Draft Pavement Impact Comparison Calculator

User Guide

April 2024

DRAFT

For consultation purposes only.

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Draft Pavement Impact Comparison Calculator

Introduction

This user guide assists the use and interpretation of NHVR's Pavement Impact Comparison Calculator (the Pavement Calculator).

Background

Consultation for the Heavy Vehicle Productivity Plan 2020 - 2025 (HVPP) identified that not all road managers have pavement engineering capability to inform their route assessments for heavy vehicle access decision-making. Recommendations were made for the NHVR to assist road managers in this regard.

Austroads research report AP-R658-21 '*Investigation of Pavement Assessment Methodologies for Performance Based Standards Access*' contained the following aligning recommendations:

- Local government road managers should be provided with pavement assessment information or tools as part of access decision making
- Pavement assessment review should include a comparison with a reference vehicle and consideration of the freight task
- ESA or SARs metrics can be used as way of defining the cumulative effect of heavy vehicles on the pavement

The Pavement Calculator is a dashboard hosted in Microsoft Excel, that will help road managers, regardless of pavement engineering capability, to understand the long-term pavement effects of freight activity on roads.

More specifically, the Pavement Calculator will estimate and compare:

- vertical loading, for a user-built vehicle, across different common pavement types
- standardised impacts for a nominated freight task (payload per ESA / SAR; and Wear Productivity Index)
- marginal cost of pavement wear

The Pavement Calculator only calculates vertical pavement loading using ESA, SAR4, SAR5, SAR7 and SAR12 approaches (e.g. it does not assist with determining horizontal loading or torsional effects of vehicles on pavements).

While ESA and SAR4 have the same exponent for the purposes of calculations, these have been identified separately to assist users with different understanding of pavement types and their associated vertical loading calculations.

User guide structure

This user guide is divided into four (4) sections (Table 1).

Table 1. User guide structure

Section	Purpose
Limitations	Identifying the limitations and of the Pavement Calculator.
User interface	Explanation on the widgets, filters and manual inputs.
Operational guide	Step-by-step instructions on how to operate the Pavement Calculator.
Calculations and sources	Brief explanation on the calculations and sources used to develop the Pavement Calculator.

Limitations

Although the Pavement Calculator provides meaningful insights, these are to be considered in light of the limitations detailed below (Table 2) and results are to be interpreted accordingly.

These limitations will influence future product enhancements.

Table 2. Tool limitations

Section	Purpose
Vehicle types	The Pavement Calculator considers a total of 223 vehicles types, across all mass schemes and PBS levels, as described by NHVR's Common Heavy Freight Vehicle Configurations Chart and PBS Vehicle Configurations Chart. The Pavement Calculator does not currently consider uncommon combinations not contained in these charts.
Fleet mass data	The NHVR has sourced tare mass data for component units from national registration data records. The tare mass for entire vehicles were built from the average registered tare mass of component units.

	Tare mass data is used to create the 'default masses' (e.g. a consistent benchmark across all vehicle types). Note: The NHVR prefers users manually enter axle masses, as default masses may not reflect real world operations. The payload mass is the difference between GVM/GCM (dependent on the vehicle type and mass scheme), and the tare mass for the vehicle. Note that the user can adjust the payload.
Road friendly suspension (RFS)	The Pavement Calculator does not equate the vertical loading effects of Higher Mass Limit (HML) vehicles as equivalent to General Mass Limit (GML) vehicles, if fitted with RFS. Instead, the Pavement Calculator considers RFS Factors, as per Austroads' Pavement Wear Assessment Method for PBS Vehicles (AP-R372-11). Not all axle group types have an RFS Factor. The original researchers/authors have been engaged, to identify understand if there are unpublished factors for other axle group types (e.g. quad axles). Note that the user is able to turn off RFS for each axle group for combinations operating under HML. For users accustomed to equating vehicles operating at HML and fitted with RFS, as having a pavement effect equivalent to GML, they may enter GML masses to obtain the relevant outputs.
Average marginal costs	The NHVR are only aware of TMR's average marginal cost of pavement wear (i.e. other published information could not be found). The user is encouraged to set their own costs as manual input if they do not want to use costs for Qld. Notes: • marginal cost could not be identified for SAR7. • default marginal cost may not accurately reflect actual costs for all areas of Australia. Manual input is recommended.

Pavement Calculator: User interface

The Pavement Calculator is a dashboard hosted in Microsoft Excel. It allows for self-service analytics and provides the user with a transparent and consistent method to evaluate the pavement wear of known or simulated freight combinations.

The Pavement Calculator is made up of a number of widgets, filters and manual inputs:

- A *filter* is a manual intervention that sorts information by a defined category.
- A *manual input* is a manual intervention that requires the user to enter information.
- A *widget* is a digital interface that presents information or provides a service.

The user interface is colour-coded (refer to legend located on the dashboard):

- Light red cells with bold borders allow for user adjustment;
- Dark red cells relate to vehicle A;
- Dark blue cells relate to vehicle B;
- Green cells relate to axle groups and tyres;
- Yellow relates to road friendly suspension;
- Light blue cells relate to axle masses; and
- Prompts and instructions messages are identified in red text as required.

Filters (drop down menus)

Table 3. Calculator page - filters

Filter name	Function
Fleet	Defines if the vehicles are conventional vehicles or PBS vehicles.
Combination	Defines the specific combination type for the vehicle. List is dependent on the fleet selection.
Mass scheme	Defines the mass scheme for the combination type. List is dependent on the combination selection.

Filter name	Function
PBS level	Defines the PBS level for the PBS Vehicle (does not apply to conventional vehicles). List is dependent on the mass scheme selection.
Control box – Vehicle components	Defines whether the user wants to use the default the axle groupings and tyre sizes or manual identify the axle groupings and tyre sizes.
Control box – Axle masses	Defines whether the user wants to use the default axle masses or manually identify the axle masses. Note that the default values are calculated from axle masses proportionally adjusted to equal the GCM. This may not accurately represent real-world conditions. Manul input is recommended.
Control box – Maximum payload	Defines whether the user wants to use the default payload, based on the average tare mass or manually identify the payload.
Vehicle components – manual entry	If manual entry is selected in the Control box – Vehicle components, a filter will appear with a pre-selected list of axle groupings and tyre sizes. Note different tyre sizes and drive / non-drive only applicable in some instances, where there is an impact to RFS or mass limits.
RFS (Optional)	If a combination is selected at HML, the user has the option of opting out of using RFS.
Marginal cost	Defines the source of the marginal cost, either by jurisdiction (only QLD has dollar values) or manual entry.

Manual inputs (enter value)

Table 4. Calculator page – manual inputs

Input	Function
Control box - maximum payload	Defines the maximum payload of the vehicle, if 'manual entry' is selected under 'maximum payload'.
Axle masses – Manual entry	If manual entry is selected in the Control box – Axle masses, the user can enter in the individual masses for each axle group.
Marginal cost inputs	If manual entry is selected as the source, the user is able to manually identify the costs for each pavement type.

Widgets (automated outputs)

Table 5. Calculator page widgets

Widget	Function
Combination masses	Identifies the configuration and default masses for a selected vehicle.
Vehicle components	Identifies the default axle group code and default tyre size.
RFS	Identifies the default RFS factor if combination is operating as HML.
Axle masses	Identifies the standard axle mass, MDL upper mass limit and default masses. Note that the default values are calculated from axle masses proportionally adjusted to equal the GCM. This may not accurately represent real-world conditions. Manul input is recommended.
ESA	Identifies the pavement wear on unbound pavements utilising the ESA methodology. Percentage difference highlighted for Scenario B.
SAR4	Identifies the pavement wear on unbound pavements utilising the SAR4 methodology. Percentage difference highlighted for Scenario B.
SAR5	Identifies the pavement wear on sealed roads with asphaltic concrete pavement utilising the

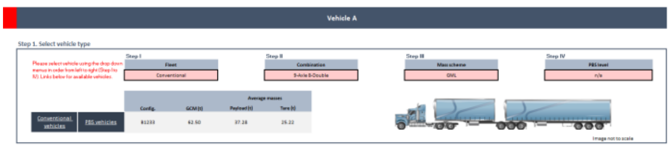
Widget	Function
	SAR5 methodology. Percentage difference highlighted for Scenario B.
SAR7	Identifies the rutting and loss of shape of flexible pavements with bound layers SAR7 methodology. Percentage difference highlighted for Scenario B.
SAR12	Identifies the pavement wear on sealed roads with cement stabilised pavement utilising the SAR12 methodology. Percentage difference highlighted for Scenario B.
Selection summary	Identifies a summary of vehicle choice, whether vehicle components have been adjusted, whether RFS has been applied and whether axle masses have been adjusted.
Output comparison	Identifies the difference in GCM, payload and tare masses between vehicles, along with payload per ESA/SAR; estimate cost of pavement wear to transport 100t by 1km for each vehicle; and the Wear Productivity Index (WPI) ratio for a 100t payload freight task. The WPI ratio gives the ratio of pavement damage that Vehicle B will cause compared to Vehicle A. For example, if Vehicle B is more damaging than Vehicle A the ratio will be above 1.0. Conversely, if Vehicle B is less damaging than Vehicle A, the ratio will be below 1.0.

Operational guide

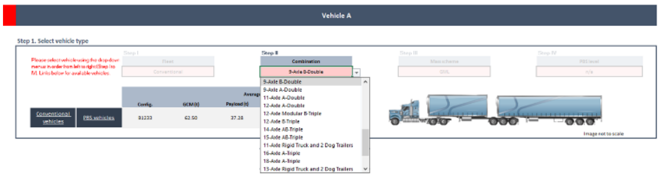
Below outlines the recommended order of actions when using the Pavement Impact Comparison Calculator.

Step 1: Vehicle A selection

Table 6. Step 1. Vehicle A selection

Instruction	
Navigate to Step 1. Vehicle selection.	
For Vehicle A, click the ***fleet filter*** (Step I) and select the desired fleet type from the dropdown menu. Refer to the NHVR common configuration charts for vehicle selection options. Links supplied. If the vehicle does not exist an error message will be displayed.	

For Vehicle A, click the ***combination filter*** (Step II) and select the desired combination type from the dropdown menu.



For Vehicle A, click the ***mass scheme filter*** (Step III) and select the desired mass scheme from the dropdown menu.

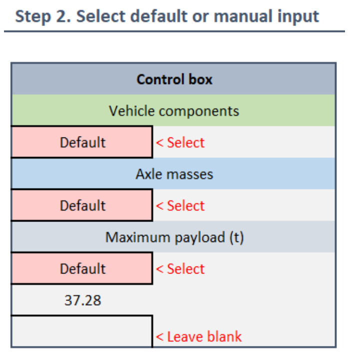
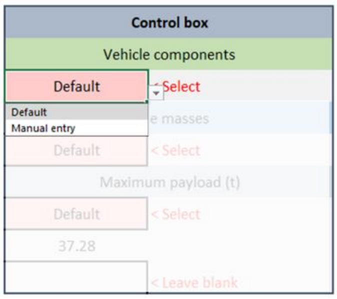
For Vehicle A, click the ***PBS level filter*** (Step IV) and select the desired PBS level from the dropdown menu.

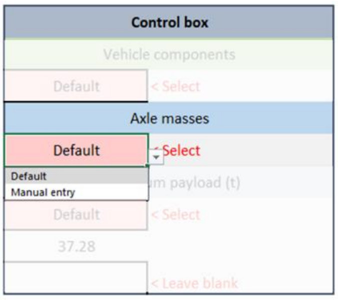
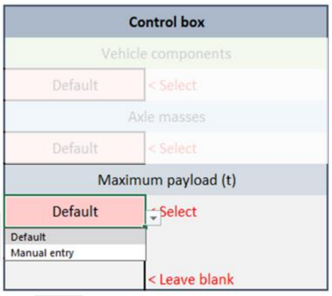
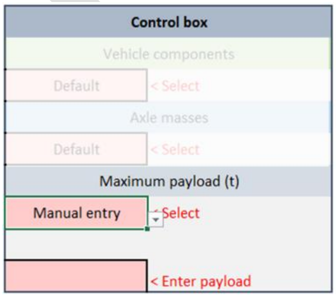
If a conventional vehicle, select **n/a**.

Note: Vehicle section drop down menus must be undertaken in order (Steps I – IV).

Step 2: Select default or manual input for Vehicle A

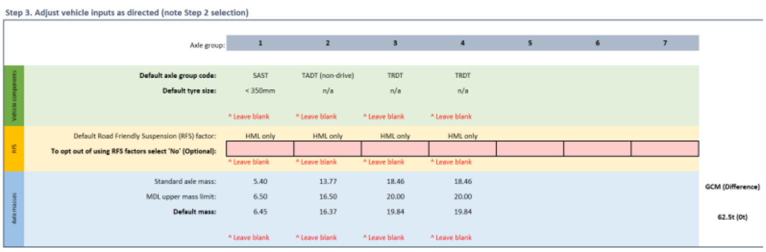
Table 7. Step 2. Select default or manual input for vehicle A

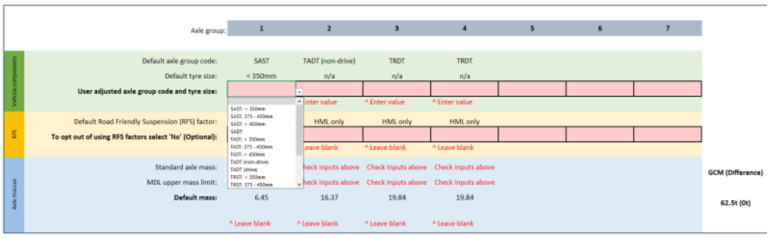
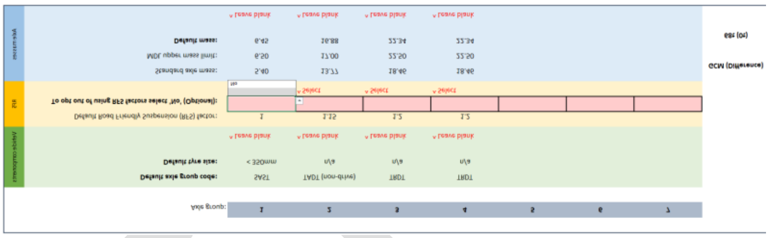
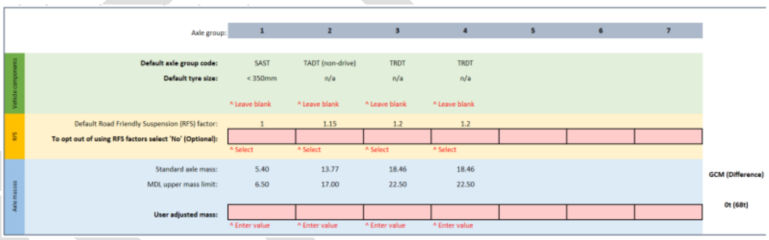
Instruction	
Navigate to Step 2. Select default or manual input for vehicle A	
Using the dropdown menu within the control box, select the source for the ***vehicle components***: default or manual entry.	

Instruction	
Using the dropdown menu within the control box, select the source for the ***axle masses***: default or manual entry. Note that the default values are calculated from axle masses proportionally adjusted to equal the GCM. This may not accurately represent real-world conditions. Manul input is recommended.	
Using the dropdown menu within the control box, select the source for the ***maximum payload***: default or manual entry. If manual entry is selected, enter the maximum payload in the cell, as prompted by the red text.	 

Step 3: Adjust vehicle inputs as directed for vehicle A

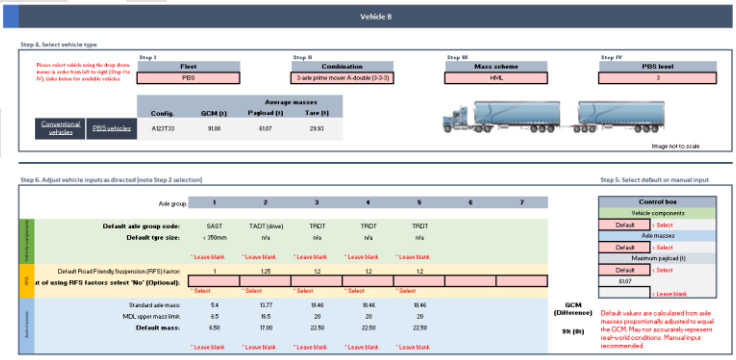
Table 8. Step 3. Adjust vehicle inputs as directed for vehicle A

Instruction	
Navigate to Step 3. Adjust vehicle inputs as directed (note Step 2 selection)	

If the source of the ***vehicle components*** is default (refer to Step 2), then no action is necessary. If the source of the ***vehicle components*** is manual entry, then select from dropdown menu, as prompted by the red text. Note, number of axle groupings is to remain consistent with the vehicle selection.	
If the combination selected is operating at HML, RFS is automatically applied. ***To opt out of using RFS factors***, select 'No' using the dropdown menus for each axle group.	
If the source of the ***axle masses*** is default (refer to Step 2), then no action is necessary. If the source of the ***axle masses*** is manual entry, then enter the masses, as prompted by the red text.	

Steps 4 – 6: Vehicle B selection and inputs

Table 9. Vehicle B selection and inputs

Instruction	
Repeat steps 1 – 3 (as per Vehicle A) for vehicle B selection and inputs.	

Step 7: Select marginal cost inputs

Table 10. Step 7. Select marginal cost inputs

Instruction

Select the source of the ***marginal cost***. Note that SAR7 does not have a marginal cost.

If manual entry is selected, enter dollar values for each pavement type, as prompted by the red text.

Note that only QLD has a marginal cost. Manual entry is encouraged.

Step 7. Select marginal cost inputs (Optional)

Key: Greater impact | Lesser impact | Equal impact

	Payload per ESA or SAR		Estimate cost of pavement wear to transport 100t payload by 1km		Manual entry	< Select	Wear Productivity Index Ratio
	Vehicle A	Vehicle B	Vehicle A	Vehicle B			Veh. B / Veh.A
ESA	4.99	4.66				< Enter value ($/km)	1.07
SAR4	4.99	4.66				< Enter value ($/km)	1.07
SAR5	4.15	4.03				< Enter value ($/km)	1.03
SAR7	2.86	2.99				< Enter value ($/km)	0.96
SAR12	1.13	1.38				< Enter value ($/km)	0.82

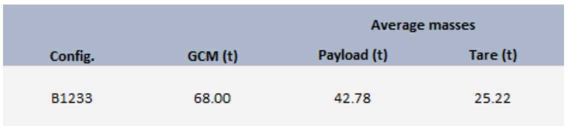
Results

Note: Outputs identified in this section are for illustrative purposes only. Images are from a range of different vehicle selections.

Table 11. Pavement calculator outputs

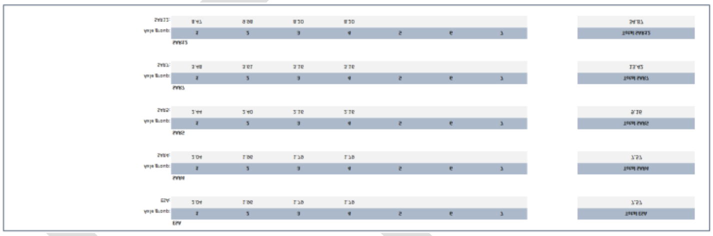
Results

Completion of Step 1 (refer to operational guide), will result in the identification of vehicle configuration, GCM, payload and tare masses.

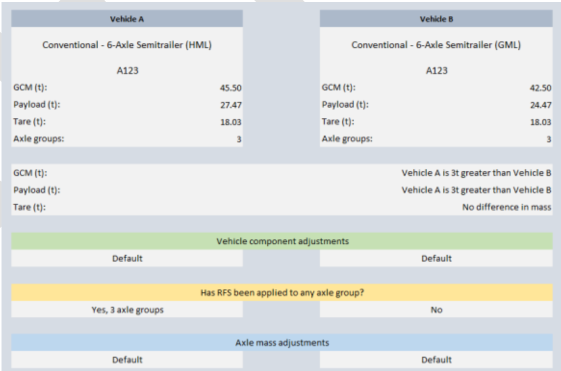


		Average masses	
Config.	GCM (t)	Payload (t)	Tare (t)
B1233	68.00	42.78	25.22

Completion of Steps 1 – 3 will result in the ESA and SARs for each axle group and total ESA / SAR



Completion of Steps 1 – 6 will result in the selection summary for vehicle A and vehicle B.



Vehicle A		Vehicle B	
Conventional - 6-Axle Semitrailer (HML)		Conventional - 6-Axle Semitrailer (GML)	
A123		A123	
GCM (t):	45.50	GCM (t):	42.50
Payload (t):	27.47	Payload (t):	24.47
Tare (t):	18.03	Tare (t):	18.03
Axle groups:	3	Axle groups:	3

GCM (t):	Vehicle A is 3t greater than Vehicle B
Payload (t):	Vehicle A is 3t greater than Vehicle B
Tare (t):	No difference in mass

Vehicle component adjustments	
Default	Default

Has RFS been applied to any axle group?	
Yes, 3 axle groups	No

Axle mass adjustments	
Default	Default

Completion of steps 1 – 7 will result in the output comparison for vehicle A and vehicle B.

	Payload per ESA or SAR		Estimate cost of pavement wear to transport 100t payload by 1km		Wear Productivity Index Ratio
	Vehicle A	Vehicle B	Vehicle A	Vehicle B	Veh. B / Veh.A
ESA	4.99	4.66			1.07
SAR4	4.99	4.66			1.07
SAR5	4.15	4.03			1.03
SAR7	2.86	2.99			0.96
SAR12	1.13	1.38			0.82

Calculations and sources

Table 12. Sources

Source	Data type	Author	Publication
ABS, 2022	CPI	ABS	Consumer Price Index: Weighted Average of Eight Capital Cities, Index Numbers and Percentage Changes, Tables 3 and 4
Austroads, 2011	Road friendly suspension factor	Austroads	Pavement Wear Assessment Method for PBS Vehicles (AP-R372-11), Table 4.8
Austroads, 2019	Standard Axle Masses (Non-pig axles)	Austroads	AGPT02-17 Guide to Pavement Technology Part 2: Pavement Structural Design, Tables 7.7 and 7.8
Austroads, 2016	Standard Axle Masses (Pig axles only)	Austroads	National Steer Axle Mass Limits (AP-R505-16), Tables 4.1 and 4.2
NHVR	Mass and Dimension Limits	NHVR	Heavy Vehicle (Mass, Dimension and Loading) National Regulation
TMR, 2018a	Average Marginal Costs	TMR	Guide to Traffic Impact Assessment Practice Note: Pavement Impact Assessment, Table 6
TMR, 2018b	SAR and ESA Calculations	TMR	Guide to Traffic Impact Assessment Practice Note: Pavement Impact Assessment, Section 2

Fleet and combination identification

Conventional fleet refers to non-PBS freight vehicles.

Conventional fleet vehicles are sourced from the NHVR: Common Heavy Freight Vehicle Configurations Chart.

PBS fleet refers to vehicles that allow heavy vehicle operators to use innovation to optimise vehicle designs, to achieve greater productivity and improved safety, while making the least possible impact on the environment and road infrastructure.

PBS vehicles are designed to perform their tasks as productively and safely as possible, and to operate on networks that are appropriate for their level of performance. PBS vehicles are tested against 16 stringent safety standards and 4 infrastructure standards to ensure they can safely operate on roads. The basic principle of PBS is matching the right vehicles to the right network (i.e. a performance based approach to access).

It is a voluntary scheme that sits alongside the long-standing conventional regulatory system for heavy vehicles.

PBS Fleet vehicles are sourced from the NHVR: PBS Vehicle Configurations Chart.

Summary information on PBS vehicles and the PBS scheme can be found at Performance Based Standards – A guide for road managers. More detailed information can be found at the NHVR website.

Mass schemes

General Mass Limits (GML) is the allowable mass for all types of heavy vehicles under the HVNL Regulations.

More information on GML can be found at https://www.nhvr.gov.au/road-access/mass-dimension-and-loading/general-mass-and-dimension-limits

Concessional Mass Limits (CML) allows mass limits above GML provided the operator is accredited under the National Heavy Vehicle Accreditation Scheme (NHVAS).

More information on CML can be found at https://www.nhvr.gov.au/road-access/mass-dimension-and-loading/concessional-mass-limits

Higher Mass Limits (HML) allow particular heavy vehicles to access additional mass entitlements above CML providing:

- operators of vehicles or combinations running HML on tri-axle groups are accredited under the Mass Management Module of the National Heavy Vehicle Accreditation Scheme (NHVAS), with an accreditation label fitted to the hauling unit

- vehicles are fitted with certified road friendly suspension
- vehicles are on an authorised HML route.

More information on HML can be found at https://www.nhvr.gov.au/road-access/mass-dimension-and-loading/higher-mass-limits

Masses for specific combinations were sourced from the NHVR: Common Heavy Freight Vehicle Configurations Chart and PBS Vehicle Configurations Chart.

PBS level

Based on on-road performance, PBS vehicles are classified into one of four levels in accordance with the Standards and Vehicle Assessment Rules.

Network levels are based on geometric requirements — that is, how much road space is required for safe vehicle operation.

For more information refer to Performance Based Standards – A guide for road managers.

Axle groups

Axle group means one or more shafts positioned in a line across a vehicle, on which one or more wheels intended to support the vehicle turn. Axle groups include single axle group, tandem axle group, twinsteer axle group, tri-axle group or quad-axle group.

For each axle, there may be a single (1) tyre or dual (2) tyres.

Drive and non-drive axle groupings have only been distinguished for the TADT axle group. This is due to the difference in the Road Friendly Suspension factor, as specified in Austroads (2011).

Axle groups have been assigned a unique code (Table 13). The axle masses for the respective axle groups can be found in

Appendix B: Standard axle and MDL axle masses

Table 13. Axle codes

Code	Axle Group
SAST	Single axle single tyre
SADT	Single axle dual tyre
TAST	Tandem axle single tyre
TADT (non-drive)	Tandem axle dual tyre
TADT (drive)	Tandem axle dual tyre (drive)
TRST	Tri-axle single tyre
TRDT	Tri-axle dual tyre
QADT	Quad-axle dual tyre
QAST	Quad-axle single tyre
TSST	Twin Steer Single Tyre
PSADT	Pig Single axle dual tyre
PTADT	Pig Tandem axle dual tyre
PTRDT	Pig Tri-axle dual tyre

Configuration code

The configuration code is consistent with the Australian Trucking Association's (ATA) configuration code. For more information refer to the Description of Truck Configurations Technical Advisory Procedure.

A – Articulated unit

R – Rigid unit

T – Trailer unit

B – B trailer

N – Numbers refer to the number of axles in each axle group

For example:

R22T12 describes a 7-axle truck and dog. It is a rigid unit with twin steer, tandem drive, pulling a 3-axle dog trailer.

B1244 describes a 11-axle B-double. It is an articulated unit, single steer, tandem drive prime mover pulling two quad-axle trailers in a B configuration.

A122T22 describes a 9-axle A-double. It is an articulated unit with a single steer axle, tandem drive prime mover pulling a tandem axle trailer, plus a tandem axle dolly and tandem axle trailer.

Road friendly suspension

To be eligible for HML, vehicles must be fitted with certified road-friendly suspension. Road-friendly suspension systems reduce the impact of laden axles on road pavements and most bridge structures.

For a suspension system to be considered as road-friendly, it must be certified to the requirements set out in the Department of Infrastructure, Transport, Regional Development, Communications and the Arts' Vehicle Standards Bulletin 11 – Certification of Road-Friendly Suspensions.

The Department also provides a list of Certified road-friendly suspensions.

The RFS factors for TADT (drive and non-drive) and TRDT are identified as per Austroads' Pavement Wear Assessment Method for PBS Vehicles (AP-R372-11).

The original researchers/authors have been engaged, to identify understand if there are unpublished factors for other axle group types (e.g. quad axles).

A nominal RFS factor of 1 has been applied to all other axle groups (Table 14).

Note that the user is able to turn off RFS for each axle group for combinations operating under HML.

For users accustomed to equating vehicles operating at HML and fitted with RFS, as having a pavement effect equivalent to GML, they may enter GML masses to obtain the relevant outputs.

Table 14. Road friendly suspension factors

Code	RFS factor
SAST	1
SADT	1
TAST	1
TADT (non-drive)	1.15

Code	RFS factor
TADT (drive)	1.25
TRST	1
TRDT	1.2
QADT	1
QAST	1
TSST	1
PSADT	1
PTADT	1
PTRDT	1

Pavement wear

Equivalent Standard Axles (ESA) and Standard Axle Repetitions (SAR) are both measures of pavement wear that can be caused by vehicles on different pavement types (Table 15).

Calculations are based off TMR's Guide to Traffic Impact Assessment Practice Note: Pavement Impact Assessment (Table 16 and Appendix A: Hypothetical scenario).

Table 15. Pavement wear measures

Measure	Pavement type
ESA	Unbound pavements. Type of damage = overall damage.
SAR4	Sealed roads with granular pavement. Type of damage = overall damage
SAR5	Sealed roads with asphaltic concrete pavement. Type of damage = fatigue of asphalt.
SAR7	Used to assess the rutting and loss of shape of flexible pavements with bound layers.
SAR12	Sealed roads with cement stabilised pavement. Type of damage = fatigue of cemented materials

Table 16. Pavement wear calculations

Measure	Calculations
ESA	ESA per Axle Group = (Axle Mass / Standard Axle Mass) ^ 4 ESA per Axle Group with RFS = ((Axle Mass / Standard Axle Mass) ^ 4)/RFS Total ESA = Sum of ESAs per Axle Group Payload per ESA = Payload / ESA Estimate cost of pavement wear to transport 100t by 1km = (100 / payload) * (Total ESA * marginal cost) WPI ratio = ((100 / payload) * total ESA for Vehicle B) / ((100 / payload) * total ESA for Vehicle A)
SAR4	SAR4 per Axle Group = (Axle Mass / Standard Axle Mass) ^ 4 SAR4 per Axle Group with RFS = ((Axle Mass / Standard Axle Mass) ^ 4)/RFS Total SAR4 = Sum of SAR4s per Axle Group Payload per SAR4 = Payload / SAR4 Estimate cost of pavement wear to transport 100t by 1km = (100 / payload) * (Total SAR4 * marginal cost) WPI ratio = ((100 / payload) * total SAR4 for Vehicle B) / ((100 / payload) * total SAR4 for Vehicle A)
SAR5	SAR5 per Axle Group = (Axle Mass / Standard Axle Mass) ^ 5 SAR5 per Axle Group with RFS = ((Axle Mass / Standard Axle Mass) ^ 5)/RFS Total SAR5 = Sum of SAR5s per Axle Group Payload per SAR5 = Payload / SAR5 Estimate cost of pavement wear to transport 100t by 1km = (100 / payload) * (Total SAR5 * marginal cost) WPI ratio = ((100 / payload) * total SAR5 for Vehicle B) / ((100 / payload) * total SAR5 for Vehicle A)
SAR7	SAR7 per Axle Group = (Axle Mass / Standard Axle Mass) ^ 7 SAR7 per Axle Group with RFS = ((Axle Mass / Standard Axle Mass) ^ 7)/RFS

Measure	Calculations
	Total SAR7 = Sum of SAR7s per Axle Group Payload per SAR7 = Payload / SAR7 Estimate cost of pavement wear to transport 100t by 1km = (100 / payload) * (Total SAR7 * marginal cost) WPI ratio = ((100 / payload) * total SAR7 for Vehicle B) / ((100 / payload) * total SAR7 for Vehicle A)
SAR12	SAR12 per Axle Group = (Axle Mass / Standard Axle Mass) ^ 12 SAR12 per Axle Group with RFS = ((Axle Mass / Standard Axle Mass) ^ 12)/RFS Total SAR12 = Sum of SAR12s per Axle Group Payload per SAR12 = Payload / SAR12 Estimate cost of pavement wear to transport 100t by 1km = (100 / payload) * (Total SAR12 * marginal cost) WPI ratio = ((100 / payload) * total SAR12 for Vehicle B) / ((100 / payload) * total SAR12 for Vehicle A)

Appendix A: Hypothetical scenario

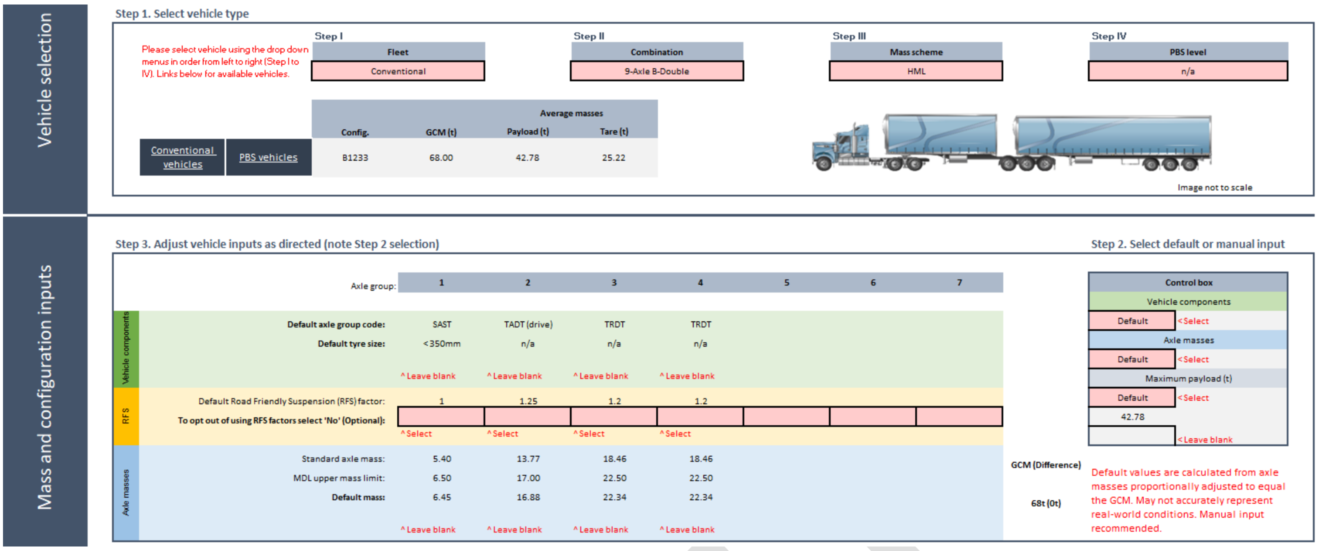


Figure 1. Hypothetical scenario

Table 17. Conventional 9-axle B-double operating at HML mass of 68t (42.78 payload)

Axle groupings	1	2	3	4	
Axle configuration	SAST	TADT (drive)	TRDT	TRDT	
RFS	Yes	Yes	Yes	Yes	
Standard axle mass (t)	5.40	13.77	18.46	18.46	
RFS factor	1	1.25	1.2	1.2	
MDL mass limit	6.50	17.00	22.50	22.50	
Default mass	6.45	16.88	22.34	22.34	
ESA calculation	((6.45 / 5.4) ^ 4) / 1	((16.88 / 13.77) ^ 4) / 1.25	((22.34 / 18.46) ^ 4) / 1.2	((22.34 / 18.46) ^ 4) / 1.2	
ESA result	2.04	1.81	1.79	1.79	**Total: 7.42**
SAR4 calculation	((6.45 / 5.4) ^ 4) / 1	((16.88 / 13.77) ^ 4) / 1.25	((22.34 / 18.46) ^ 4) / 1.2	((22.34 / 18.46) ^ 4) / 1.2	
SAR4 result	2.04	1.81	1.79	1.79	**Total: 7.42**
SAR5 calculation	((6.45 / 5.4) ^ 5) / 1	((16.88 / 13.77) ^ 5) / 1.25	((22.34 / 18.46) ^ 5) / 1.2	((22.34 / 18.46) ^ 5) / 1.2	
SAR5 result	2.43	2.21	2.16	2.16	**Total: 8.97**
SAR7 calculation	((6.45 / 5.4) ^ 7) / 1	((16.88 / 13.77) ^ 7) / 1.25	((22.34 / 18.46) ^ 7) / 1.2	((22.34 / 18.46) ^ 7) / 1.2	

Axle groupings	1	2	3	4	
SAR7 result	3.47	3.33	3.17	3.17	**Total: 13.13**
SAR12 calculation	((6.45 / 5.4) ^ 12) / 1	((16.88 / 13.77) ^ 12) / 1.25	((22.34 / 18.46) ^ 12) / 1.2	((22.34 / 18.46) ^ 12) / 1.2	
SAR12 result	8.43	9.21	8.22	8.22	**Total: 34.09**

* Note: Results will vary in the calculator if using default values due to decimal place rounding. The calculator calculates with no rounding of decimal places, while the above table is to 2 decimal places.

Table 18. Payload per ESA / SAR

Measure	Calculation	Result (t)
Payload per ESA (t)	42.78 / 7.42	5.77
Payload per SAR4 (t)	42.78 / 7.42	5.77
Payload per SAR5 (t)	42.78 / 8.97	4.77
Payload per SAR7 (t)	42.78 / 13.13	3.26
Payload per SAR12 (t)	42.78 / 34.09	1.25

* Note: Results will vary in the calculator if using default values due to decimal place rounding. The calculator calculates with no rounding of decimal places, while the above table is to 2 decimal places.

Table 19. Estimate cost of pavement wear to transport 100t by 1km

Pavement type	Calculation	Result (t)
Sealed roads with granular pavement (ESA / SAR4)	(100 / 42.78) * (7.42 * 0.16)	$2.78
Sealed roads with asphaltic concrete pavement (SAR5)	(100 / 42.78) * (8.97 * 0.06)	$1.26
Sealed roads with cement stabilised pavement (SAR12)	(100 / 42.78) * (34.09* 0.04)	$3.19

* Note: Results will vary in the calculator if using default values due to decimal place rounding. The calculator calculates with no rounding of decimal places, while the above table is to 2 decimal places. For example, in the above scenario, for sealed roads with cement stabilised pavement, the estimated cost of pavement wear to transport 100t by 1km is $3.50 in the calculator (as opposed to $3.19 in the above example due to differences in decimal place rounding).

Appendix B: Standard axle and MDL axle masses

Table 20. Standard axle and MDL axle masses

Axle Code	Tyre Size	Mass Scheme	Standard Axle Mass (t)	MDL Maximum Mass (t)	Road Friendly Suspension (RFS) Factor
SAST	< 350mm	GML	5.40	6.5	
SAST	< 350mm	CML	5.40	6.5	
SAST	< 350mm	HML	5.40	6.5	1
SAST	375 - 450mm	GML	5.91	6.7	
SAST	375 - 450mm	CML	5.91	6.7	
SAST	375 - 450mm	HML	5.91	6.7	1
SAST	> 450mm	GML	7.24	6.7	
SAST	> 450mm	CML	7.24	6.7	
SAST	> 450mm	HML	7.24	6.7	1
SADT	n/a	GML	8.16	9	
SADT	n/a	CML	8.16	9	
SADT	n/a	HML	8.16	9	1
TAST	< 350mm	GML	9.08	11	
TAST	< 350mm	CML	9.08	11	
TAST	< 350mm	HML	9.08	11	1
TAST	375 - 450mm	GML	9.99	13.3	
TAST	375 - 450mm	CML	9.99	13.3	
TAST	375 - 450mm	HML	9.99	13.3	1
TAST	> 450mm	GML	12.13	14	
TAST	> 450mm	CML	12.13	14	
TAST	> 450mm	HML	12.13	14	1
TADT (non-drive)	n/a	GML	13.77	16.5	
TADT (non-drive)	n/a	CML	13.77	17	
TADT (non-drive)	n/a	HML	13.77	17	1.15
TADT (drive)	n/a	GML	13.77	16.5	
TADT (drive)	n/a	CML	13.77	17	
TADT (drive)	n/a	HML	13.77	17	1.25
TRST	< 350mm	GML	12.34	15	
TRST	< 350mm	CML	12.34	15	
TRST	< 350mm	HML	12.34	15	1
TRST	375 - 450mm	GML	13.46	20	
TRST	375 - 450mm	CML	13.46	20	
TRST	375 - 450mm	HML	13.46	20	1

Axle Code	Tyre Size	Mass Scheme	Standard Axle Mass (t)	MDL Maximum Mass (t)	Road Friendly Suspension (RFS) Factor
TRST	> 450mm	GML	16.52	20	
TRST	> 450mm	CML	16.52	20	
TRST	> 450mm	HML	16.52	20	1
TRDT	n/a	GML	18.56	20	
TRDT	n/a	CML	18.56	21	
TRDT	n/a	HML	18.56	22.5	1.2
QAST	< 350mm	GML	15.30	15	
QAST	< 350mm	CML	15.30	15	
QAST	< 350mm	HML	15.30	15	1
QAST	375 - 450mm	GML	16.72	20	
QAST	375 - 450mm	CML	16.72	20	
QAST	375 - 450mm	HML	16.72	20	1
QAST	> 450mm	GML	20.50	20	
QAST	> 450mm	CML	20.50	20	
QAST	> 450mm	HML	20.50	20	1
QADT	n/a	GML	23.05	20	
QADT	n/a	CML	23.05	21	
QADT	n/a	HML	23.05	27	1
TSST	< 350mm	GML	9.08	11	
TSST	< 350mm	CML	9.08	11	
TSST	< 350mm	HML	9.08	11	1
TSST	375 - 450mm	GML	9.99	11	
TSST	375 - 450mm	CML	9.99	11	
TSST	375 - 450mm	HML	9.99	11	1
TSST	> 450mm	GML	12.13	11	
TSST	> 450mm	CML	12.13	11	
TSST	> 450mm	HML	12.13	11	1
PSADT	n/a	GML	8.16	8.5	
PSADT	n/a	CML	8.16	8.5	
PSADT	n/a	HML	8.16	8.5	1
PTADT	n/a	GML	13.77	15	
PTADT	n/a	CML	13.77	15	
PTADT	n/a	HML	13.77	15	1
PTRDT	n/a	GML	18.46	18	
PTRDT	n/a	CML	18.46	18	
PTRDT	n/a	HML	18.46	18	1