Mass limits for three-axle buses
Discussion paper
June 2018

National Transport Commission

Report outline

Title	Mass limits for three-axle buses
Type of report	Discussion paper
Purpose	For public consultation
Abstract	This paper investigates whether there is a need to increase the mass limits that apply to three-axle buses to accommodate the current number of passengers that such buses may carry. It also assesses the implications of a potential increase in three-axle bus mass limits. The paper addresses project options, industry impact, risks and benefits. It is based on research and stakeholder engagement with states and territories, industry.
Submission details	Any individual or organisation can make a submission to the NTC. Submissions will be accepted until 24 July 2018 online at www.ntc.gov.au, via Twitter or LinkedIn or by mail to: Chief Executive Officer National Transport Commission Level 3/600 Bourke Street Melbourne VIC 3000 Where possible, please provide evidence, such as data and documents, to support your position. We publish all submissions online, unless you request us not to. The *Freedom of Information Act 1982* (Cwlth) applies to the NTC.
Key words	Three-axle, bus, mass, loading, capacity, coach, tourist bus, tourism, passengers, baggage allowance, double decker, articulated bus
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For some time, there has been a mismatch between regulatory provisions for determining bus occupancy numbers and the settings for maximum bus axle mass limits.

In recent years, bus mass has increased to accommodate the rising tare weight of three-axle buses associated with the introduction of regulatory requirements for specific safety and environmental improvements, and the increasing average weight of adult Australians.

The NTC's three-axle bus limit review gathers the necessary data to identify whether there is a need to increase the mass limits that apply to three-axle buses, to accommodate the current number of passengers that such buses may carry, and to assess the potential implications of an increase in three-axle bus mass limits.

This paper explores mass limits that currently apply to three-axle buses, offers an early assessment of the size and nature of the problem presented by current three-axle bus limits, and offers early options for government and industry to consider to address the issues.

The desired outcome for the review is ensure that mass limits for three-axle buses optimise the productivity of passenger transport without negatively affecting road safety or potentially competitive freight carriers.

The results of this review will inform recommendations on a national approach to Australia's transport ministers in November 2018.

Issues

Three-axle buses are regularly used for long-distance regional charter and scheduled coach travel because of greater levels of comfort, driveability and their ability to traverse harsh rural conditions. However, there has been a recent shift towards three-axle buses for metro timetabled services because they offer greater passenger capacity.

Three-axle buses in Australia are reported to be exceeding regulated axle mass limits when fully loaded. The call from industry for higher mass limits arises both from the increased average weight of the Australian population over recent years and the increased tare weight of buses due to regulatory requirements for specific safety and environmental improvements. A component of the gross mass is also likely to include passenger luggage, with buses having the lowest permissible luggage weight of any transport mode.

The NTC has assessed the potential implication of any mass limit increase on pavement wear and found that it is unlikely to have a significant impact on road maintenance costs.

We also investigated the extent of freight being carried on buses and found this very rarely happens and does not contribute to overloading.

Based on our analysis, the NTC believes the mass limit should be increased to a figure agreed by industry, road managers and manufacturers. We suggest:

- front axle: 7 tonnes
- tandem (drive and tag): 14 tonnes
- tandem (drive and tag with tyre above 375 mm): 16 tonnes

The evidence also suggests the current luggage calculations allowed for in the Australian Design Rules should be amended to allow three-axle passengers to carry up to 23 kg each.

Next steps

The NTC's three-axle bus review will recommend to transport ministers a course of action to be adopted nationally and an implementation plan for giving effect to that recommendation.

The NTC requests comments and feedback on the information and options presented in this paper by 24 July 2018.

We expect to provide a summary of our evaluation and final recommendations to the Transport and Infrastructure Senior Officials Committee in September 2018.

If endorsed, the recommendations will proceed to the Transport and Infrastructure Council in November 2018.

We will consider all comments and feedback to this discussion paper before developing our final recommendations.

1 Context

Key points

- There are more than 2,000 three-axle buses operating in Australia.
- They can be divided into route services and charter services.
- Operators have been asking for a mass increase because of the increase in bus tare weights.
- The NTC was tasked with reviewing the mass limits to identify whether overloading was occurring and to consult on the impact this was having.
- The NTC previously reviewed the mass limits for two-axle buses, which resulted in a two-tonne increase.
- This paper aims to capture the problem and offer options to resolve it.

For some time, there has been a mismatch between regulatory provisions for determining bus occupancy numbers and the settings for maximum bus axle mass limits.

In recent years, bus mass has increased to accommodate the rising tare weight of three-axle buses associated with the introduction of regulatory requirements for specific safety and environmental improvements, and the increasing average weight of adult Australians.

While similar issues for two axle bus mass limits are being addressed through a national notice, three axle buses are used in operational situations such as tourism and long distance scheduled passenger transport which require additional analysis.

Neither the impact of mass increases for three-axle buses, nor the feasibility of alternative policy responses have been investigated to a significant extent. The purpose of this project is to undertake this investigation and recommend an optimum national policy position.

1.1 Objectives

The aim of this paper is to present the NTC's initial review of three-axle bus mass limits and to seek stakeholder feedback on whether there is a need to increase the mass limits that currently apply to three-axle buses.

In this discussion paper, we consider the current three-axle bus mass limits and assess whether they are set to optimise the productivity of bus passenger transport, without negatively impacting on road safety or infrastructure.

Our assessment considers safety, pavement and infrastructure risks and any competition issues, as well as the fair and reasonable ability of operators to comply with the current mass limits. No increase in passenger numbers will be countenanced as a part of our assessment.

The objective of this review is to:

- identify the size and nature of the problem presented by the current axle mass limit that applies to three-axle buses
- develop, assess and consult on options to address any issues identified
- recommend a course of action to be adopted nationally and an implementation plan for giving effect to that recommendation.

Findings from our review will form the basis of proposed national reform recommendations to be presented to the Transport and Infrastructure Senior Officials Committee in September 2018 and, if endorsed, to the Transport and Infrastructure Council in November 2018.

1.2 Background

Buses provide an essential link to public transport in Australia. Buses in Australia provide a variety of services, generally in one or more of the following categories:

- route services – these follow a fixed route and a published timetable and are operated by government or private companies
- school services – these transport students to and from school, often under a government-subsidised scheme
- long-distance services – these provide intrastate and interstate travel between major towns and cities
- tourist services – these operate one-day and extended tours to popular destinations
- charter services – these offer buses for hire to transport like-minded people to a chosen destination
- shuttle services – these provide point-to-point transport such as from airports to hotels
- private vehicles – these are maintained by companies, schools, churches or other organisations to transport their members.

A three-axle bus is any bus that has three axles, although the majority have a front steer axle and a tandem axle at the back made up of a drive axle and a tag axle behind it.

Currently 2,229 three-axle buses are registered in Australia, and they typically fall into two categories, which are explained in Table 1.

Table 1. Two categories of three-axle buses

	Long-distance coach	Double decker or articulated
	 [1]	 [2]
Service type	Charter Scheduled long distance Rail replacement	Timetabled Bus rapid transit
Area	Regional and rural	Metro
Standing room	No	Yes
Luggage space	Yes	No
Safety	Electronic brake system Fire retarder Anti-rollover Lane departure warning	Electronic brake system Fire retarder Anti-rollover
Access	Wheelchair lift	Low-floor wheelchair access Hand rails Back doors (for quick departure)
Emissions control	Euro IV, V or VI engine	Euro IV, V or VI engine
Comfort	Air-conditioning Toilet Seatbelts Reclining seats	Air-conditioning
Trends	USB adapters Wi-Fi Water tanks or bottles Screens on backs of seats Wheelchair accessible toilet Gully kitchen Fatigue monitoring Double-glazed windows Brake assist (with cameras)	Shift towards double deckers Rapid transit (without timetables) Brake assist (with cameras)

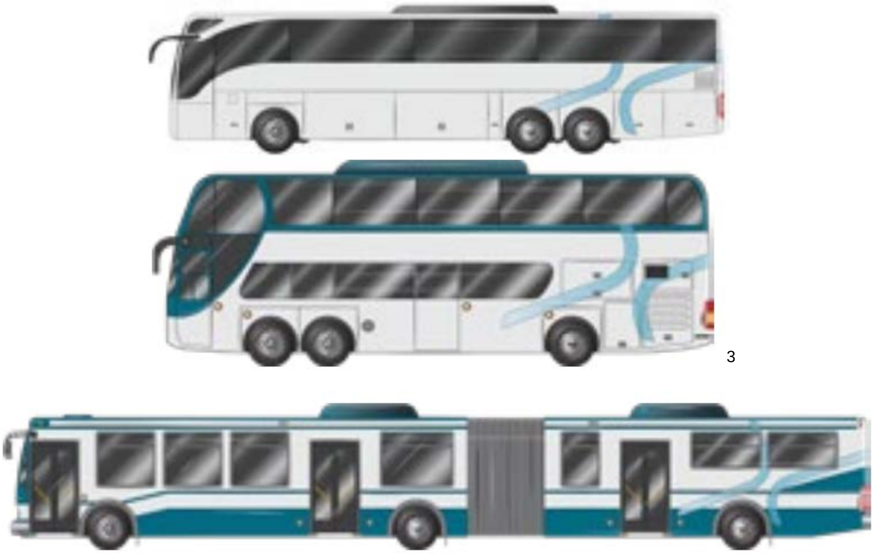
[1] BCI Explorer

[2] Gemilang Australia and MAN A95

A three-axle bus comes in several configurations (see Figure 1). It will have at least two wheels on each axle, with either two at the front or two at the rear. It can come in the form of a regular bus, an ultra-low floor bus, a double decker, a coach or an articulated bus.

Three-axle buses are generally used for longer distances because they provide more comfort and can carry more weight. However, some buses used for shorter trips may also have three-axles.

Figure 1. Three-axle bus variations: three-axle bus or coach; three-axle double decker; three-axle articulated bus


[3]

Source: National Heavy Vehicle Regulator

- Currently, there are 2,229 three-axle buses operating in Australia.
- Buses are used for only five per cent of passenger transits in Australia's cities and only make up one per cent of total road use (see Figures 2 and 3).
- In 2015–16, more than 21 billion passenger kilometres were made by bus across Australia (see also Figure 4).
- In 2015–16, 96,000 buses were registered on Australia's roads. This is an increase of 16,000 since 2008 (and an increase of 20 per cent in eight years) (BITRE, 2016).
- Buses account for 1.6 gigagrams of CO_2 equivalent emissions, which is around two per cent of all transport.
- More than 3,000 bus companies are operating across Australia servicing towns and regions, tour and charter services and major cities and most are small to medium sized businesses (NTC, 2016).
- In the coach sector more than 5,000 coaches are in operation nationally, with a rolling stock value of more than $2 billion (NTC, 2016).

The bus industry has been seeking higher mass limits for buses for some time. This is in response to the growing average weight of adult Australians and the heavy equipment required to be compliant with disability legislation and environmental controls.

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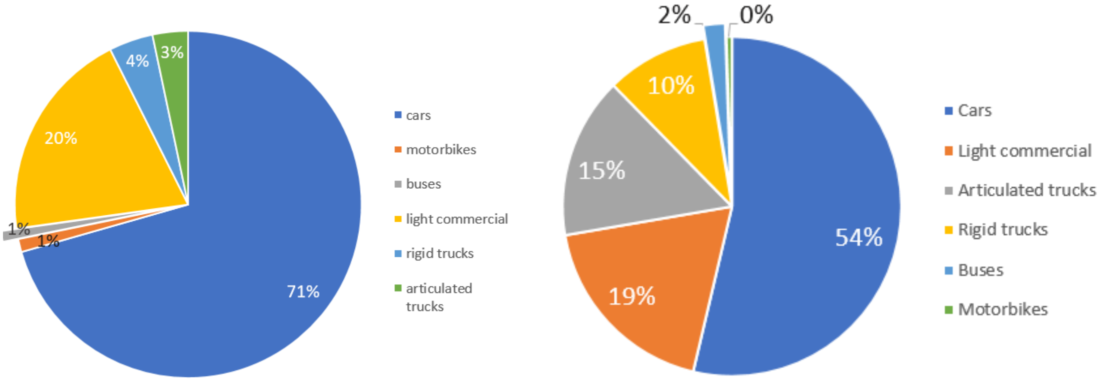
[3] Please note this is not the usual model of double decker. It is unusual to have a tandem axle at the front of the bus and single at the back.

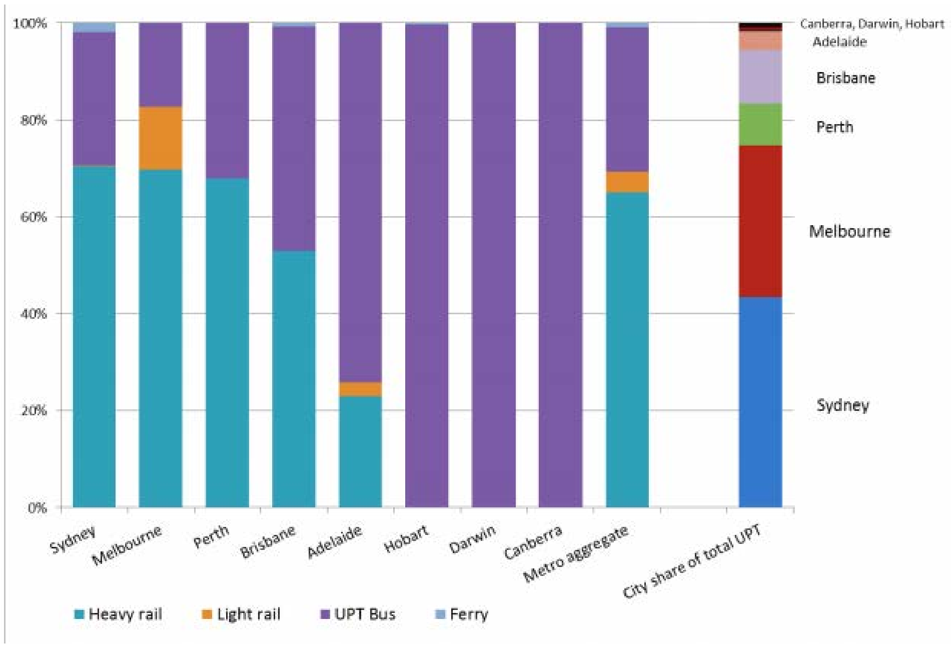
Figure 2. Bus travel only accounts for one per cent of total road use in Australia and only two per cent of carbon emissions



Source: (BITRE, 2016)

Mass limits for two-axle buses recently increased nationally to 18 tonnes. In March 2018 New South Wales increased its three-axle mass limit to 22 tonnes (to help improve bus operator efficiency) ahead of all other states and territories. However, the limits for three-axles have not changed in other states and territories falling under the Heavy Vehicle National Law.

Figure 3. Share of urban passenger transport by mode and capital city

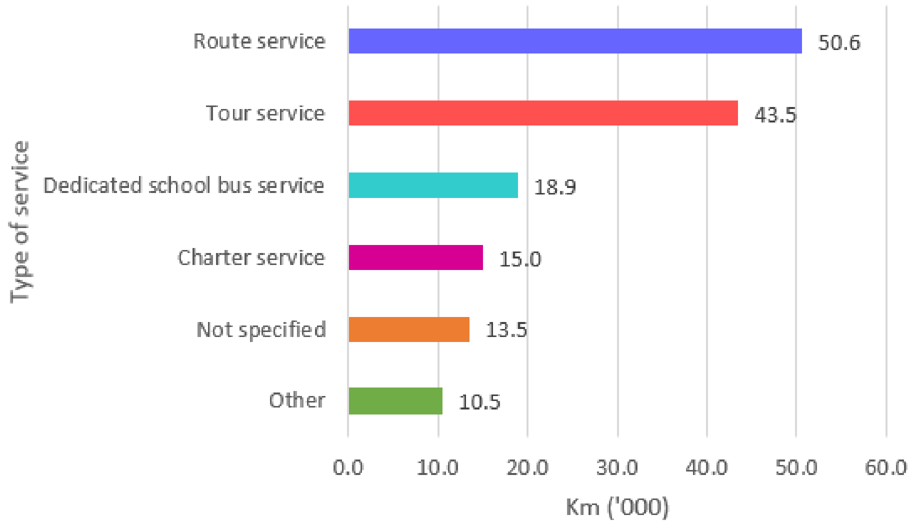


Source: (BITRE, 2013)

Maintaining operationally effective mass limits is an ongoing challenge because bus technology and government regulation continues to evolve and change.

Industry has been seeking a higher limit to reflect these changes, as well as to accommodate the growth in the average weight of adult passengers. The mass limits of three-axle buses have been in the policy spotlight since the NTC's review of two-axle bus mass limits in 2014.

Figure 4. Average kilometres travelled by buses with 20 or more seats throughout Australia, over 12 months, ending 30 June 2016



Source: (ABS, 2016)

1.2.1 The problem

There has been a mismatch between regulation for determining bus passenger numbers and maximum axle mass limits. Three-axle buses are widely used in long-haul, tourist and charter operations, where a component of their gross mass is likely to include passenger baggage.

To date, no analysis has been done to see if three-axle buses are running over mass and whether mass limits should be reviewed to optimise the productivity of bus passenger transport, without negatively impacting on road safety and infrastructure.

Based on our assessment, we suspect that route services running during peak times and coaches running at capacity are already running at close to or over the existing mass limit. There may therefore be a problem to address through a change in regulation; however, we are seeking further evidence to confirm this.

According to research conducted by Taverner Research on our behalf, multiple sources contend that the gross loaded mass of 3-axle buses is likely to often exceed the current allowable limits. The contributing causes of the increased total weight are:

- The weight of added equipment, including wheelchair lifts and related changes to doors
- The increasing average weight of the Australian population, which is now well above those assumed in setting current weight limits and passenger numbers
- Increases in the weight of passenger effects included in both stowed luggage and effects carried on-board, such as laptop computers.

1.2.2 Two-axle bus mass limits

In February 2014 the NTC released a discussion paper *Mass limits for two-axle buses*, which identified and discussed options to facilitate an increase in mass limits for buses fitted with two single axles.

The need for the higher mass limits arises both from the increased average weight of the Australian population over recent years, and the increased tare weight of buses as a direct result of regulatory requirements for specific safety and environmental improvements.

Therefore, the NTC recommended an increase in the mass limit for two-axle buses from 16 tonnes to 18 tonnes. This was proposed to be implemented in the first instance by a Class 3 National Notice, which would be replaced by an amendment to the Heavy Vehicle (Mass, Dimension and Loading) National Regulation once all jurisdictions had agreed to the conditions that should apply to such a bus.

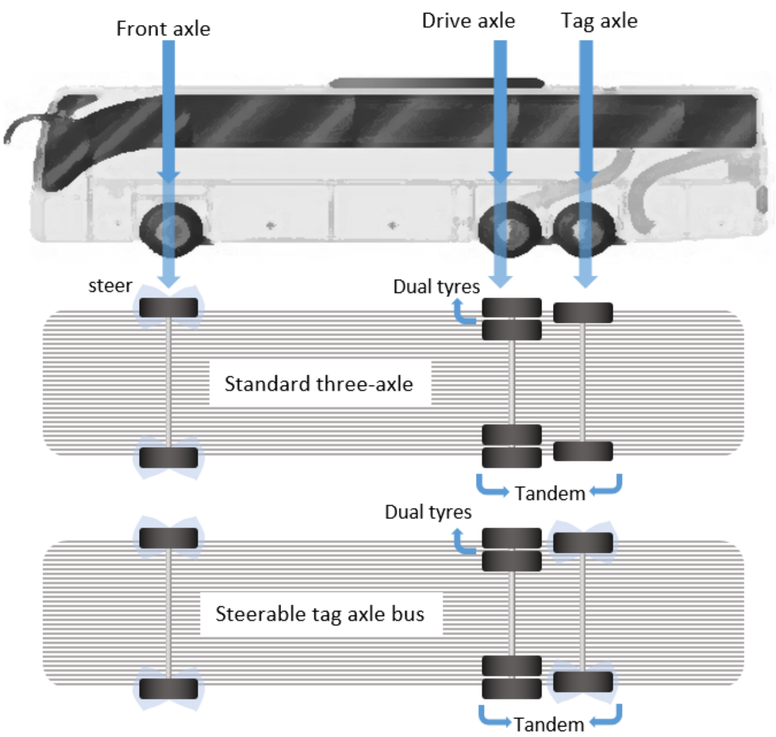
1.3 Issues

The main issues discovered during our initial review include:

1. The Australian limits are among the lowest in the world, despite having one of the heaviest populations.
2. There are different mass limits across each state and territory.
3. Added technology increases the tare mass of three-axle buses and coaches. This technology is needed to meet disability and environmental regulations.
4. Luggage allowances on buses are much lower than on all other transport modes.
5. The bus and coach transport market is shifting towards heavier vehicles such as double deckers and larger coaches for productivity gains (greater capacity at similar running costs).

Figure 5 illustrates the design of a typical three-axle bus.

Figure 5. Three-axle bus diagram from side and underneath perspectives



1.3.1 Current mass limits

There is some variability in the allowable axle mass limits across states and territories.

Table 2 lists the steer-axle mass limits by jurisdiction for both two-axle and three-axle buses across Australia.

Table 2. Steer-axle limits, by jurisdiction

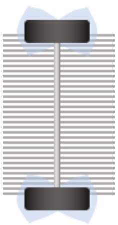
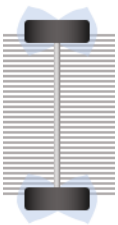
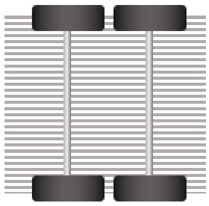
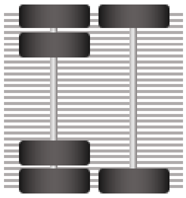
Jurisdiction	Truck steer axle	Bus steer-axle	Tandem axle group single	Tandem axle group dual on drive axle	Tandem axle group dual on both axles
					
ACT	6.0	6.5	10.0	14.0	16.5
NSW	6.0	7.0	11.0	14.0	16.5
NT	6.0	10.0	11.0	13.0	16.5
SA	6.0	6.5	11.0	14.0	16.5
Tas.	6.0	6.5	11.0	14.0	16.5
Vic.	6.0	6.5	11.0	14.0	16.5
Qld	6.0	7.0	11.0	14.0	16.5
WA	6.0-7	7.0	14.0	16.5	17.5

Table 3 lists the drive-axle limits by jurisdiction for both two-axle buses and three-axle buses across Australia.

Table 3. Drive-axle limits, by jurisdiction

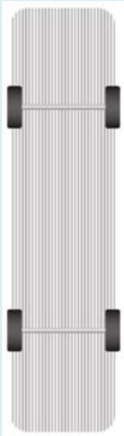
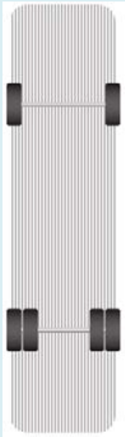
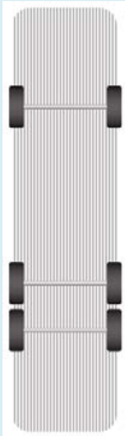
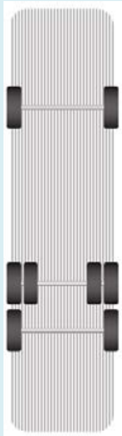
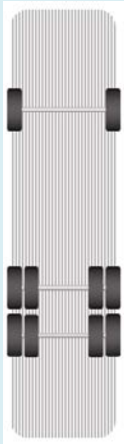
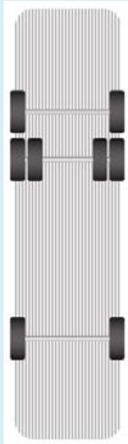
Jurisdiction	Single 2-axle	Drive dual 2-axle	Single tandem 3-axle	Dual drive 3-axle	Dual tandem 3-axle	Tandem steer at front
						
ACT	18	18	20.5	20.5	23	23
NSW	18	18	20.5	20.5	23	23
NT	18	19	20	22	22.5	-
SA	18	18	17.5	20.5	23	-
Tas.	18	18	20.5	20.5	23	23
Vic.	18	18	20.5	20.5	23	23
Qld	18	18	20.5	20.5	23	23
WA	18	20	20.5	20.5	22.5	-

Table 4 shows how Australia's mass limits for three-axle buses are low in comparison with other countries.

It is interesting to note that Australia has one of the lowest bus mass limits in the world, despite our average adult weight being among the highest.

Table 4. How Australia compares with international jurisdictions in weight limits

Jurisdiction	Men average weight (kg)	Women average weight (kg)	Total GVM 3-axle (t)	Passenger calculating capacity (kg)	Steer-axle limit 3-axle (t)
Australia	85.9	71.1	20.5	65	6.5
Australia – airlines	85.9	71.1	n/a	76	n/a
US	88.3	74.7	27	79.4	9
Canada	90.7	74.8	22	82	9
Europe	84.6	66.6	26	75	9.5
UK	83.6	70.2	25	65	10
New Zealand	85.1	72.6	22	68	7.2
Singapore	71.9	59.4	28	60	12
Hong Kong	72.5	59.4	24	57	8
China	70.5	59.4	25	50	10
South Africa	70.8	65	24	68	7.7
Ireland	88	73.8	24	65	10

Average	80.6 kg	67.6 kg	24.7 t	66.9	9.2
difference	+5.3 kg	+3.5 kg	-4.2 t	–1.94 kg	–2.74 t
	Result: we are heavier as a population		Result: our mass limits are considerably lower		

1.3.2 Buses are regularly running overloaded

Multiple industry sources contend that the gross loaded mass of three-axle buses is likely to often exceed the current allowable limits.

Our research explored how three-axle bus operators are currently managing their total loaded weight. Of the 23 survey respondents that run three-axle buses, 30 per cent confirmed that they take no action to limit the total loaded weight, 70% take at least one step, including 35% that take more than one step.

The most common step reported was to carry fewer than the approved number of passengers (44 per cent), followed by limiting the weight of stowed luggage that passengers can take with them (35 per cent), or requesting passengers to keep the weight of their stowed luggage and carry-on personal effects under a specified limit (26 per cent).

Some ask passengers to sit in specific parts of the bus to limit the load on some axles (17 per cent) and a few (17 per cent) reported taking other steps to limit the total loaded weight.

There are no weight management policies or guidelines that the NTC is aware of which assist bus operators in this task.

1.3.3 Technology is increasing tare mass

Since 2000 we have seen a rapid uptake in technology installed on buses, which provide both safety and amenity benefits.

The rate of technological advancement is likely to continue as technological advancement in electrification, hydrogen and gas power, as well as driverless technology progresses.

However, heavier mechanical parts are the main cause for the increase in tare weight and are unlikely to change as they are regulated in the *Disability Standards for Accessible Public Transport 2002* and *Vehicle Standard (Australian Design Rule 80/00 — Emission Control for Heavy Vehicles) 2005.*

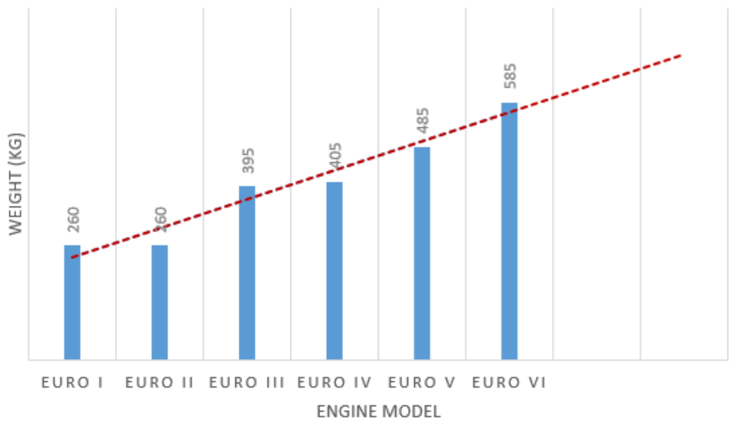
A major culprit is the wheelchair lift. It can weigh up to 600 kg on its own and, when combined with the specialised doors, glazing for those doors, removable seats and seatbelts, this equipment can easily add more than a tonne of weight. One person in a motorised wheelchair can add 400 kg.

Emission-controlled engines are the second major cause. All bus engines are manufactured in Europe where the regulation of carbon emissions, as per the EU Clean Air for Europe programme, is much higher than in Australia.

Figure 6 lists the weights of regulation engines and how their weight has increased over time to align with European standards (European Environment Agency, 2012).

Figure 6. Emission-controlled engines and increase in weight to meet regulations

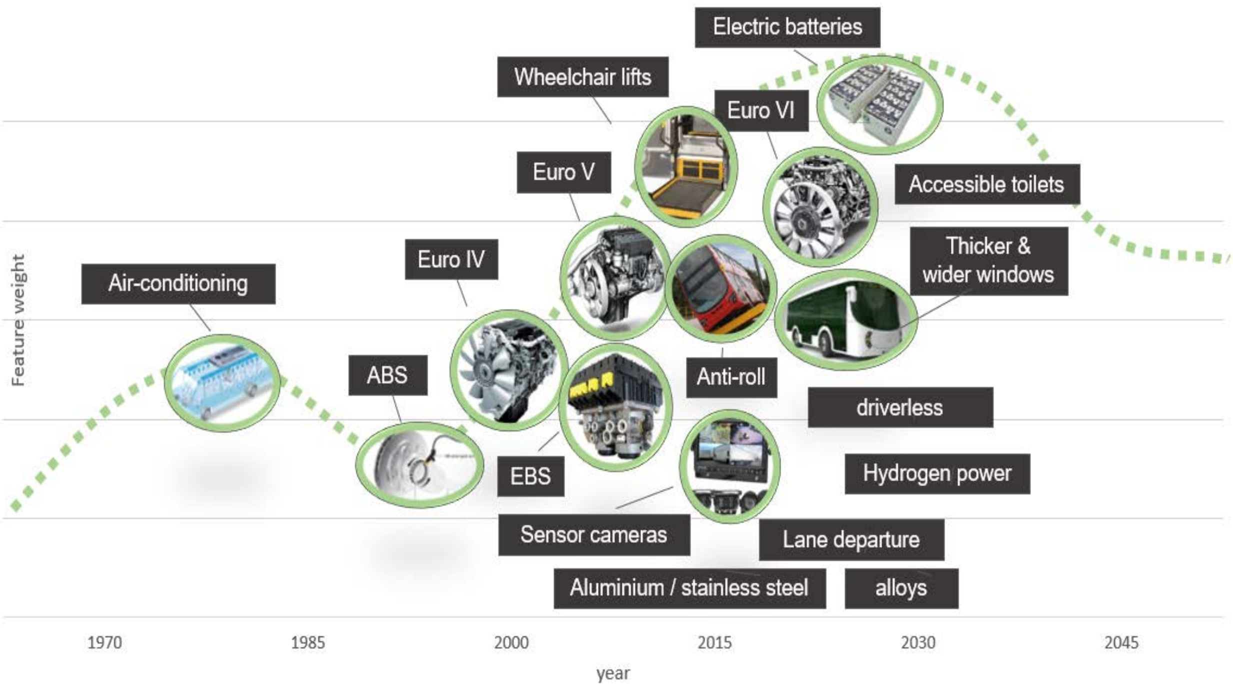
Engine model	Weight (kg)
Euro I	260
Euro II	260
Euro III	395
Euro IV	405
Euro V	485
Euro VI	585



This means imported buses are running more efficiently than our regulation requires. Despite the obvious benefits for the community, these engines are steadily growing heavier to correspond with Europe's tighter emissions controls (European Environment Agency, 2012) and currently can weigh around 600 kg.

Figure 6 shows how rapidly technology has changed over the past decade and how this has greatly increased the mass that is on a bus chassis (tare weight). It also shows how this speed of innovation is unprecedented for the bus industry.

Figure 7. Visualisation of growth in technology and resulting tare weight increases



The biggest shift in bus weight has occurred due to the technology required to be compliant with state and territory legislation, including the Bus Safety Regulations 2010 (Vic), the *Passenger Transport Act 2014* (NSW), the Passenger Transport Regulations 2009 (SA) and the Vehicle and Traffic (Vehicle Standards) Regulations 2014 (Tas). This technology is not usually subsidised by government and is installed at an operator's own cost. Table 5 shows a summary of equipment that is generally required by law across different states and territories and the weight this adds.

Table 5. Technology required to meet regulation or operational requirements

Regulation	Required equipment	Average weight (kg)
Disability Discrimination Act	Wheelchair lifts or low floor access	350–600
Fire protection	Fire retarder and liquid	50
Emissions control	Euro IV, V, VI compliant engine	350
Environmental protection	AdBlue fluid	80
Anti-rollover	Bus superstructure	1,000
Ticketing systems	Opal, Myki etc	20
Seatbelts for school buses	Seatbelts	150–200 (4pp)
	Total	**2,000–3,000**

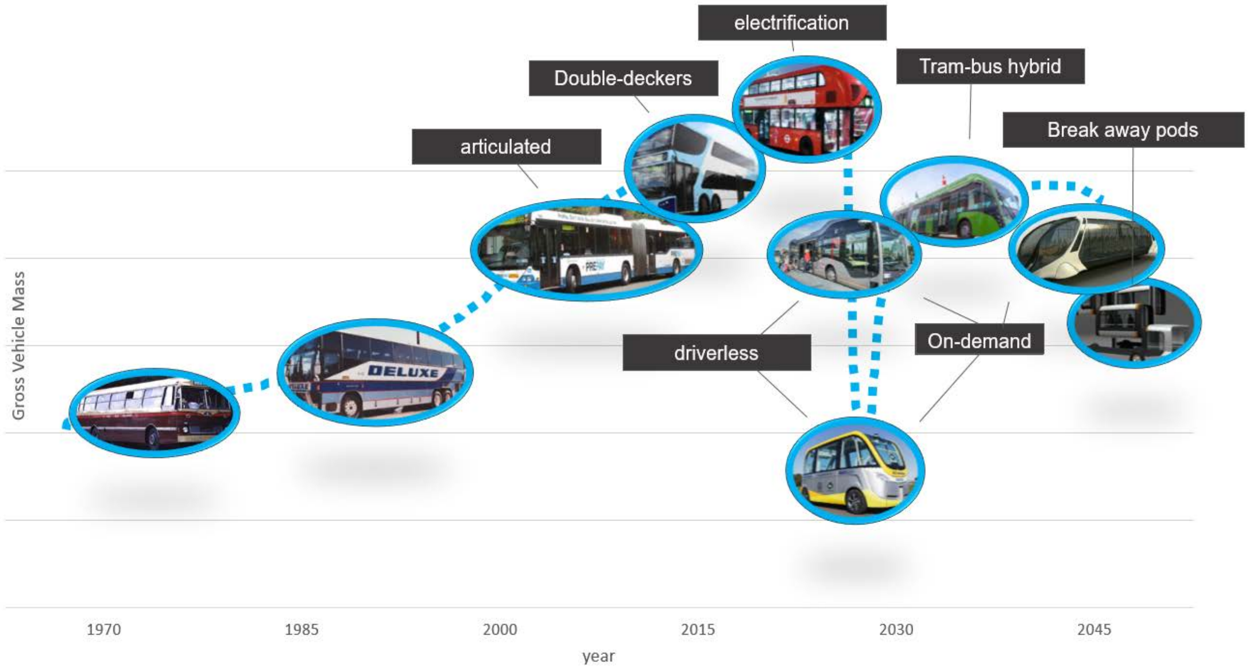
The measurements used to set bus mass limits are now outdated. There has been a steady change in bus manufacturing over the past few decades and alternatives such as articulated buses are now available to operators (see Figure 7).

The past decade has seen a massive and rapid shift towards alternative buses that offer greater capacity for reduced operating costs. The market is currently diversifying with the introduction of hybrid, fully electric, hydrogen and driverless buses. As these new vehicles are introduced, bus weight is expected to steadily rise, but to a point.

Electric bus technology requires heavy batteries, therefore smaller vehicles are expected to be preferred (at least initially) by the market into the future. Bus weight is expected to be prohibitive for larger vehicles and for longer distance journeys until battery technology improves.

Further, the market is shifting towards on-demand services, which mean buses operate in a web-like network of smaller trips. This doesn't require the same number of passengers for a single journey, prefers customised routes and suits smaller buses.

Figure 8. Visualisation of changes in vehicles and resulting gross vehicle mass increases



1.3.4 Australians are getting heavier

According to the Australian Bureau of Statistics (ABS):

- The average Australian adult man weighs 85.9 kg.
- The average Australian adult woman weighs 71.1 kg.
- The average Australian child weighs 36 kg.

The Australian Design Rule (ADR) 58/100 says 65 kg should be used to calculate passenger weight. The average current combined weight of a man, woman and child is 64.3 kg.

Three-axle buses and coaches carry people of all ages. They often consist of ages ranging from babies to the elderly. This is more likely to occur for timetabled route services, including long-distance travel. However, for charter coaches, it's more difficult to calculate because a variable group made up of all adults, with luggage or equipment, may hire a coach.

If children are not part of the calculation, it's likely that passengers would average a higher mass of approximately 79 kg. The impact this would have on overall bus mass isn't considered significant enough to justify a change to the design rule. To review these calculations in more detail, please see Chapter 2.2.1.

1.3.5 Luggage allowances on connecting transport modes are higher

There is a disconnect between the amount of luggage people can take on board a coach in comparison with all other transport modes. For example, baggage allowances on airlines are on average 23kg. According to the ADR 58/100, coach operators and manufacturers are expected to calculate luggage at 15 kg per person.

Three-axle coaches are regularly used for long-distance tours and to collect tourists from airports. Their customers have usually just disembarked from a plane and carry the same luggage checked-in on the airline onto the coach. They also usually have carry-on bags, which can weigh up to 7 kg. We found this luggage allowance is often not enforced, and it is likely that most passengers connecting from another transport mode are carrying luggage that more realistically weighs around 23 kg.

1.3.6 Buses are not carrying freight

We do not believe there is interest from operators to carry freight. Operating costs increase as weight increases and the margin on freight is too low to make any reasonable profit. Further, most long-distance operators run charter and on-demand replacement services, so are unable to pre-plan (or to guarantee) delivery of freight.

1.3.7 Bus transport services are evolving

The demand for public transport is growing in line with population growth. In metropolitan areas, including suburbia, operators are beginning to run three-axle double deckers.

These buses are highly efficient and only take up the same road space as a regular commuter bus that carries half the passengers, which helps tackle congestion. Communities benefit through an increase in access to mobility.

Local and state governments are beginning to see the value in these buses and it's likely they will be rapidly rolled out across the country. However, the tare weight of these buses averages around 14–15 tonnes and, with passengers at capacity levels on board, can quickly reach the current mass limit of 20.5 tonnes.

1.3.8 Customer demand for improved features and amenity

Operators have told us that they constantly compete with increasingly cheaper airline tickets and that their customers expect the same level of features they can access on an aeroplane.

In Europe it's becoming standard on three-axle buses to offer Wi-Fi, USB adapters, wider and further reclining seats, water bottles, snacks, television sets, tables for laptops, reading lights, tinted windows, pillows, blankets and many other comfort features. All additional features add weight and cost money.

Customers tend to avoid bus and coach travel for long-distance travel and prefer flights or trains. This is because of the perceived lower levels of comfort and slower journey times in a coach. However, research has shown that coach travel can be a much more efficient way of travelling and that there is space in the market to convert customers who take trains or airlines to instead take a coach, such as business travellers (Hensher & Wang, 2016).

Further, train fleets across parts of Australia are getting close to retirement age and run at similar travel times to coaches (also partly due to the congestion of the rail network). For example, the journey between Sydney and Melbourne is 12 hours either by coach or train. The cost of a new train fleet, at approximately $2 billion (Brook, 2018), is a much higher capital investment for governments than outsourcing to coach services.

1.3.9 Safety and road wear

Our research informed us that the risks from increasing current weight limits mentioned in some discussions of the weight limit are:

- increased pavement damage; and
- increased crash risks that could arise if greater vehicle weight results in longer stopping distances and reduced stability when cornering.

Industry stakeholders interviewed by Taverner Research have argued in formal submissions that neither risk is substantial. The arguments supporting the contention that there is no material increase in pavement damage likely to result from an increase in the allowed weight limits are:

- modern three-axle buses have two steerable axles, which reduces the damage to the pavement from the drag of a fixed axle;
- many buses are in any case travelling over the current limit, so regularising current practice will not increase the actual risk of pavement damage; and
- most pavement damage is done by heavy trucks, which can have a total mass very much greater than a fully-loaded three-axle bus.

The impact of three-axle buses on road assets is calculated using several measures. These include dimensions, such as height, width and length, as well as mass, axle spacing, tyre width, road overhang, turning circle and load projection. How these different factors come together sets the level of weight a three-axle bus can carry.

Manufacturers calculate a mass limit according to the structural integrity of the bus or coach. Currently, the manufacturer’s limit is up to eight tonnes higher than the regulated mass limit. This means most buses on our roads can safely carry more weight.

Road asset owners manage their road maintenance investments by calculating the expected pavement wear on a road network. Generally, wear on the road increases as the axle mass of a heavy vehicle, such as a truck or bus, increases.

There are ways to minimise pavement wear. Techniques such as using wider tyres or dual-tyre axles and shifting loads between steer and rear axles can help spread the pressure impact on the point of contact with the road. However, tyre placement can affect passenger capacity volumes and must be carefully considered in bus vehicle design.

Higher mass limits need to first consider the implications for road managers who are responsible for maintaining road network assets. We discuss road wear in more detail in Chapter 2.3.1.

The arguments supporting the contention that there is no material increase in the safety risks from increasing the allowed weight limits for three-axle buses are:

- the manufacturers set safe loaded weight limits based on actual bus performance in terms of stopping distance and turning circles;
- the manufacturer-recommended limits are well above the current allowed weight limits;
- the manufacturer limits have been reviewed and accepted by multiple authorities in Europe as safe on appropriate roads in European jurisdictions; and
- the technology for managing speed and stopping distances and other technologies (such as warning systems and autonomous controls over vehicle separations, lane changes, and so on) make modern, heavier 3-axle vehicles much safer overall than older models with a lower total loaded weight and less advanced equipment.

Some hypothetical, but realistic, total loaded weights for three-axle buses were considered. These assumed that the average passenger now weighs 80kgs, with up to 15kgs of luggage and personal effects (total of 95kgs per passenger). These were compared to the weight calculated with the same passenger numbers using the weights assumed in setting the current limits (65kgs body weight per passenger, plus 15kgs for luggage, total 80kgs per passenger).

These calculations also incorporated the added weight due to installation of air conditioning, additional equipment required to meet standards for serving passengers with disabilities (including wheelchair lifts and associated equipment), installation of seatbelts, and other changes to meet Euro6 safety standards.

Based on these calculations, a GVM limit of 22.5 to 23.0 tonnes would be required to ensure that three-axle vehicles with a wheelchair lift and other disability related equipment, seatbelts and equipment to meet Euro6 standards can operate within a revised weight limit.

1.3.10 Themes

In summary, we have grouped the issues identified in this chapter into three themes.

These themes are discussed in more detail in Chapter 2:

- tare mass increase, see Chapter 2.1
- loaded mass increase, see Chapter 2.2
- infrastructure impacts, see Chapter 2.3.

1.4 Consultation

1.4.1 Questions to consider

1. Do you believe the suggested limits allows three-axle buses to run at full capacity, for both route services and charter services?
2. What would the increased cost of road wear be in your jurisdiction if the mass limits for three-axle buses were increased to the suggested limits?
3. Are you aware of any other issues (not raised in this paper) that you believe would have a negative impact on industry, government or the community, should the mass limits be raised as per the suggested options?

1.4.2 How to submit

Any individual or organisation can make a submission to the NTC.

To make an online submission, please visit www.ntc.gov.au and select ‘Submissions’ from the top navigation menu.

Or, you can mail your comments to: Attn: Melissa O’Brien, National Transport Commission, Level 3/600 Bourke Street, Melbourne VIC 3000.

Where possible, you should provide evidence, such as data and documents, to support your views.

Unless you clearly ask us not to, we will publish all submissions online. However, we will not publish submissions that contain defamatory or offensive content.

The *Freedom of Information Act 1982 (Cwlth)* applies to the NTC.

1.5 Method

We expect to provide a summary of our evaluation and final recommendations to the Transport and Infrastructure Senior Officials Committee in September 2018 and then to the Transport and Infrastructure Council in November 2018. We will consider comments and feedback to this discussion paper before developing our final recommendations.

The NTC will work with the NHVR, road managers and industry members to develop a high-level plan for implementing recommendations approved by the Council. The plan will include the allocation of implementation tasks to responsible parties, establishment of milestones and appropriate governance arrangements.

2 Issues

Key points

The main issues discovered during our research are grouped into the three themes below. These themes are discussed in this chapter:

- tare mass increase;
- loaded mass increase; and
- infrastructure impacts.

2.1 Tare mass increase

2.1.1 Technology is increasing tare mass

The pace at which new technology is available is unprecedented for the bus industry (see Figures 1 and 2). We believe this is a major cause of three-axle overloading because the regulation mass limits do not reflect manufacturer's limits and innovation in vehicle design and technology.

These innovations, while adding weight, add benefits to industry, governments and communities. They allow greater levels of access to all members of the community and encourage safer driving practices. Generally, buses now come equipped with the items listed in Table 6.

Table 6. Approximate weight of standard bus features

Feature	Approximate weight	Cumulative weight
Three-axle tare	13.5 t	13,500
Air-conditioning	300 kg	13,800
Electronic braking system	30 kg	13,830
Anti-lock braking system	15 kg	13,845
Anti-rollover	1 t	14,845
Fire retarder	50 kg	14,895
Emissions control compliant engine	350 kg	15,245
Lane departure	20 kg	15,265
Adaptive cruise control		
Fatigue monitoring		
Collision warning		
Brake assist		
On-board television notices	10 kg/unit	15,285
Long-distance features		
Toilet	50 kg	15,315
Wheelchair lift	320 kg	15,335
Double-glazed windows	300 kg	15,635
Seatbelts	4 kg/seat	15,835
Drinking water tank	50 kg	15,885
AdBlue fluid	80 kg	15,965
Fuel tanks (300 L + 20 L)	0.85 kg/L	16,237
Audio-visual equipment	< 50 kg	16,287
Passengers (45)	65 kg/person (2,925)	19,212
Luggage	23 kg/person (1,035)	20,247
Tyres	45 kg/tyre (270)	20,517
Summary: ▪ This isn’t at full capacity. ▪ This assumes some children are on board. ▪ Weights are estimates only and some allowance should be given.		**Total: 20.5 t**

Result: ***This doesn't allow any margin for error and shows how difficult it is for industry to manage weights when none of these items can be removed or adjusted.***

Technology is rapidly evolving and we are likely to see transformation in bus and coach travel over the next decade (see Table 7). Advanced technology is already being rolled out, such as electrification, and others are being trialled internationally, including driverless and hydrogen technology. These innovations require a much higher mass limit to be able to run. However, the benefits, in terms of a reduction in carbon emissions and running costs, suggest market demand may grow for these vehicles.

Table 7. Estimate of gross vehicle mass for future three-axle vehicles

New technology coming to market	
 [4]	
Hybrid	Up to 26 tonnes
Electrification (batteries)	Up to 28 tonnes
Gas (hydrogen) powered	Up to 25 tonnes
Autonomous driving	Likely to reduce mass

We cannot predict what buses will look like in 2030, but we can begin to prepare. We can also pre-empt customers' expectations according to the technology that is being rolled out overseas (see Table 8).

> *Analysis of the data revealed that price is the dominant factor in seducing customers. However, journey length, higher commercial travel speeds, ample leg space, on board Wi-Fi and the entertainment system also play a role. Moreover business travellers are prepared to pay for extra services. The authors conclude that when an* ***adjusted service is offered, business travellers form an interesting (additional) target group for the intercity coach business*** [the NTC's emphasis]. (Lannoo, Van Acker, Kessels, Cuervo, & Witlox, 2018)

[4] Proterra Catalyst

Table 8. Customers' expectations for future technology and comforts

Customer features	
 [5]	 [6]
Wi-Fi	< 5 kg
Screens	< 10 kg/unit
USB port	< 2 kg/unit
Bottled water	25 kg
Snacks	< 20 kg
Accessible toilets	100 kg
Fully-reclining seats	< 15 kg/unit
On-demand app connectivity	n/a
Tray tables	< 2 kg/unit

Table 9 lists the weights of emission-controlled engines currently on the market.

Table 9. Emission-controlled engines and their approximate weight

Engine model	Weight (kg)
Euro I	260
Euro II	260
Euro III	395
Euro IV	405
Euro V	485
Euro VI	585

[5] PT Blue Bird

[6] Daimler AG

2.2 Loaded mass increase

2.2.1 Increased passenger weight is not a major cause of overloading

The weight of passengers is undoubtedly growing. However, the impact this has on bus services has not been quantified.

Between 1995 and 2011–12, the weight of men and women increased by around four per cent according to the Australian Bureau of Statistics. We now are one of the most overweight countries in the world (see Figure 9).

> *In 2009 the European Aviation Safety Authority (EASA) conducted a comprehensive survey of passenger weight. EASA weighed 22,901 passengers. The findings from this survey was an average male adult weight of 94 kilograms and an average female weight of 75 kilograms. Australia's adult population is very similar to those of North America and Europe.*
>
> *Given this,* ***the only reasonable conclusion is that there is a less than medium probability that the average weight of adults boarding a bus in Australia will be less than 65 kilograms and a greater than medium probability that a bus which is carrying adults in every seat will be over its GVM*** [the NTC's emphasis]. (Hourigan, 2015)

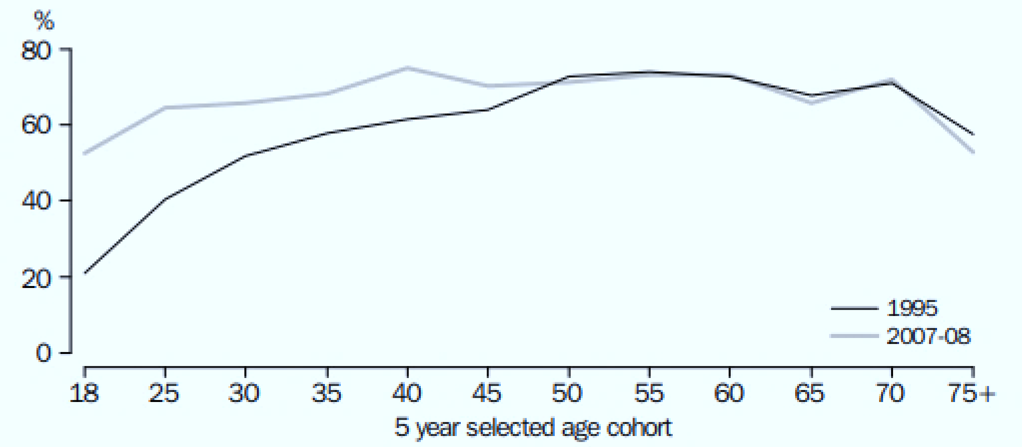
2.2.2 Australian Design Rule 58/100

According to the *Vehicle Standard (ADR 58/00 – Requirements for Omnibuses Designed for Hire and Reward) 2006:*

58.3.1. In determining the occupant capacity of an omnibus, the loading condition shall be that in which a mass of **65 kg** is located in each of the 'Manufacturer's' nominated seating and standing positions for driver, passengers and crew.

58.3.2. Where luggage space is provided, other than for personal hand luggage, and the vehicle is for carriage of passengers and luggage, a mass of **15 kg** shall be added for each passenger and shall be distributed uniformly throughout the luggage space.

Figure 9. Proportion of Australian people overweight or obese by age



(a) Measured Body Mass Index.
(b) Excludes persons for whom measured height or weight was not available.
Source: National Nutrition Survey 1995 and National Health Survey 2007-08

A Dutch study from 2005 measured the combined weight of passengers and their luggage. The results found that people in Europe were generally falling between 70 and 82 kg and were carrying around 20 kg of luggage (see Table 10).

Table 10. Average passenger and luggage weights in Europe (kg)

Date	*Location*	*Trip type*	*Average passenger weight*	*Average luggage weight per person*
03.01.2005	NL	International occasional service	82.6	25.72
07.01.2005	NL	International occasional service	80.0	23.31
08.01.2005	NL	International occasional service	79.6	20.77
15.01.2005	AT	Airport feeder service	74.6	21.22
18.02.2005	UK	Domestic occasional service	81.1	17.39
19.02.2005	UK	Domestic occasional service	80.3	18.70
		International occasional service	82.5	20.64
		Unknown	-	15.17
20.02.2005	UK	International regular service	77.3	19.08
30.03.2005	AT	International regular service	71.1	14.11
01.04.2005	UK	International regular service	71.8	18.82
12.04.2005	ES	Domestic regular service	71.2	5.24
		Domestic occasional service	73.8	10.74
		International occasional service	73.5	8.82
Total	All	All	75.6	16.76

Source: Dutch Emissions Authority (NEa) (Schoemaker, 2007)

We have calculated the difference in measuring passengers at 65 kg compared with 80 kg. Because buses do not regularly travel at capacity, it is not expected to be a reason for overloading.

The difference, at 15 kg per person, does not shift the gross mass enough to be considered significant. The difference does become significant when carrying around 100 people, as per Table 11.

Table 11. Difference between measuring average passenger weight at 65 kg and 80 kg at full capacity

	40 pp route bus (kg)	**57 pp coach (kg)**	**100 pp double decker (kg)**
Full capacity at 65 kg	2,600	3,705	6,500
Full capacity at 80 kg	3,200	4,560	8,000
Difference	**600**	**855**	**1,500**

The maximum weight difference in weight is 1.5 tonnes, which at first glance seems like a large amount. In operating context, however, this isn't likely to occur very often. This figure would only occur when a double decker bus is at full capacity, which would include 15 people standing.

Data from the B-Line double deckers running in the northern beaches in Sydney (see Case Study 1), suggests this only occurs during the morning peak between 7.30 am and 8.30 am (see Figure 10).

2.2.3 Calculating passenger loading

Loading captures how full a bus is, over the course of its journey, which can be used to calculate mass. On most route services, passengers alight and depart at different stops, which keeps the loading low. In comparison a charter service picks up all customers at one location and delivers them all to a second.

If all seats are taken on a charter bus, it is considered utilised at 100 per cent. If a route service was full by the time it departed its first stop and reached its end journey full, it would still only be considered utilised at 50 per cent because it returns to its depot empty. If it started out empty and picked up passengers along its route, it would be considered utilised at 25 per cent.

Table 12 shows estimates of metropolitan bus utilisation that have been determined using outputs from the Veitch Lister Consulting (VLC) transport models for Brisbane, Sydney and Melbourne.

This is presented as the proportion of time that the fleet operates at a given utilisation. The transport model output gives the estimated patronage and the utilisation was found by dividing by the average fleet capacity.

Table 12. Average metropolitan bus utilisation

City	Utilisation (% average)
Sydney	12.5
Melbourne	6.7
Brisbane	10.3

Source: (Pekol Traffic and Transport, 2013)

In 1998 the Queensland Department of Transport and Main Roads (TMR) surveyed long-distance charter service demand and published an average utilisation of 29 per cent for buses arriving and 32 per cent for departure.

Although dated, this study is still useful for calculating capacity. This is because the demand for coach travel hasn't increased in the way that route services have and may have decreased with the introduction of cheaper air travel.

With the above information in mind, a realistic scenario would look like the capacity rates that were calculated by Pekol Traffic and Transport in 2013 (see Table 13).

Table 13. Average passenger utilisation of bus services

Passenger type	Capacity of bus (% average)
Route buses	8
School buses	13
Charter	35

Source: (Pekol Traffic and Transport, 2013)

We have taken a conservative approach and analysed capacity at 25 per cent and 40 per cent to calculate the impact passenger weight would have on a service.

Tables 14 and 15 shows that at 40 per cent capacity, measuring passengers' weight at 80 kg, would increase the overall mass by 240 kg on a route bus, 345 kg on a coach and 600 kg on a double decker.

Table 14. Difference in overall weight at 40 per cent capacity

	40 pp route bus (kg) 16 pp	57 pp coach (kg) 23 pp	100 pp double decker (kg) 40 pp
40% capacity at 65 kg	1,040	1,495	2,600
40% capacity at 80 kg	1,280	1,840	3,200
Difference	**240**	**345**	**600**

At 25 per cent capacity, measuring passengers' weight at 80 kg would increase the overall mass by 150 kg on a route bus, 210 kg on a coach and 375 kg on a double decker.

Table 15. Difference in overall weight at 25 per cent capacity

	40 pp route bus (kg) 10 pp	57 pp coach (kg) 14 pp	100 pp double decker (kg) 25 pp
25% capacity at 65 kg	650	910	1,625
25% capacity at 80 kg	800	1,120	2,000
Difference	**150**	**210**	**375**

Result: The above calculations show that increased passenger weights would have a minor impact on the overall mass of route buses (and coaches when not running at full capacity).

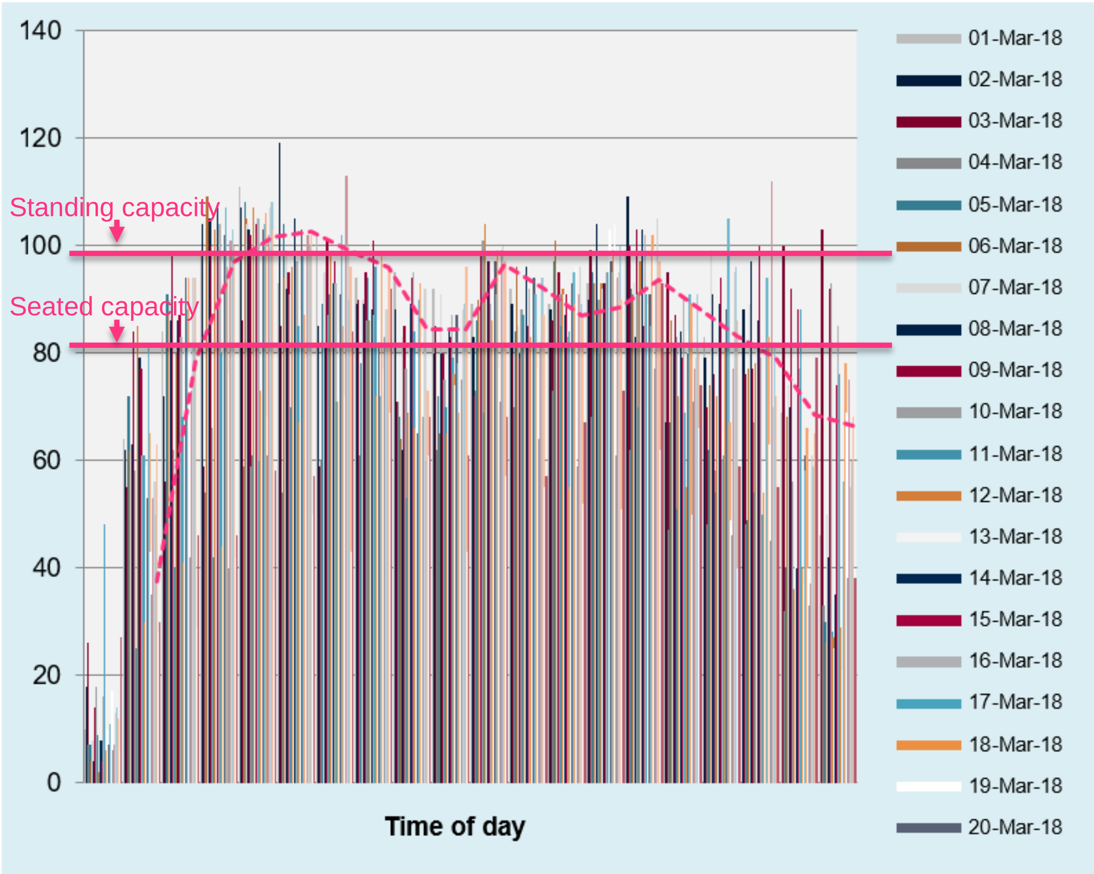
Case Study 1: Northern Beaches B-Line

The Northern Beaches B-Line provides public transport links on one of Sydney's most congested road corridors. It is due to be completed in 2019. Almost 7,000 new weekly buses have been introduced, with the majority run on three-axle double deckers.

Data recovered from Opal card tap-ons (Figure 10) suggests these B-Line services are running at 25 per cent capacity on average at a minimum. This captures weekends, public holidays and school holidays (March 2018 included Easter holidays).

Analysing the maximum numbers for passengers-in-transit shows far greater numbers, with some services running over capacity during the peak morning (see Figure 11).

Figure 10. Maximum number of passengers-in-transit on a service, by time of day



Source: (Transport for NSW, 2018)

The tare weight of a double decker is around 14–19,000 kg without passengers or luggage (Schoemaker, 2007).

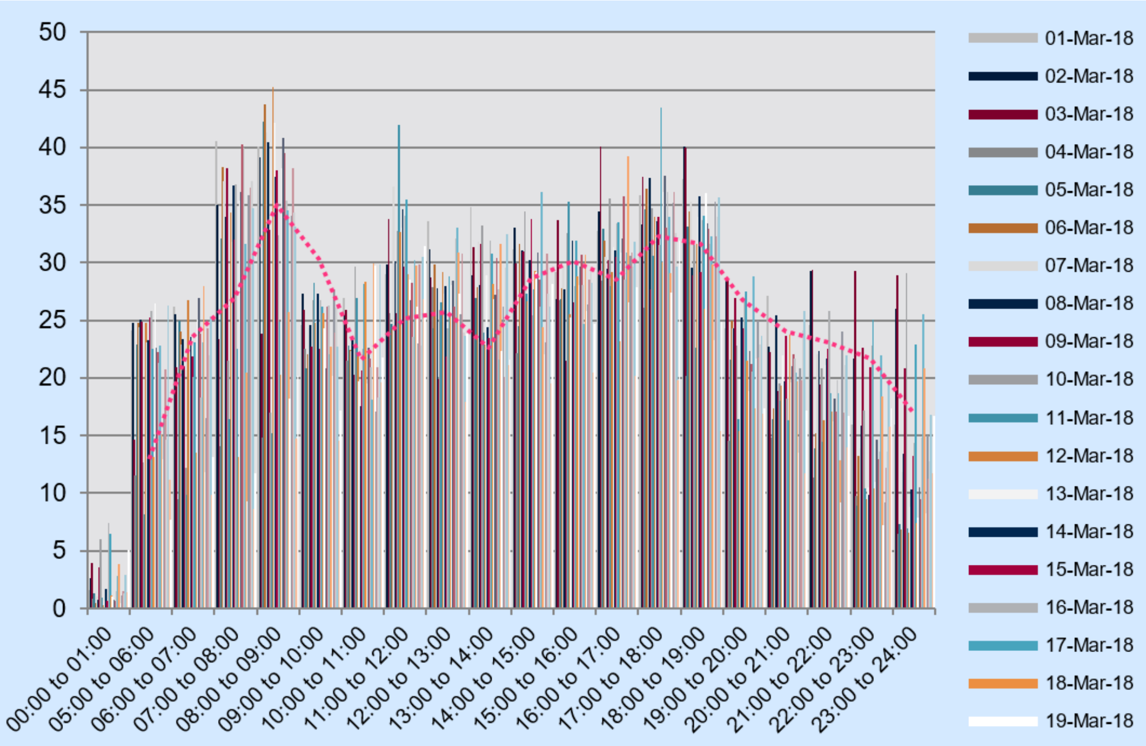
At capacity (101 total capacity), the added weight would be 7,929 kg (based on ABS statistics for average weight). As such, it's possible these double deckers could already be running overloaded (up to 26,900 kg) – particularly considering the extra weight of passengers' bags containing heavy items such as laptops.

101 × (men = 85.9 kg × women = 71.1 kg / 2) = 7,929 kg

+ 14,500

= **22,429 kg**

Figure 11. **Average number of passengers-in-transit, by time, along the B-Line route**



Source: Transport for NSW, 2018

Result: These new double decker services are running overloaded during the morning peak.

2.2.4 Luggage weight is partly responsible for overloading

The difference that passenger weight makes in a coach at full capacity is around 855 kg (see Table 16), which is not significant in comparison with the weight of technology such as wheelchair lifts, which can range between 250 and 600 kg (see Chapter 2.1). However, when you add the increased weight of luggage, the figure becomes more significant.

Table 16. **Increased weight of a coach due to luggage in comparison with capacity limits**

	57 pp coach (kg)		57 pp coach (kg)	Total weight (kg)
Full capacity at 65 kg	3,705	15 kg luggage pp	855	4,560
Full capacity at 80 kg	4,560	25 kg luggage pp	1,450	6,010
Difference	**855**	Difference	**595**	**1,450**

Result: Table 16 shows a fully laden coach is likely to be running at 1.45 tonnes above what the carrying capacity states in the ADRs.

Luggage is only taken on long-distance coach services, airport shuttles and charter services. Passengers taking luggage are often connecting with other transport modes such as flights or cruises. As such, the luggage they are taking is usually at the same weight as the luggage allowances for the connecting transport mode (see Table 17).

Table 17. Luggage allowances by transport mode and class of travel (kgs)

	Carry-on	Economy	Business
Regional flights			
Qantas	7	23	32
Virgin	7	23	32
Regional Express	7	23	23
Fly Corporate	7	15 (30*)	15 (30*)
Domestic flights			
Qantas	7	23	32
Jet Star	7	23	32
Virgin	7	23	32
International flights			
British Airways	23	32	60
Norwegian	10	32	64
Qatar Airways	15	45	60
Air France	12	23	32
KLM	12	23	32
Air New Zealand	7	23	32
Garuda Indonesia	7	30	40
Emirates	7	23	32
Malaysian Airlines	7	30	40
United	7	23	32
Regional trains			
VLine	30	30	30
NSW TrainLink	20	20	20
Queensland Rail	20	20	20
TransWA	20	20	20
Interstate trains			
The Ghan	20	40	60
Indian Pacific	20	40	60
Overlander	20	40	60
Average	**13**	**27**	**38**
Cruise liners			
P&O	64	–	–
Carnival	64	–	–
Princess	No restriction	–	–
Average overall			

* 30 kg if connecting with an international flight or cruise

Case Study 2: Premium tourism

Several tourism companies offer premium coach tours for international tourists. These tours offer premium travel and accommodation in five-star hotels. They range in price from $4,000 to $20,000 depending on the length of travel. An example premium travel itinerary is shown in Figure 12.

Figure 12. Example of a premium coach tour itinerary

Customers are collected at the closest international airport and their luggage stowed. Tours range in number, but to be profitable for operators they usually have at least 30 customers.

Tours can range up to 60 customers and use of more than one coach. Customers have been observed to carry luggage that is allowed by their connecting flights. This includes customers travelling at business and first classes.

Result:

55 adults at average weight (80 kg) = **4,400**

55 suitcases at 23 kg each = **1,265**

55 carry-on items at 7 kg each = **385**

Total weight = 6,050 + 15,000 (standard tare bus weight) = 21,050

Operators have told the NTC they do not have the ability to manage luggage weight for international tourists. This is because of the limited time available at pick-up zones (see Table 18) and because customers would be left stranded with their luggage at the airport.

This differs from flights that can charge for extra baggage. Even if bus operators weighed and charged customers for excess baggage, the bus would still be running overloaded (unlike a plane, which has no mass limits).

Some operators explained that there is limited time available to pick-up customers at airports and that this limits any opportunities to enforce luggage limits. Some airports offer extra time at a cost. However, this would affect the profit margin of the service.

Table 18. Time allocated to coach pick-up at airports

Airport	Pick-up zone time
Perth	10 minutes
Adelaide	1 hour for free
Sydney	Charge per first hour, then every 15 minutes $15–152
Brisbane	Charge per first hour, then every 15 minutes $15–77

Result*: *In some cases, there is limited time available to weigh luggage at airports. If operators were to recuperate this cost by charging for extra baggage, it may be a reasonable option. However, we note that some passengers choose to travel by coach because of the lower ticket price. Charging more may hinder some passengers from being able to travel.

For premium services, however, we don't believe this would be an issue. The argument against charging for luggage is that it may create poor perception of the bus operators, especially because luggage allowances are already considerably lower than those of all other modes of transport.

Case Study 3: Community charter

We've heard from several operators about their experience chartering non-tourism-related coach services. Most of these were for community groups or organisations. The amount of luggage these groups carries is usually much higher than an average tourist and significantly higher than a commuter.

Table 19 lists luggage capacity demands reported by operators to the NTC.

Table 19. Estimated luggage type and weight by community group, for 50 people

Organisation	Luggage type	Estimated extra weight per person	Total luggage weight stored on coach
Teenage rugby club	Sports equipment	25 kg	1,250 kg extra
High school camp	Tents and other camping equipment	30 kg	1,500 kg extra
Pensioners' trip	Motorised wheelchairs, oxygen tanks and other medical equipment	40 kg	2,000 kg extra
Boarding school end of year	Textbooks, homewares, clothing, memorabilia	45 kg	2,250 kg extra
The army	Guns and other weaponry, and supplies	50 kg	2,500 kg extra

Result: Depending on the organisation, bus operators conducting community charters are likely to overload very easily due to heavy luggage. Further, current regulations are discouraging operators from accepting such charter bookings. Charging extra for this type of luggage would not be practical because community groups are already operating within limited budgets.

2.2.5 Axle configuration and the broader heavy vehicle industry

To address the issue of axle spacing, road managers have suggested the steer axle limit would need to be increased to support an increased overall mass. This has implications for the rest of the heavy vehicle sector, which would also benefit from an increase on the front steer axle.

Most heavy vehicles have a mass limit of 6.5 tonnes on the steer axle. To equally distribute weights for an overall mass limit, the steer axle mass would need to increase. Changing this to 7 tonnes was found to be optimum when combined with a wider tyre greater than 375 mm and that this would have a minimal effect overall.

Buses are already given higher tolerance to limits than trucks in some states and territories. This is because of the benefits to community and government. However, the impact raising the steer axle to 7 tonnes would have on the broader heavy vehicle industry needs to be considered.

2.3 Infrastructure impacts

2.3.1 Increased road wear

According to industry views, due to three-axle weight distribution and improved suspensions, the damage to roads by modern three-axle buses was thought to be less than with two-axle and older three-axle buses.

Road wear is generally calculated by weight to the power of four – that is, the higher the mass the higher the wear by four times. The number of people on board also affects the level of wear because this adds to the overall weight.

Outside of peak times most route buses run at a low capacity. This is partly because people get on and off at regular intervals along routes and there is low patronage outside of work hours. Charter buses run at higher capacities because people tend to stay on board longer; however, there is still some pick-up and drop-off.

Traditionally, pavement wear was calculated according to the individual wear of each axle; however, Austroads found the discrepancies in pavement meant this formula didn't offer the most accurate result.

To assess potential pavement wear, the equivalent standard axle (ESA) equation uses the power of four relationship (X^4). For example, a load that is 2 per cent higher than the normal running mass will result in a 16 per cent greater impact on the pavement. Logically, this means an increase in the mass limit would create an increase in pavement wear.

> *ARRB research indicates that increased axle mass due occurs when axle group allowable mass limits are increased (high mass limits, HML, concessional mass limits, CML, etc.) with the consequence of greater usage of high productivity vehicles which in turn has led to higher on road average heavy vehicle axle group masses. These developments have contributed to accelerated deterioration being observed in pavements with lower design strengths, and pavements nearing the end of their life-cycles.* (Austroads, 2013)

In general, the greater the width of a tyre, the less deterioration of pavement because the contact profile shape is more balanced and the stress more distributed.

In 2016 Austroads found that the optimum steer-axle mass was seven tonnes, as long as it was fitted with a wide tyre:

> *Following from this, a key finding of the report was that a 6.5 t steer axle load on a narrow tyre caused more damage compared to a 7.0 t load on a wide tyre, but less when compared to a 7.2 t load on a wide tyre. Analysis scenarios were only conducted at 7.0 t and 7.2 t, but it is clear that break-even point in terms of pavement damage is between these two increments. What this means practically, is that an increase in steer axle mass limit from 6.5 t to 7.0 t would be best accompanied by a change in tyre size.* (Austroads, 2016)[7]

However, the age of the road is also a factor when considering pavement wear:

> *… research conducted has determined that, with regard to the fatigue damage of asphalt and cemented materials, the standard load for an axle group type is dependent upon the thickness and modulus of the asphalt and the underlying pavement structure.* (Austroads, 2015)

[7] This finding was relevant only to sealed unbound granular pavements.

A study commission by the New Zealand Ministry of Transport found road wear costs increased by up to 50 per cent for mass increases on three-axles buses (Table 20). This cost was for the road wear component only of the maintenance budget, which was around 20 per cent of total maintenance and operation costs. It also assumed that the vehicles were running at full capacity (Infrastructure Decisions Support, 2016).

Table 20. Summary of predicted damage cost increases for three-axle buses in New Zealand

Analysis vehicle	Load Scenario	Rear Group Limit (tonnes)	Rear Group Load Share Split	Predicted Increase in Cost ($M)		
				State Highways	Local Roads	Total
All 3-axle buses	General Mass Limits	13.6	60/40%	-	-	-
		14.5	55/45%	0.2 0.3 0.4	0.5 0.6 0.8	0.7 (25%) 0.9 (33%) 1.2 (50%)
All 3-axle urban and rural buses including double deck buses (66-seaters)	As per VDAM 2015 Schedule 2, Part C	14.6	60/40%	3.0 3.8 5.3	4.9 6.1 8.5	7.9 9.9 13.8
		16.0	60/40%	5.7 7.1 9.9	8.9 11.1 15.5	14.6 18.2 25.4
		16.0	55/45%	3.1 3.9 5.4	5.0 6.2 8.7	8.1 10.1 14.1
All 3-axle urban and rural buses - rear axle set	Increase to 16.7 tonnes	16.7	60/40%	7.9 9.9 13.9	12.2 15.3 21.4	20.1 25.2 35.3
		16.7	55/45%	4.1 5.2 7.2	6.5 8.2 11.4	10.6 13.4 18.6

Source: (Infrastructure Decisions Support, 2016)

Table 21. Total kilometres travelled in 2014 (buses with 20 seats or more)

Route bus	Tour bus	TOTAL
728,000,000	108,000,000	836,000,000

Source: (NTC, 2016)

Case study 4: Impact of increasing the mass limit by 2 tonnes in Queensland

The cost of road maintenance is quantified by ESA per kilometre. This rating is used by all states and territories, as well as overseas, to calculate the amount of wear a vehicle causes on a road. The cost can then be captured in road pricing.

TMR Queensland assisted the NTC with calculations for a minor increase to a three-axle limit. TMR found a modest increase of 2 tonnes would increase the cost of road wear that vehicles create by 93 per cent on asphalt and 72 per cent on sealed roads (see Table 22).

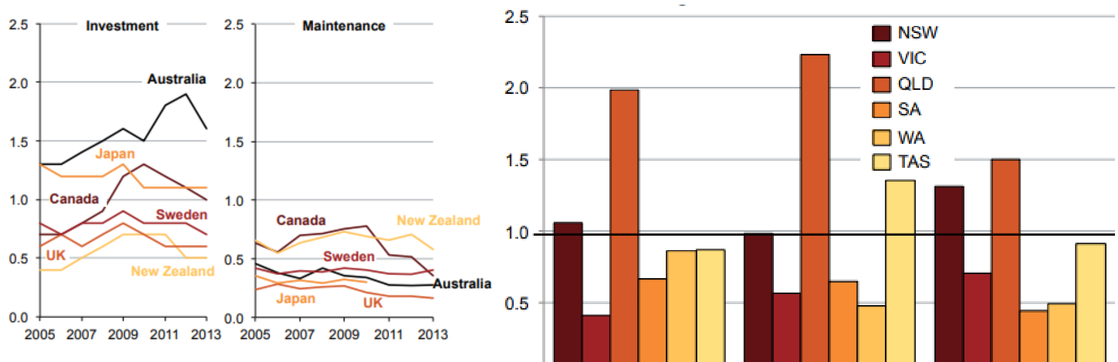
Table 22. ESA for asphalt pavements by half tonne increments

Axle type	Axle load (tonnes)	ESA	% increase
Complying tandem axle (dual tyre axle plus single tyre axle)	14.0 (regulation mass)	1.45	–
Increase complying axle load by 0.5 t	14.5	1.73	19
Increase complying axle load by 1 t	15.0	2.04	40
Increase complying axle load by 1.5 t	15.5	2.40	77
Increase complying axle load by 2 t	16.0	2.80	93

Axle type	Axle load (tonnes)	ESA	% increase
Complying tandem axle (dual tyre axle plus single tyre axle)	14.0 (regulation mass)	1.34	–
Increase complying axle load by 0.5 t	14.5	1.54	15
Increase complying axle load by 1 t	15.0	1.77	32
Increase complying axle load by 1.5 t	15.5	2.02	51
Increase axle load by 2 t	16.0	2.30	72

For TMR, this is particularly concerning because they have the highest cost of road maintenance among all the states and territories, with a third of their expenditure going on roads (see Figure 13).

Figure 13. Investment in infrastructure is high compared with other countries, but spend on maintenance is low, and road investment is higher in Queensland than all other states



Notes: Includes road, rail, inland waterways, maritime ports and airports and takes account of all sources of financing. Infrastructure investment covers spending on new transport construction and the improvement of the existing network. Infrastructure maintenance covers spending on preservation of the existing transport network.

Source: (Terrill, 2016)

The challenge is paying for this increased road wear. In 2012–13 the cost of road maintenance in Queensland was $561 per capita, almost double the national average (Commonwealth Grants Commission, 2014).

For the years 2013–14 to 2016–17, $581.8 million was allocated to maintain, preserve and operate Queensland's state road network. This was out of a total budget of over $4 billion for the state network (TMR, 2013). In 2014–15 more than $7.3 billion was spent on total road expenditure across Queensland; however, only $2.6 billion was recuperated in road-related revenue (BITRE, 2016).

> *There is a difference between what's good for the budget and what's good for the public. Running a government is not the same thing as running a corporation: if a project offers net benefit to the community, there is an argument that the community should have it. Governments have several funding options available to them:*
>
> - *Raising those taxes that are least distorting to the economy, primarily Commonwealth taxes on income and consumption;*
> - *Reductions to lower value spending (especially to low value transport infrastructure); and*
> - *User charges and betterment levies (with a clear contender being road user charging).* (Terrill, 2016)

Following is an assessment of how to recuperate the cost to road maintenance budgets should the mass limit be increased.

2.3.2 How to recover costs for road wear

PAYGO model

The Pay as You Go (PAYGO) model is a cost recovery pricing model that attributes road investment and maintenance costs to different heavy vehicle (HV) classes. It does this by taking road expenditure, which is split into different categories, and assigning the costs to HV classes using each category's relationship to HV use and road usage data. The costs are recovered through a combination of registration fees and a road user charge (RUC) levied on diesel.

The PAYGO model attributes some costs directly to each vehicle class and then distributes costs deemed common across all classes. It attempts to reduce cross-subsidy by ensuring that, at a minimum, the costs that are attributable to a given HV class are recovered through the charges paid by that vehicle class.

There are no tests on the efficiency or appropriateness of road expenditure or guarantees of minimum service standards. The PAYGO model sets HV charges based on historic costs, and there is no direct flow of revenues back to road investment and maintenance.

Data availability

The NTC, as part of its PAYGO pricing model, uses two sources of available data to attribute costs to different vehicle classes, including heavy vehicles:

- the ABS's Survey of Motor Vehicles (SMVU – 9208.0), which includes fuel consumption and vehicle kilometres travelled by vehicle class including for three-axle buses
- state and territory registration data, which provides registration numbers for all vehicle classes, including three-axle buses.

To allocate costs associated with vehicle mass, the model also uses SMVU estimates of average vehicle mass across most heavy vehicle classes; however, this data is not available for bus categories. For average bus weights by bus categories, including three-axle buses, the model relies on advice obtained as part of the 2005 price determination.

Data and PAYGO model output

Table 23 captures the key aggregated input and output data relating to three-axle buses for the most recently available year in each case.

Table 23. Estimated cost of three-axle buses on road maintenance

Cost directly attributable to 3-axle buses	$11.6 m
Non-directly attributable costs allocated to 3-axle buses	$5.5 m
Total road costs of 3-axle buses	$17.1 m
Number of 3 axle buses (national, 2016–17 registration data)	2,229
Registration charge (roads component, 2017–18)	$2,260
Estimated registration revenue from 3-axle buses (roads component registration charges) ($)	$5 m
Fuel used by 3-axle buses (litres, 2016 SMVU)	51.1 L
RUC rate (cents per litre, 2017–18)	25.8 c
Estimated RUC revenue from 3-axle buses ($)	$13.4 m
Estimated total revenue from 3-axle buses ($)	**$18.4 m**
Vehicle kilometres travelled by 3-axle buses (2016 SMVU)	136.1 m

Result: There were 2,229 registered three-axle buses in Australia in 2016–17 that travelled an estimated 136 million kilometres. This is less than one per cent of the total vehicle kilometres travelled for HVs, which is around 16.8 billion kilometres. The combined estimated revenue from registration and road user charges was about $18.4 million.

Implications for changing weight limit

Given the total cost attributable to three-axle buses is only $17.1 million a year, it is unlikely that a proportion of the fleet carrying weight above the current weight limit some of the time is the cause of significant extra road wear. Likewise, if there was to be an increase in the maximum allowed weight for three-axle buses, any change in behaviour is unlikely to have a significant impact on road costs.

Also, because the PAYGO model is just a cost recovery model, any adjustment within the PAYGO model would (if anything) only result in a negligible adjustment in relative registrations charges of other vehicle classes compared with three-axle buses – that is, it would have no impact on road maintenance and investment funding.

Given the lack of connection between charges and actual maintenance needs induced by the vehicle classes use, any increase in registration charges for three-axle buses would generate additional funding in the state of registration, but this doesn't necessarily proportionately reflect where the buses are being driven and any damage to roads being done.

Finally, even if there were additional revenue raised through PAYGO, the current funding arrangements (through consolidated revenue) mean that it is uncertain whether any additional funding would flow to the relevant road agencies for additional maintenance.

2.4 Compliance

The bus and coach industry is heavily regulated to ensure its safe operation on the road network. Carrying people requires a much greater level of compliance than cargo, and this seems to cause a much greater level of burden on small operators.

One operator reported being fined when a compliance officer assessing a stopped coach found a bandage in the first aid kit that was out of date. Other operators have reported being fined for similarly minor reasons such as being a few minutes past break time, being over mass only slightly on one axle (but not overall), standing in the airport parking zone for a few minutes too long.

The impact of this level of compliance is not the risk of being fined but the time and effort taken to ensure compliance and the impact this has on their company's reputation (particularly if a driver is issued with a fine and a full load of passengers are watching it happen from their seats).

Operators have explained it can take many hours of their staff's day checking compliance, particularly measuring equipment and balancing loads.

For these reasons, it is a reminder that any recommendation must balance the benefits for both large and small bus operators.

Case study 5: Deregulation in Norway

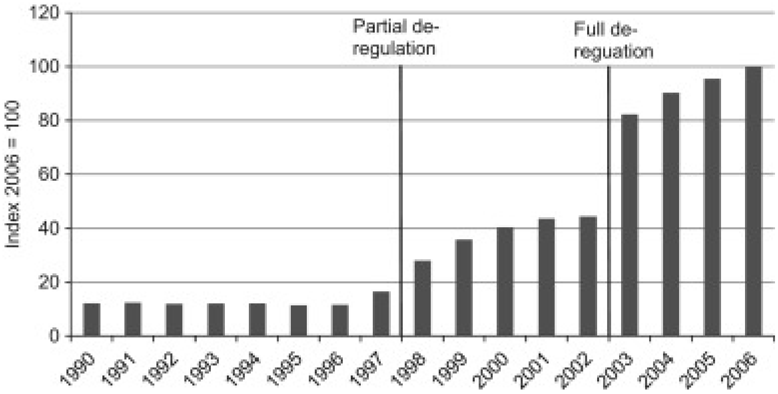
Because of Norway's difficult terrain, coach travel is often the only feasible transport mode. However, to protect the market share of rail travel, the bus industry was required to prove they were not in competition with rail travel.

In 1999 the government lifted this requirement and licence requirements to operate in other countries when it was found that the benefit to passengers outweighed this level of market protection.

The similarities of this case include the difficult terrain, strong levels of state regulation and dissatisfaction from the public. Norway has been one of the few countries to deregulate coach travel and therefore offers insight to the Australian context.

In 2003, when regulation was removed entirely, passenger numbers more than doubled (Figure 14).

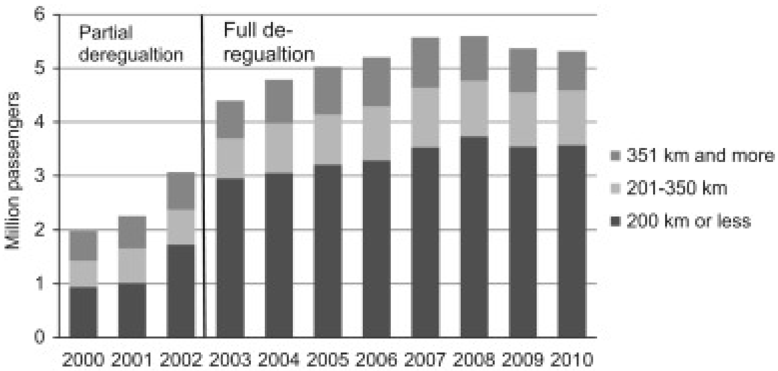
Figure 14. Growth following deregulation of the bus industry in Norway



Source: (Aarhaug & Fearnley, 2016)

The numbers of passengers steadied in 2008, however, remained high (Figure 15). This was largely due to the high frequency of services that weren't possible under the previous regulations. This means passenger growth is a by-product of deregulation, which allows operators the freedom to innovate and offer new services.

Figure 15. Consolidation in passenger numbers following deregulation in Norway



Source: (Aarhaug & Fearnley, 2016)

While passenger growth in the more traditional, longer lines didn't grow as rapidly, the number of new routes more than doubled.

> *Our research shows that deregulation has created a market, where there was no market before. This market has had **positive effects, providing benefits to a relative large number of people** [NTC's emphasis], who are enabled to make trips they could not make before… In fact, political regulation was the major factor preventing market entry. (Aarhaug & Fearnley, 2016)*

The results of Norway's experiment influenced changes in Sweden, Germany and the UK, which have had similar results.

Further:

*Th*e Norwegian experience offers several lessons that can be valid internationally

1. **The express coach industry is able to provide a service that is not provided by rail** – even when the routes run in parallel. It serves smaller markets, and offers a more flexible network. An interesting observation is that there are lines that are able to operate profitably, without subsidies, where the alternative has been to offer no service what so ever, or to rely heavily upon subsidies.

2. ***The express coach industry is able to grow new markets rapidly as they open up.*** *The rapid growth following the partial deregulation, and then again after the full deregulation, illustrates this. The industry was able to double the size of operations within two years of the market opening in 2003. A similar growth capacity was demonstrated with the partial deregulation around 1998.*

3. ***The express coach industry is greatly influenced by the developments in the local bus industry.*** *A very important explanatory factor describing developments in the express coach market, is the local bus market. Many express coach operators have local PSO* (social cost of public service obligations) *services as their main activities, while express coach operations are more of a spin-off. Structural changes in local markets, like mergers and acquisitions, translate directly into the express coach markets.*

Source: (Aarhaug & Fearnley, 2016)

3 What options are there?

There are two options for moving forward, which we will explore in this chapter:

- Option 1: No change to the limit, with mitigating strategies to enforce the current limit
- Option 2: Increase the axle-mass limits.

Option 1: No change to the limit

If no change to the current mass limit is made and no mitigating weight management strategies are put in place, the current situation will continue to cause overloaded buses to run on our road networks. This is an unacceptable outcome.

There are no weight management policies or guidelines that the NTC is aware of which assist bus operators and drivers to manage their loaded weight.

However, if the preferred option was to retain the current mass limits for three-axle buses, then there are a range of options which could be included in such guidelines for operators to manage the loaded weight issues discussed within Section 2.2, these include:

- passenger and luggage calculations that are more realistic for today's society;
- considerations for charging for excess baggage;
- guidance for weight spacing across axles; and
- use of trailers.

This option ignores the issue of tare mass increases and is not supportive of optimising three-axle bus services.

Option 2: Increase the axle-mass limits

Option 2 is to increase the axle mass limits for three-axle buses to a limit which enables operators to optimise their efficiency without compromising safety, or unduly damaging infrastructure.

We have outlined the likely benefits and risks of increasing the mass limit in Table 24 to try to determine an appropriate limit.

Table 24. Risk and likelihood of risk, by tonnes increases

Mass (tonne)	Increase (tonne)	Benefit	Risk	Likelihood
20.5	None	None	✗ Industry would revert to 2-axle buses because of the higher mass limit	High
21	0.5	Medium Would reflect increase in tare weight	No change as this would protect services already running at capacity	Medium
22	1.5			
23	2.5	High ✓ Industry would reduce compliance costs ✓ Industry could increase the types of services offered ✓ Governments could take up advantages of double deckers ✓ Manufacturers can offer cheaper parts	✗ Increase in road wear	Medium Wear would likely increase – however, operators would want to keep their costs low and weight adds fuel costs
24	3.5			
25	4.5			
26	5.5	✓ Match overseas regulation ✓ Manufacturers would find it easier to import and could offer more innovative practices	✗ Open market for much larger vehicles and subsequent road wear	
No limit		✓ As above. ✓ Plus, regulation would be prepared from hybrid and electric vehicles which are significantly heavier.		Very High

Increasing the mass limits to a figure agreed by state and territory governments and industry

We contend that the mass limits for three-axle buses should be raised. This is consistent with the recent two-axle increase, and with most other countries in the world, to cater for the growing population, disability requirements, environmental protection and new technology and to better prepare for the future shift to electric, hybrid and driverless buses.

This will allow industry to minimise their compliance costs, invest in safer technology and continue or even increase their services for the community.

The same benefits apply to government-funded public transport services and will allow transport agencies to invest in more productive vehicles such as double deckers.

The benefits to the community are paramount and we believe the increased cost to road maintenance should be addressed in the review of road pricing.

Further, it is likely that a change in mass limit does not result in any actual change on the ground or to day-to-day operating masses.

This is because three-axle buses are generally already running over mass and it's in industry's interest to keep weights to a minimum because of the higher cost involved in fuelling higher mass vehicles.

Amending the luggage calculations in the ADRs to 23 kg

We also recommend luggage allowances in the ADRs be adjusted to 23 kg to align with all other transport modes. However, a change in the luggage calculations in the ADR will require a mass limit increase to immediately reflect this change in luggage allowance. An alternative is to take the luggage allowance figure out of the ADR and instead use a clause of 'appropriate mass' so any future changes can be reflected. Not only will this allow more seamless connections between transport modes, but it will reflect a more accurate weight of the passenger and their luggage to determine the overall weight of a loaded three-axle bus.

Table 25 summarises the pros and cons of raising the axle-mass limit.

Table 25. Benefit matrix of raising the mass limit

	Benefits	Negatives
Operators	1. In line with two-axle increase 2. In line with other countries 3. Reduction in compliance 4. Can run at full capacity 5. Luggage allowances in line with other transport modes	N/A
Manufacturers	1. Less investment in expensive, lighter materials 2. Can offer new models to market with Euro VI engines 3. Can offer greater capacity vehicles	Manufacturers specialising in lighter materials may reduce their market share slightly
Passengers	1. No reduction in services 2. More (or same) amount of luggage 3. Possibility of greater comfort	N/A
Charter clients	1. No increase in cost 2. Operators more willing to charter for heavier groups such as sports clubs or camping groups	N/A
Road managers	Less enforcement	Possible, yet minor increase in road wear
Regulators	National consistency	Will need to amend the Heavy Vehicle National Law and publish communications material about the changes

4 Conclusion

Key points

Based on our analysis, the NTC believes the mass limit should be increased to a figure agreed by industry, road managers and manufacturers. We suggest:

- front axle: 7 tonnes
- tandem (drive and tag): 14 tonnes
- tandem (drive and tag with tyre above 375 mm): 16 tonnes

The evidence also suggests the current luggage calculations allowed for in the Australian Design Rules should be amended to allow three-axle passengers to carry up to 23 kg each.

Results

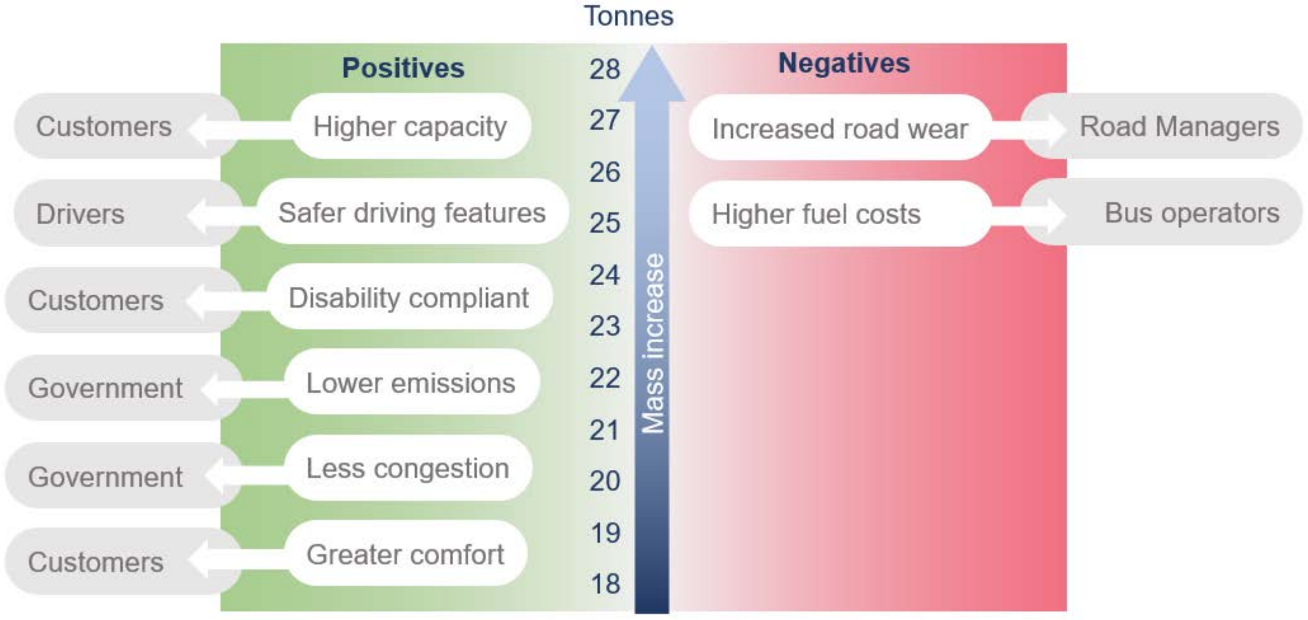
Our analysis found that three-axle buses are likely to be running over mass on Australian roads, with the majority falling within peak times for route services and long-distance coaches at full capacity.

We concluded the reasons behind overloading were:

- a disconnect with luggage allowances on other transport modes
- heavier mechanical parts needed to meet the requirements of the Federal Disability Discrimination Act 1992
- emissions standards for engine exhaust (Emissions Requirements for Diesel Heavy Duty Vehicles, Cth).

The direct benefits of increasing the mass limit are summarised in Figure 16. The relevant clauses of regulatory requirements are included at Appendices A and B.

Figure 16. The direct benefits of increasing the mass limit



Based on our analysis, an increase in the maximum allowed weight for three-axle buses is unlikely to have a significant impact on road costs. The NTC believes the mass limit should be increased to a figure agreed by industry, road managers and manufacturers. We suggest:

- front axle: 7 tonnes
- tandem (drive and tag): 14 tonnes
- tandem (drive and tag with tyre above 375 mm): 16 tonnes

The evidence also suggests the current luggage calculations allowed for in the Australian Design Rules should be amended to allow three-axle passengers to carry up to 23 kg each.

4.1 Questions to consider

1. Do you believe the suggested limits allows three-axle buses to run at full capacity, for both route services and charter services?
2. What would the increased cost of road wear be in your jurisdiction if the mass limits for three-axle buses were increased to the suggested limits?
3. Are you aware of any other issues (not raised in this paper) that you believe would have a negative impact on industry, government or the community, should the mass limits be raised as per the recommendations?

4.2 Next steps

The project will recommend to transport ministers a course of action to be adopted nationally and an implementation plan for giving effect to that recommendation.

The NTC requests comments and feedback on the information and options presented in this paper by 24 July 2018.

We will consider all comments and feedback to this discussion paper received online, via mail or email on whether the mass limits should be increased to develop our final recommendations.

A summary of our evaluation and recommendations will be presented to the Transport and Infrastructure Senior Officials Committee in September 2018 and then to the Transport and Infrastructure Council in November 2018.

Should an increase be recommended, and supported by the National Heavy Vehicle Regulator, road agencies and industry, a National Notice will be published and made valid to a time to allow the National Heavy Vehicle Law to be amended.

Appendix A: Relevant clauses from the Disability Standards for Accessible Public Transport 2002

Clause	Detail
1.2	(1) The Disability Discrimination Act 1992 seeks to eliminate discrimination, 'as far as possible', against people with disabilities.
8.2	**When boarding devices must be provided** (1) A manual or power assisted boarding device must be available at any accessible entrance to a conveyance that has: (a) a vertical rise or gap exceeding 15 mm (AS3856.1 (1991) Clause 2.1.7 (f)); or (b) a horizontal gap exceeding 40 mm
8.6	**Maximum load to be supported by boarding device** (1) A boarding device must be able to support a total passenger and mobility aid weight of up to 200 kg.
9.1	**Minimum size for allocated space** The minimum allocated space for a single wheelchair or similar mobility aid is 800 mm by 1300 mm
9.4	**Number of allocated spaces to be provided — buses** (1) At least 2 allocated spaces must be provided in each bus with more than 32 fixed seats (2) At least one allocated space must be provided in each bus with less than 33 fixed seats
11.7	**Grabrails to be provided in allocated spaces** Grabrails, must be provided in all allocated spaces.
12.6	**Automatic or power-assisted doors** (1) Doors may be fully automatic (2) Power-assisted doors must not require passengers to grip or twist controls in order to operate opening devices
28.4	**Accessible seats to be available for passengers with disabilities** (1) Accessible seats must be kept for passengers with disabilities. (2) Operators must allocate unbooked accessible seats to other passengers only after all other standard seats are filled.
30.1	**Disability aids to be in addition to baggage allowance** (1) Disability aids (for example, equipment and apparatus including mobility, technical and medical aids) are to be in addition to normal baggage allowances. (2) If possible, disability aids are to be treated in the same way as cabin or accompanied baggage.
Part 4	**Target date — 31 December 2022** All public transport services are to fully comply with the relevant Standards.

Appendix B: Australian Design rules relevant to three-axle buses

Standard	Title	Year	Specifications
ADR30/01	Smoke Emission Control for Diesel Vehicles	2006	Approved Diesel Engine
ADR80/03	Emission Control for Heavy Vehicles	2011	Euro V or US/Japanese equivalent
ADR83/00	External Noise	2005	80 to 83 decibels
ADR 43/00	Vehicle Configuration and Dimensions		Maximum turning circle, ability to turn within an inner radius, rear overhang of a rigid vehicle, ground clearance and load-sharing suspension.
ADR 35/05	Commercial Vehicle Brake Systems	2013	Service Brake System operable on all road wheels through the medium of a single control.
ADR 59/00	Omnibus Rollover Strength	2006	Strength of an omnibus superstructure to withstand forces encountered in rollover crashes
ADR 66/00	Seat Strength, Seat Anchorage Strength & Padding	2006	Fittings such as hand-grips, switches, folding trays, etc. Armrest strength, fitting and accessory hardness, type of seat belt, and seats able to withstand 10 times force with padding.
ADR 68/00	Occupant Protection in Buses	2006	Fitting of seat belts to passenger seats, with the exception of route service buses and buses with less than 17 seats.
ADR 58			
3	Occupant capacity	2006	65kg per manufacturer's seating and 15kg for luggage
4	Aisle Requirements		Not less than 380 mm aisle
10	Hand Straps/Rails/Grips		Omnibuses shall be provided with a suitable number of hand straps, hand rails or hand grips for the convenience and safety of passengers.
11	Floors		Floors of omnibuses shall be finished and maintained with a skid-resistant surface, and shall be of sound construction and sealed so as to prevent fumes from the engine and dust from the roadway from entering the interior of the vehicle.
13	Passenger seats		Each passenger seating position shall have a dimension of not less than 400 mm when measured along the front of the 'Seat' cushion.
17	Fire retardant interior		Interior roof lining and other interior trimming shall be of a material not readily flammable with a durable non-absorbent surface, and interior fittings shall be firmly attached to the vehicle.
23	Fuel System		The location, use and requirements of any combustible fuel. Fully fire-proof design of fuel tank housing.
24	Fire Extinguisher		provided on every omnibus in such a position as to be readily available

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