Heavy Vehicle Brake Calculator Final Report

Improving Braking Performance of Heavy Vehicles

ABSTRACT

The Final Report for the National Heavy Vehicle Regulator on the Development of a Heavy Vehicle Brake Calculator conducted by ARTSA Institute, and Industry Stakeholders

January 2024

ARTSA-i

Contents

Background

ARTSA (now ARTSA Institute) in 2018, submitted a successful application for Round 4 funding of the National Heavy Vehicle Safety Initiative.

The advanced Braking Calculator was developed to assist vehicle technicians, engineers such as Accredited Vehicle Examiners (AVEs), and regulators to assess and potentially improve the braking performance of multi-heavy vehicle combinations**.**

The calculator is designed to be user friendly and free to use for accredited users that undertake a training program. The calculator can be used to design and check heavy vehicle service-, emergency- and parking-brake systems. The calculator is a Beta version that has a feedback button that will allow users to make suggestions on how to improve the calculator.

The calculator has several advanced features, as follows:

- Allows the brake systems on up to 5 axles per group to be individually specified.
- Predicts wheel lock-up during braking.
- Calculates mass transfer between vehicles, between axle groups on each vehicle and between axles in a group.
- Includes a drum-brake discount factor to model brake drum heating.
- Allows pneumatic controls to be modelled so brake wear can be considered.
- Calculates on a specified slope; not just on a flat surface.
- Simultaneously calculated for laden and unladen conditions.
- A user feedback button that allows feedback and requests for clarifications to be made directly to the Reference Group.

The calculator can be used:

- To calculate compliance with Code G brake modifications under Vehicle Standards Bulletin No. 6..
- To calculate compliance with Australian Design Rule 38 for heavy trailers.
- Train vehicle technicians about consequences of brake set-up changes.
- Train vehicle engineers on good brake design practice.
- Assist with crash reconstruction.

ARTSA-i approached its members and stakeholders to support the initiative and there was strong support. A representative from the NHVR was also on the reference group.

Brake Calculator Reference Group

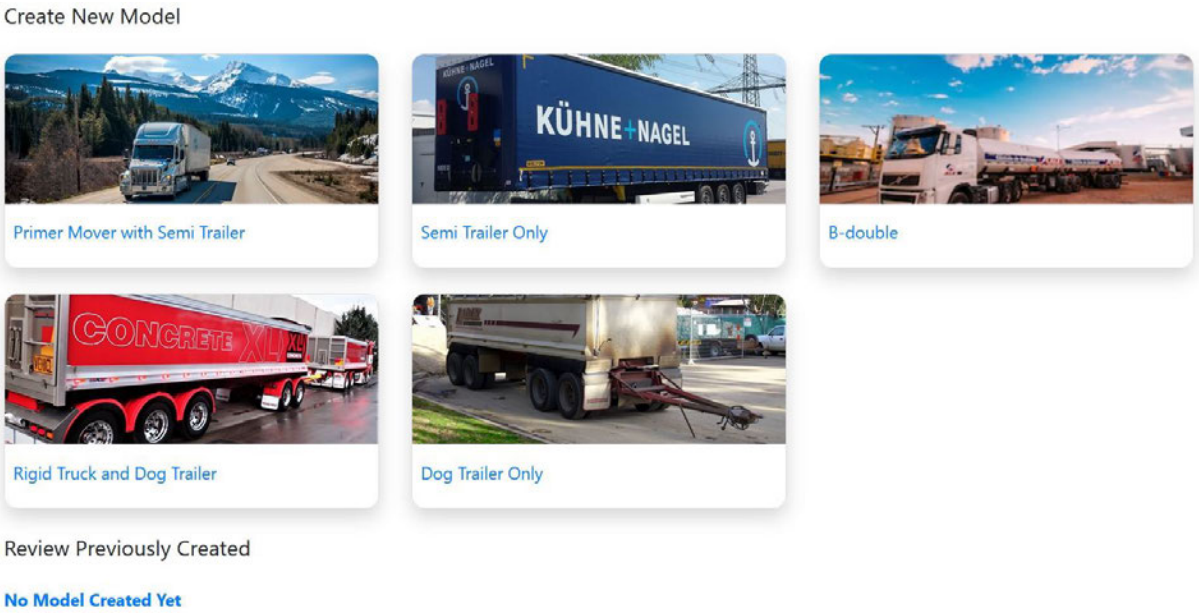
A Reference Group provided advice and direction for the initiative.

The Refence Group had extensive expertise of heavy vehicle braking systems.

Reference Group Members

Peter	Hart	Hartwood Consulting/ARTSA
Les	Bruzsa	NHVR
Ian	Thompson	BPW
Rob	Smedley	Smedleys Engineers/ARTSA
Bob	Edwards	Transport Engineering/ARTSA
Rachel	Michaud	Knorr-Bremse/ARTSA

What Does the Calculator Do?



The brake calculator allows the user to calculate the deceleration and stopping distance due to the service (foot) brake of the following types of heavy combination vehicles:

- Prime mover + Semitrailer. (5 axles on each vehicle)
- Rigid truck + two-axle (dog) trailer. (5 Axles on each vehicle)
- Prime mover + B-double trailer set. (5 axles on each vehicle)

Additionally, the following vehicles can be calculated:

- Semitrailer only (with the towing vehicle set to zero).
- Rigid truck only (with the trailer set to zero).
- Two-axle (dog) trailer only with rigid truck set to zero.
- Centre-axle trailer only (which is a Semitrailer with the axle group generally in the centre)

The calculator is applicable to vehicles that have compressed air braking systems. Virtually all vehicles with a gross rating over 12t have full air brakes and can be studied using the calculator.

The ARTSA-i Brake Calculator allows the user to determine changes to performance that will occur if the brake system on the vehicle is changed. Thereby road testing may be avoided in some instances.

The purpose of the ARTSA-i brake calculator is to provide a tool that brake engineers can use to predict the braking performance of a combination vehicle to check compliance with technical standards. The relevant technical standards are:

- ADR 35/0* - Commercial vehicle braking systems.
- ADR 38/0* - Trailer Brake Systems.
- Vehicle Standards Bulletin Section G – National Heavy Vehicle Modification Code, brake certification.
- Performance Based Standards (PBS) – Directional Stability Under Braking.

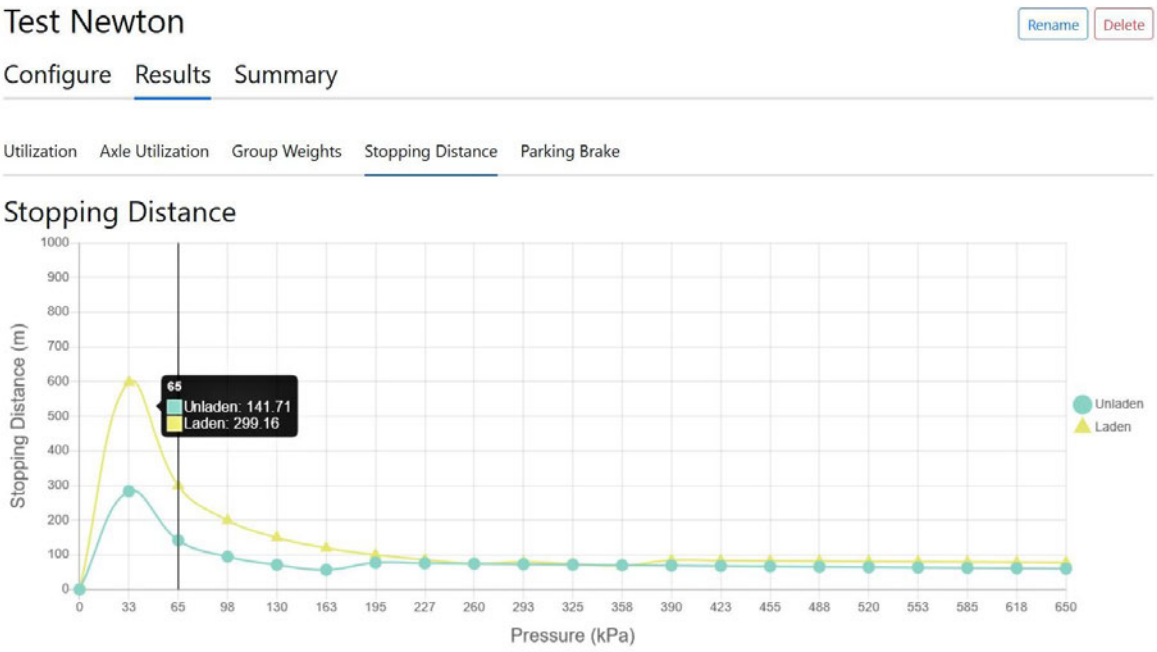
* The last character is the revision level of the ADR rule. The current rules are 35/07 & 38/05.

The vehicle combination starting speed is specified by the user. Noting that the starting speed for tests specified in ADR 35 is different to that specified in ADR 38. The user can do two calculations using different starting speeds.

The brake calculator is not useful to calculate roadworthiness of vehicles because this depends upon the actual condition of the brakes on a vehicle, which can only be assumed for calculation purposes. Furthermore, the calculator assumes that the braking performance of the wheels on each end of an axle is identical, which may not be true in practice.

The ARTSA-I brake calculator calculates the combination vehicle braking at twenty brake control levels in the range 0 – 650 kPa. 650 kPa is also referred to as 1.0E. Therefore, the control increments for calculations is 32.5 kPa (0.05E). The brake control level is the air control pressure at the brake pedal in the motive vehicle. The axle control level at the axle group can be different because of air-valve characteristics in the axle control system. The user can specify the air system transfer characteristic between the brake control and the axle.

A comprehensive user manual has been produced and is available for accredited users of the calculator. It is attached to this report.



Brake Calculator Training

Because of the complexity of brake design, the Reference Group determined that that only accredited users who have been through two half day web-based training and assessment sessions would be given access to the calculator.

The training provides detailed information about heavy vehicle braking systems and will be of great benefit to industry personnel involved in maintaining, developing and regulating heavy vehicle braking systems.

The course was designed for OEM personnel, vehicle technicians, engineers such as Accredited Vehicle Examiners (AVEs), and regulators.

Participants received:

- detailed information about heavy vehicle braking and the brake design rules.
- in depth understanding of how to use the ARTSA-i brake calculator.
- accreditation to use the Beta version of the calculator free of charge.

The Course Outline is shown below:

- Session 1, Day 1 – Brake system basics 9:00am – 9:30am
- Session 2, Day 1 – Brake stability and Brake Rules 9:30am – 10:45am
- Session 3, Day 1 –Brake Calculator Demonstration 11:00am – 12:30pm
- Session 4, Day 2 – Practical Trailer brake Design Example 9:00am – 9:30am
- Session 5, Day 2 - Design Examples -Combination Vehicles 9:30am – 10:15am
- Session 6, Day 2 – Advanced Calculator Techniques 10:30am – 11:00am

- Session 7, Day 2 - Examples of satisfactory brake designs 11:00am – 12:00pm
- Session 8, Day 2 - Follow-up & Questions 12:00pm – 12:30pm

The first course was conducted on the 28 and 29 of November 2023 – with seven participants. Further courses are planned for early 2024.

To compliment training, ARTSA-i commissioned a 29 minute-long brake training video that describes the brake technologies to be found on USA, European and Japanese manufactured heavy vehicles.

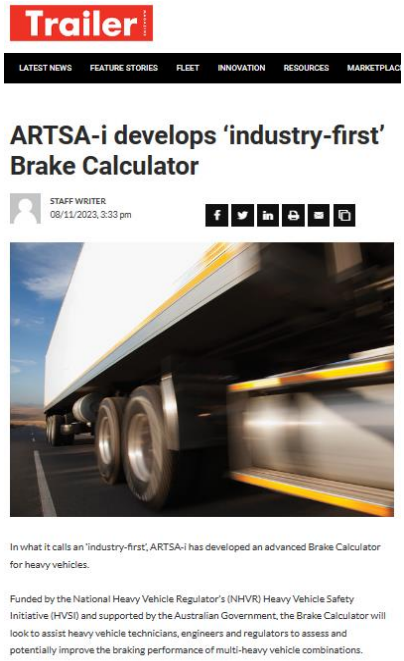
Communications Program

An extensive communications program was conducted after the project launch on 7 November 2023 at the HVTT Conference in Brisbane. The campaign targeted vehicle technicians, engineers such as Accredited Vehicle Examiners (AVEs), and regulators.

Two videos were produced – one marketing the calculator and the other providing instructions for its use. The videos are available at [ARTSA-i Online Brake Calculator Instructional video - YouTube]

The media release is in Appendices.

A sample of media coverage received is below:


Trailer

LATEST NEWS FEATURE STORIES FLEET INNOVATION RESOURCES MARKETPLAC

ARTSA-i develops 'industry-first' Brake Calculator

STAFF WRITER
08/11/2023, 3:33 pm

In what it calls an 'industry-first', ARTSA-i has developed an advanced Brake Calculator for heavy vehicles.

Funded by the National Heavy Vehicle Regulator's (NHVR) Heavy Vehicle Safety Initiative (HVSI) and supported by the Australian Government, the Brake Calculator will look to assist heavy vehicle technicians, engineers and regulators to assess and potentially improve the braking performance of multi-heavy vehicle combinations.

PRIME MOVER

HOME INDUSTRY NEWS FEATURES TEST DRIVE MINDSET DELIVERY PROFILE

The ARTSA-I Brake Calculator

PETER HART
July 18, 2023, 4:10 pm

In my June *Prime Mover* magazine article, I described how Australian trailer braking systems on new trailers can be certified by calculations.

The brake calculator project is funded by the National Heavy Vehicle Regulator's (NHVR) Heavy Vehicle Safety Initiative (HVSI), supported by the Australian Government.

The ARTSA-I continues to promote the initiative through its web site:

ARTSA-i New Brake Calculator

The ARTSA Institute has developed an advanced Braking Calculator to assist vehicle technicians, engineers such as Accredited Vehicle Examiners (AVEs), and regulators to assess and potentially improve the braking performance of multi-heavy vehicle combinations.

The Brake Calculator project has been funded by the National Heavy Vehicle Regulator's (NHVR) Heavy Vehicle Safety Initiative (HVSI), that is supported by the Australian Government.

The beta version of calculator is user friendly and free to use for accredited users (see training below) and can be used to design and check heavy vehicle service-, emergency- and parking-brake systems. A feedback button will allow users to make suggestions on how to improve the calculator.

Benefits of using the ARTSA-i calculator: - predicts wheel lock-up during braking - mass transfer between vehicles, and axle groups is indicated - allows pneumatic controls to be modelled so brake wear can be considered. - can be applied to design-rule, VSB 6 modification code, PBS or in-service brake performance checks.

Because of the complexity of brake design, only accredited users that have been through two half day web-based training and assessment sessions will be given access.

The training will provide detailed information about heavy vehicle braking systems and be of great benefit to industry personnel involved in maintaining, developing and regulating heavy vehicle braking systems. To register for the course, go to **www.artsa.com.au/training.**

Lessons Learned

What worked well - what didn't, what we would do differently?

The ARTSA-i brake calculator allows a novice user to specify a complex vehicle in under 60s. It does this by providing 'generic' vehicle templates. This approach successfully simplifies the task of getting to know and use the calculator.

The ARTSA-i brake calculator applies physical theory to do complex brake calculations. Different users required different features. Development of specialist features took a long time, in part because the Reference Group was itself was unsure what features were desirable. As the user group grows, further suggestions for changes and features can be anticipated.

The project has been underway for several years. All involved wanted it to be finished before now. The coding of the project was complicated, and it took a long time to determine a workable approach to designing the Graphical User Interface.

Now that the Graphical User Interface has been successfully developed, the calculator could be extended to other performance measures, such as rollover vulnerability, vehicle torsional stiffness and chassis rail stress profiles.

ARTSA-i spent more to develop the brake calculator that was budgeted for. The time and effort needed to code the project exceeded the original estimates. This was due to the difficulty in knowing what to expect because such a project was outside ARTSA-I experience.

Appendices

Launch Media Release

7 November 2023

Heavy Vehicle Braking Initiative

News Release

In an industry first, the ARTSA Institute has developed an advanced Braking Calculator to assist vehicle technicians, engineers and regulators to assess and potentially improve the braking performance of multi-heavy vehicle combinations.

The Brake Calculator project is funded by the National Heavy Vehicle Regulator's (NHVR) Heavy Vehicle Safety Initiative (HVSI), supported by the Australian Government.

Chair of ARTSA Institute, Martin Toomey, said "The Institute is pleased to be able to assist industry in improving the performance of heavy vehicle braking systems.

"The Brake Calculator follows the *Guide to Braking and Stability Performance for Heavy Vehicle Combinations* which ARTSA published several years ago."

Dr Peter Hart, the developer of the calculator and ARTSA-i Life member, explained the beta version of the calculator will be free to use for accredited users and has many benefits in comparison to existing calculators. A feedback button will allow users to make suggestions on how to improve the calculator.

"The brake calculator was developed to provide a sophisticated yet easy-to-configure web application that vehicle technicians, engineers and regulators can use to design and check heavy vehicle service, emergency and parking-brake systems," Dr Hart said.

The calculator predicts wheel lock-up during braking using a novel tyre-road friction model that can be set for different road surfaces.

The mass transfer between vehicles, axle groups and within each axle group is included in the model. It also allows pneumatic controls to be modelled so that brake wear can be considered.

The beta version of calculator is user friendly and free to use for accredited users and can be used to design and check heavy vehicle service-, emergency- and parking-brake systems. A feedback button will allow users to make suggestions on how to improve the calculator.

The calculator can be applied to design-rule, VSB 6 modification code, PBS or in-service brake performance checks.

Dr Hart said, "The calculator has been designed to be user friendly, but because of the complexity of brake design, it has been decided to only allow access to users

that have been through a web-based training session.

“The training will provide detailed information about heavy vehicle braking systems from basic braking systems to advanced technologies, and about brake rules.

“The training will be of great benefit to industry personnel involved in maintaining, developing and regulating heavy vehicle braking systems.”

To register for the course, visit: www.artsa.com.au/training

“A refence group from ARTSA-I, industry and a representative from the NHVR have been providing project guidance over the last few years and their work is very much appreciated” Mr. Toomey said.

For further information contact Greg Rowe, Project Manager, ARTSA-i [redacted]