable road user safety including pedestrians, motorcycle riders and bicycle riders	4. Change Management A process for the Department of Transport and Main Roads to consider the change of current business and practices for a road manager

The C-ITS Pilot was located on public roads in the City of Ipswich, Queensland. About 500 vehicles on the network were retro fitted with C-ITS technologies to secure vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) interactions. The on-board computers recorded the interactions with other CAVI vehicles and the environment. The CAVI project shared some of the recorded movement data and this is shown in Table 3.1.

Table 3.1: Example of data from the CAVI C-ITS Pilot

Speed	Vehicle Length
\\"speed\\":{\\"speedValue\\":2520	\\"vehicleLength\\":{\\"vehicleLengthValue\\":49
\\"speed\\":{\\"speedValue\\":2520	\\"vehicleLength\\":{\\"vehicleLengthValue\\":49
\\"speed\\":{\\"speedValue\\":2520	\\"vehicleLength\\":{\\"vehicleLengthValue\\":49
\\"speed\\":{\\"speedValue\\":2529	\\"vehicleLength\\":{\\"vehicleLengthValue\\":49
\\"speed\\":{\\"speedValue\\":2541	\\"vehicleLength\\":{\\"vehicleLengthValue\\":49
\\"speed\\":{\\"speedValue\\":2536	\\"vehicleLength\\":{\\"vehicleLengthValue\\":49
\\"speed\\":{\\"speedValue\\":2536	\\"vehicleLength\\":{\\"vehicleLengthValue\\":49
\\"speed\\":{\\"speedValue\\":2542	\\"vehicleLength\\":{\\"vehicleLengthValue\\":49
\\"speed\\":{\\"speedValue\\":2527	\\"vehicleLength\\":{\\"vehicleLengthValue\\":49
Longitudinal Acceleration	Lateral Acceleration
\\"longitudinalAcceleration\\":{\\"longitudinalAccelerationValue\\":-6	\\"lateralAcceleration\\":{\\"lateralAccelerationValue\\":12
\\"longitudinalAcceleration\\":{\\"longitudinalAccelerationValue\\":0	\\"lateralAcceleration\\":{\\"lateralAccelerationValue\\":-7
\\"longitudinalAcceleration\\":{\\"longitudinalAccelerationValue\\":0	\\"lateralAcceleration\\":{\\"lateralAccelerationValue\\":-7
\\"longitudinalAcceleration\\":{\\"longitudinalAccelerationValue\\":-8	\\"lateralAcceleration\\":{\\"lateralAccelerationValue\\":-7
\\"longitudinalAcceleration\\":{\\"longitudinalAccelerationValue\\":11	\\"lateralAcceleration\\":{\\"lateralAccelerationValue\\":2
\\"longitudinalAcceleration\\":{\\"longitudinalAccelerationValue\\":-4	\\"lateralAcceleration\\":{\\"lateralAccelerationValue\\":-8
\\"longitudinalAcceleration\\":{\\"longitudinalAccelerationValue\\":-4	\\"lateralAcceleration\\":{\\"lateralAccelerationValue\\":-8
\\"longitudinalAcceleration\\":{\\"longitudinalAccelerationValue\\":3	\\"lateralAcceleration\\":{\\"lateralAccelerationValue\\":-2
\\"longitudinalAcceleration\\":{\\"longitudinalAccelerationValue\\":-15	\\"lateralAcceleration\\":{\\"lateralAccelerationValue\\":9

The data included speed, longitudinal acceleration, lateral acceleration, curvature, time stamp, speed, and additional data.

The CAVI C-ITS data would be suitable for Stage 2 of this project. The CAVI project team were agreeable to collaboration for a NACOE project.

Road Analytics Company

The Australian Road Research Board (ARRB) and TMR became aware of companies that offer aggregated vehicle data from vehicles and OBD2 devices. ARRB held private discussions with various Road Analytics Companies (RAC) to determine if the data could be used for Stage 2 of this project.

One of the RAC claimed to have agreement to source data from 64 vehicle manufacturers and had access to data from 700,000 connected vehicles in Australia. The RAC stated that it had developed algorithms to identify harsh braking and acceleration events, which was displayed on interactive maps and dashboards.

The data appears to be available for immediate use and the RAC indicated that it has solved any issues for privacy with the motor companies. The RAC has also solved the issue of storing and retrieving the data which are significant issues.

If the project proceeded with this source, the Stage 2 project would seek to confirm how the data is calibrated and referenced to demonstrate the data quality and accuracy. The Stage 2 project would seek to undertake ground truthing to demonstrate the accuracy of the data and the identification of harsh braking events. The approach using this data would be based on the number of potential skid resistance events identified by the algorithms.

The RAC data appears suitable for comparison with skid resistance network testing and has a very considerable number of vehicles.

Independent trial

The Stage 2 project could undertake an independent trial. In this case, the project would purchase the OBD2 devices which are about \$100 each and ask TMR staff to participate by attaching the devices to their vehicles. The trial would supply a new data set and presents some challenges as follows:

- The participants may feel compelled to drive with additional care because of the trial. This could mean the skid resistance events may not eventuate.
- The participants may tend to travel on the same roads and provide a partial view of the network. This issue could be overcome by the time period of the trial, the location of participants, and the number of participants.
- A privacy agreement would be needed to ensure the travel data could be used. CAVI has overcome this issue and the project could leverage this knowledge.
- The participants would be using different vehicles which is an advantage to the trial as the 'fleet' represents the different skid resistance demands of different vehicles.
- TMR pool vehicles could be used for the trial, but these vehicles tend to have limited travel paths and travel only in work hours. This could reduce the variation in results. A better solution would be to directly ask TMR staff to participate with their private vehicles. TMR has approximately 7,000 staff and even a small participation rate would be suitable for the trial.
- The project would need to leverage from the CAVI or RAC for how to store and retrieve the data.
- The project would need to undertake some controlled trials to be able to understand how to identify skid resistance events. The field exercise could be undertaken in one day but generating the algorithms could take a considerable time and effort. The learnings from CAVI and RAC (if available) could be used to short-cut this exercise.
- The collection of the data essentially replicates the CAVI and RAC data set.

Undertaking an independent trial is possible and would require a full costing to understand the data management costs and cost of developing/purchasing methods to identify skid resistance events.

3.1.3 Options for Location of Trial

The investigation for location of the Stage 2 trial revealed two complimentary options:

- Road Network
- Test Track.

Using the Queensland road network would be of direct interest to the NACOE project team and would remove any complicating issues of differences in road networks. The skid resistance events could be targeted on the TMR road network and compared to network skid resistance test results. This would provide immediate benefit to TMR and allow site inspection and validation of any identified areas.

The test track at Mt Cotton (or similar) would be used to verify the following:

- Safety device data from a motor company. The vehicle would be subjected to skid resistance events on the skid resistance pan under controlled conditions to verify the safety devices were deployed as recorded by the data.
- Vehicle movement data, CAVI. The vehicle would be subjected to skid resistance events on the skid resistance pan under controlled conditions to record the movement data. The data could then be analysed to identify the skid resistance event.
- Vehicle movement data, RAC. The vehicle would be subjected to skid resistance events on the skid resistance pan under controlled conditions to record the movement data. The data could then be compared to the skid resistance events identified by the RAC.
- Vehicle movement data, Independent Trial. The vehicle would be subjected to skid resistance events on the skid resistance pan under controlled conditions to record the movement data. The data could then be analysed to identify the skid resistance event.
- The network skid resistance test equipment would also be required to undertake skid pan trials to compare with the vehicle data.

The project concluded both network and test track trials would be needed for Stage 2.

3.2 Discussion

The project identified one source of vehicle safe device data and three sources of vehicle movement data. The project considered these data sources operating on the road network and on a controlled network. The various options for the Stage 2 project are shown in Table 3.2.

Table 3.2: Options for study design

Location	Vehicle data	Movement data CAVI	Movement data RAC	Movement data Independent trial
Road Network	Data not available	Data available	Data available	Data to be created
Test Track	Data not available	Data to be created	Data to be shared by RAC	Data to be created

The table also shows the availability of data as follows:

- Red means not available.
- Yellow means available with some difficulty.
- Green means available.

The Vehicle Data from the motor company is not available and the project was unable to find another source. This option is not recommended.

The Movement Data using CAVI option provides an opportunity to use the existing CAVI data and set-up from the Queensland road network. This option has the advantage of leveraging from TMR's existing projects which should allow for easy and open collaboration. The test track exercise could be undertaken using a volunteer CAVI vehicle to demonstrate the skid resistance events. The algorithm to identify skid resistance events would be created from the skid resistance trial. This is a significant piece of work.

The Movement Data using RAC option provides an opportunity to use existing RAC data from the Queensland road network. This option has the advantage of leveraging from private industry and may present barriers of formal agreements, costs and ownership of any new knowledge. It is understood that a specific RAC has undertaken the test track exercise using various vehicles and developed an algorithm to

identify skid resistance events. The project would seek to review this information as a step to accept the skid resistance events identified by the RAC on the network.

The Movement Data using an Independent Trial option provides an opportunity to create a fleet of OBD2 enabled users and undertake tracking and reporting on the Queensland road network. The learnings from CAVI could be applied to create and manage the resulting data and this would be a significant piece of work. The trial would replicate the existing CAVI data set but at additional cost. The test track exercise could be undertaken using a volunteer OBD2 vehicle to demonstrate the skid resistance events. The algorithm to identify skid resistance events would be created from the skid resistance trial. This is a significant piece of work.

This option is not recommended as the data capture and management replicates the CAVI project with no additional benefit.

3.3 Recommendation

The best options for Stage 2 of this project are:

- movement Data using CAVI
- movement Data using RAC.

Both options have similar advantages for data availability for a road network. The CAVI project data is expected to be easily shared and available as the project was undertaken by TMR. The RAC data presents some unresolved issues of veracity and access by formal agreement.

Both options have similar advantages for identifying skid resistance events using a test track. The CAVI project would include significant analysis to generate a reliable algorithm, and this could be limited by the number of vehicles available for the test track work. The RAC project could provide a shortcut by sharing the results of the test track exercise and information regarding the analysis and resulting algorithm. It is uncertain if TMR could use this information in its own right after the project or would be obliged to continue the partnership with the RAC.

The Movement Data using CAVI is recommended for Stage 2 of this project, given the advantages of partnering with CAVI. The test track exercise should be undertaken early to determine if a way of identifying skid resistance events can be achieved. Where this is not possible, the next best option is to investigate Stage 2 with the RAC.

References

Austroads 2009, *Guide to pavement technology part 3: pavement surfacings*, AGPT03-09, Austroads, Sydney, NSW

Austroads 2011, *Guidance for the development of policy to manage skid resistance*, AP-R374-11, Austroads, Sydney, NSW

Transport Research Laboratory 2020, *The relationship between connected and autonomous vehicles, and skidding resistance*, report no. 962, by J Bullas, T Andriejauskas, PD Sanders & MJ Greene, TRL, Crowthorne, Berkshire, UK.

Appendix A Literature Review

The following extract is from the literature review undertaken for this project. The literature review was reported separately.

A.1 Summary

This project explored the use of vehicle data to support the management of skid resistance on the TMR road network. Vehicle data is available from various manufacturers and records the response of the vehicle to driver and road conditions. This new source of information about the movement of vehicles could be used to infer the road conditions under which these safety devices were used, and therefore be used to enhance network management.

The literature search showed the potential for road agencies to use harsh braking, traction control use, wiper speed use, regenerative braking, deceleration, speed/torque ratio, and vibrations measured using accelerometers, as surrogate measures to locate areas of the road network that may have low skid resistance and/or texture. The data would only be available from newer cars or phone applications and the data would have to be sourced from the motor companies or phone application owners. The data can be received by the motor companies in real time and could be shared in real time with the road agencies.

These new data streams could be used to enhance the management of the road network and alert road agencies to both real-time issues such as oil spills and the long-term issues of polishing.

The review showed very little information was available regarding vehicle data for network skid resistance. The search for road agencies using innovative sources of data revealed one promising project – the Danish Road Directorate explained the road agency is undertaking a major four-year project to develop models for the relationship from vehicle data to road condition. Various other road agencies claimed interest in this area of research but were not active.