Safety of four-wheeled lightweight electric vehicles

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Abbreviations and acronyms

AEBS	advanced emergency braking system
ATV	all-terrain vehicle
DVLA	Driver and Vehicle Licensing Agency (in UK)
EU	European Union
EV	electric vehicle
Euro NCAP	European New Car Assessment Programme
FMVSS	Federal Motor Vehicle Safety Standard
GB	Great Britain
GHG	greenhouse gas
K car	Japanese vehicle category for the smallest highway-legal passenger cars, with restricted dimensions and engine capacity
KSI	killed or seriously injured
L6e	Official vehicle type category for light quadricycle in the European Union
L7e	Official vehicle type category for heavy quadricycle in the European Union
LSV	Low-speed vehicle – name for four-wheeled lightweight vehicle in the USA, electric versions sometimes called neighbourhood electric vehicles (NEVs)
Micro-mobility	General name for four-wheeled lightweight vehicle in Japan, which includes electric versions and mini-car class – see below
Mini-car	Smallest class of four-wheeled lightweight vehicle in Japan, which can carry maximum of one person, officially categorised as a ‘Class 1 motorised bicycle’
MLIT	Ministry of Land, Infrastructure, Transport and Tourism (Japan)
NEV	Neighbourhood electric vehicle (see LSV above)
NZTA	NZ Transport Agency Waka Kotahi
ONISR	French Road Safety Observatory
Quadricycle	Name for four-wheeled lightweight vehicle in Europe, which includes electric versions. Categorised into heavy and light quadricycles, official vehicle type categories L6e and L7e, respectively
Quad	Vehicle model type described as ‘quad’ or ‘quad bike’ identified during the analysis of UK registration data, which were not quadricycles but mostly ATVs. These vehicles were investigated because the project steering group highlighted that they were of interest.
SEV	small electric vehicle
SORN	Statutory Off Road Notification. Term used in UK to describe ‘registered’ vehicle not licensed for use on public roads.
UK	United Kingdom (of Great Britain and Northern Ireland)
USA	United States of America
VRU	vulnerable road user
VSP	vehicle-specific power

Contents

Executive summary

Lightweight electric vehicles (EVs) may have a role in enabling New Zealand to move to a low-carbon transport system, especially in urban areas, by replacing the use of larger vehicles (eg, traditional cars and vans) for short urban trips and for urban freight delivery. However, there is a concern that these lightweight vehicles, known as quadricycles in Europe, tend to be much less safe than traditional passenger cars. This concern was highlighted by the European New Car Assessment Programme (Euro NCAP), which reported poor performance of quadricycles in crash tests performed in 2014 and 2016.[1] A likely major contributory factor to this difference is that, in Europe, quadricycles are subject to different safety regulations compared to passenger cars, and, unlike cars, quadricycles do not have to meet mandatory crash test requirements.

Given these conflicting priorities, there was a need for NZ Transport Agency Waka Kotahi (NZTA) to learn from the experiences of other jurisdictions that have allowed the introduction of lightweight EVs to help understand the risks and benefits of changing domestic laws to allow (or not allow) the operation of lightweight EVs on New Zealand's roads. On this basis, the following main objective was set for this research study:

- To better understand the approach to regulation of lightweight EVs and the resulting safety outcomes in different jurisdictions, especially Europe and Japan.

To achieve this, specific sub-objectives were set as follows:

- Regulation and enforcement
  - For Europe and Japan: summarise the legal descriptions of lightweight EVs and the regulatory controls and associated enforcement mechanisms to manage their use. At a top level, compare the European and Japanese situations with that in the USA.
- Number of quadricycles and benefits/costs
  - For Europe, specifically the UK, France and Germany: determine the numbers of quadricycles in use currently and how these numbers have changed in the past (and are expected to change in the future). Also, review literature and summarise information available related to expected potential benefits and costs for their future use.
- Collisions and casualties
  - For Europe, specifically the UK, France and Germany: for quadricycle collisions, determine the current number of people killed or seriously injured and compare this with other modes of transport such as cars and/or motorcycles. If available in national data, provide an overview of quadricycle accidentology.

The main findings of the study were as follows.

Regulation and enforcement

Europe, Japan and the USA were found to diverge in their approaches to regulation. The focus and amount of regulation for each aspect differ widely with regard to vehicle categorisation; occupant and vulnerable road user (VRU) protection standards; and usage restrictions in terms of the roads that can be driven on. Japan, for its type-approved micro-mobility category, is the only region that has safety standards along the lines of those required for passenger cars, including requirements for crashworthiness and VRU impact protection. It is interesting to note that the level of these standards, together with the fact that major vehicle manufacturers such as Toyota make these vehicles, shows that it is possible to enforce requirements for crashworthiness

[1] Euro NCAP quadricycle safety ratings: https://www.euroncap.com/en/vehicle-safety/quadricycle-ratings-explained/

and VRU impact protection without making these micro-mobility vehicles as heavy, inefficient, and expensive as a standard passenger car and hence negating the advantages of them. The USA regulates lightweight EVs far less than other regions, with the main restrictions covering only gross mass, top speed, and the roads on which they can be driven. Europe is the only region that does not restrict usage on higher-speed roads (motorways/expressways).

Number of quadricycles and benefits/costs

The literature review found that four-wheeled lightweight electric quadricycles are considered a promising mobility solution in the context of the growing climate crisis and increased awareness of the need for clean and sustainable mobility. Sustainable transport modes and multi-modal solutions will also need to be integrated into clean mobility solutions. Lightweight EVs fit well with this ambition, as they promote public transport use and last mile connectivity. Japan is considering the use of quadricycles as part of the efforts to decarbonise transport and promote mobility of older people and people living with disabilities. The UK is planning on transitioning all quadricycles for road use to zero emission in the coming years.

The safety of quadricycles is under debate. Existing European regulations are much less stringent for quadricycles than for most other vehicles (eg, conventional cars, vans, trucks and buses) covered by the type-approval regime, particularly in the area of crash test requirements. With an increase in use and demand for quadricycles, such requirements may need to be introduced in the future. Due to their lightweight build and relatively small size, valid concerns exist on the crash safety of these vehicles.

Some manufacturers have released promising production reports, and new microcar models are entering the market, indicating that manufacturers recognise the economic potential of these vehicles. However, other manufacturers are reported to have pulled out of this market because it was not profitable.

The current and historical fleet size data analysed for the UK, Germany and France cannot easily be compared between countries due to reporting differences and gaps in data. However, it can be observed that the total fleet size can be expected to be largest in France, followed by Germany and then the UK, which has by far the smallest fleet of quadricycles.

The sustainability and cost-of-operation benefits of quadricycles compared to passenger cars might be assumed to have led to increasing vehicle numbers in recent years, but none of the data identified would indicate such a trend. Indeed, the opposite trend is observed in the UK and Germany with sharp decreases, while France shows relatively stable numbers over the last decade. Ultimately, it appears that consumer and market trends coupled with legislative and regulatory frameworks will shape the future markets for four-wheeled lightweight EVs.

Collisions and casualties

The collision and casualty data analysed showed that in all three European countries the vehicles in scope only contribute a small fraction to overall road casualties, which is to be expected given the small vehicle fleet size compared to passenger cars. However, the casualty rates (ie, the number of killed or seriously injured occupants per million vehicles) indicate that their safety performance is worse than that of passenger cars but better than that of motorcycles: The casualty rate of quadricycles was found to be 47% to 280% higher compared to cars but 14% to 71% lower compared to motorcycles. This allows us to conclude that there is a risk of total casualty numbers increasing, potentially substantially, if significant numbers of road users change from cars to quadricycles and quadricycle safety standards remain at current European Union levels. It is noted that this result should be treated with caution because:

- the exposure metric used (per million licensed vehicles) does not consider how much the vehicles are used or where they are used (ie, operating environment)

- the low numbers of quadricycle casualties and licensed quadricycles make the results sensitive to small changes.

Detailed information on accidentology was sparse for the vehicle categories of interest. In the UK, the majority of quadricycle collisions (more than half) involved one other vehicle (in most cases a car), followed by single-vehicle collisions (some of which involved a pedestrian), and finally, forming the smallest group, collisions involving two or more other parties. In France, only the split between drivers and passengers was known: Approximately three quarters of people killed or seriously injured were drivers, which is in line with expectation under the assumption that single occupancy is arguably the main mode of operation.

Abstract

Four-wheeled lightweight electric vehicles may have a role in enabling New Zealand to move to a low-carbon transport system by replacing the use of larger vehicles (eg, traditional cars and vans) for short urban trips and for urban freight delivery, but there is concern about the safety of these vehicles. NZ Transport Agency Waka Kotahi (NZTA) is seeking to learn from the experiences of Europe, Japan and the USA – in particular, what approach was taken to regulation and the resulting safety outcomes. A review of regulations and published literature on benefits and costs was undertaken and vehicle registration and collision data was analysed for this research study.

Europe, Japan and the USA were found to diverge in their approaches to regulation. The focus and amount of regulation for each aspect differ widely with regard to vehicle categorisation; occupant and vulnerable road user protection standards; and usage restrictions in terms of the roads that can be driven on. Japan is the only region that has safety standards that include requirements for crashworthiness and vulnerable road user impact protection along the lines of those required for passenger cars. The USA regulates the vehicles far less, with the main restrictions covering only gross mass, top speed, and the roads on which they can be driven. Europe is the only region that does not restrict usage on higher-speed roads (motorways/express-ways).

The current and historical fleet size data analysed for three European countries shows that the total fleet size is largest in France, followed by Germany and then, with the by-far smallest fleet, the UK. The data identified indicates a shrinking fleet size over the past years in the UK and Germany; France showed relatively stable, but not growing, numbers over the last decade.

The collision and casualty data analysed showed that in all three European countries the vehicles in scope only contribute a small fraction to overall road casualties, which is to be expected given the small vehicle fleet size compared to passenger cars. However, the casualty rates (that is, the number of killed or seriously injured occupants per million vehicles) indicate that their safety performance is worse than that of passenger cars (47% to 280% higher) but better than that of motorcycles (14% to 71% lower).

1 Introduction

Lightweight electric vehicles (EVs) may have a role in enabling New Zealand to move to a low-carbon transport system, especially in urban areas, by replacing the use of larger vehicles (eg, traditional cars and vans) for short urban trips and for urban freight delivery. However, there is a concern that these lightweight vehicles, known as quadricycles in Europe, tend to be much less safe than traditional passenger cars. This concern was highlighted by the European New Car Assessment Programme (Euro NCAP), which reported poor performance of quadricycles in crash tests performed in 2014 and 2016.[2] A likely major contributory factor to this difference is that, in Europe, quadricycles are subject to different safety regulations compared to passenger cars, and unlike cars, quadricycles do not have to meet mandatory crash test requirements.

Given these conflicting priorities, there was a need for NZ Transport Agency Waka Kotahi (NZTA) to learn from the experiences of other jurisdictions that have allowed the introduction of lightweight EVs to help understand the risks and benefits of changing domestic laws to allow (or not allow) the operation of lightweight EVs on New Zealand's roads. To help fulfil this need, TRL was commissioned to perform the research study reported.

Lightweight EVs are called different names in different jurisdictions. To help the reader's understanding, the common names of relevant vehicle categories for different jurisdictions are given below (Table 1.1).

Table 1.1 Common names for lightweight EV categories in the main jurisdictions

Jurisdiction	Vehicle categories	Notes
Europe	Quadricycles (light and heavy)	L6e and L7e are official vehicle type categories for light and heavy quadricycles, respectively
Japan	Micro-mobility vehicles and mini-cars	Sometimes called new mobility
USA	Low-speed vehicles (LSVs)	Electric versions sometimes called neighbourhood electric vehicles (NEVs)

1.1 Objectives

The following main objective was set for this research study:

- To better understand the approach to regulation of lightweight EVs and the resulting safety outcomes in different jurisdictions, especially Europe and Japan.

To meet this, specific sub-objectives were set as follows:

- Regulation and enforcement
  - For Europe and Japan: summarise the legal descriptions of lightweight EVs and the regulatory controls and associated enforcement mechanisms to manage their use. At a top level, compare the European and Japanese situations with that in the USA.
- Number of quadricycles
  - For Europe, specifically the UK, France and Germany: determine the numbers of quadricycles in use currently and how the numbers have changed in the past (and are expected to change in the future). Also, summarise information available related to expected potential benefits and costs for their future use.

[2] Euro NCAP quadricycle safety ratings: https://www.euroncap.com/en/vehicle-safety/quadricycle-ratings-explained/

- Collisions and casualties
  - For Europe, specifically the UK, France and Germany: for quadricycle collisions determine the current number of killed or seriously injured (KSI) casualties and compare with other modes of transport such as cars and/or motorcycles. If available in national data, provide overview of quadricycle accidentology.

1.2 Approach

The study was broken down into three main tasks to address each of the sub-objectives as follows:

- **Task 1: Regulation and enforcement**
  - For Japan and Europe (with a focus on the UK, France and Germany), comprehensive reviews of relevant type approval and national legislations, such as driver licensing, were performed to compile:
    - a legal description of quadricycles and a summary of their regulated technical requirements, including safety and limits on power or speed
    - a summary of controls and associated enforcement mechanisms to manage the use of quadricycles, including driver licensing, annual registration tax, periodic technical inspection and limits where they can be used (if any).
  - For the USA, a rapid review of relevant legislation was performed to enable similarities and significant differences between the jurisdictions to be highlighted and discussed.
- **Task 2: Number of quadricycles and benefits/costs**
  - Literature review
    - A review of national and local government policies, including environmental drivers and targets, and manufacturer announcements on expected production and sales targets, was performed to gather information on potential influencing factors and expectations for the future uptake of lightweight EVs.
  - Identification of quadricycles by make/model in the UK
    - A list of makes/models of quadricycles in the UK was compiled to enable analysis of the UK registration and collision data sets because neither of these data sets have specific identifiers for quadricycles.
  - Vehicle registration database analysis
    - Analyses of vehicle registration data for the UK, France and Germany was performed to extract the number of registered quadricycles in these countries currently and over recent years.
- **Task 3: Collisions and casualties**
  - For the UK, France and Germany, analyses of national collision data were performed to determine the number of KSI quadricycle users and if possible vulnerable road users (VRUs) involved in quadricycle collisions. Where possible, the rates of KSI casualties for quadricycles (per million registered vehicles) were compared with those for passenger cars to provide indications of the relative risk of injury for users of these different vehicle types.

During the first steering group meeting, it was noted that, although out of scope, the following topics were of interest and relevant information found should be highlighted in the report:

- boundary definitions between quadricycles and four-wheeled electric cycles for freight delivery
- regulation of all-terrain vehicles (ATVs) – in particular, side-by-sides.

2 Regulation and enforcement

2.1 Europe

2.1.1 Introduction

The regulation and enforcement of lightweight vehicles is partially harmonised across the European Union (EU). Vehicle categorisation and type approval requirements are set at the EU level and include provisions for battery electric vehicles. At the time of writing, the UK continues to apply identical regulations after having left the EU. The rules regarding vehicle registration and taxation, usage restrictions, driver licensing and roadworthiness inspections are harmonised in some respects, but detailed legislation varies between countries.

2.1.2 Vehicle categorisation

Lightweight four-wheeled vehicles ('quadricycles') with a maximum design speed exceeding 6 km/h, at least one seating position and intended to travel on public roads are classified as L-category vehicles at EU level. Regulation (EU) 168/2013[3] sets out technical definitions for L-category classification and sub-categorisation. Note that vehicles that meet both L-category and M- or N-category (four-wheeled passenger and goods vehicles) definitions can be approved as L-category vehicles. The UK currently continues to apply this regulation after having left the EU.

Vehicle categorisation criteria are described in Article 2, Article 4 and Annex I of the regulation. Four-wheeled vehicles are contained in categories L6e and L7e:

- L6e – Light Quadricycle: A vehicle with four wheels with a mass in running order (note: excluding driver and propulsion batteries) of not more than 425 kg and a maximum design speed of not more than 45 km/h
- L7e – Heavy Quadricycle: A vehicle with four wheels, other than that classified for the category L6, with a mass in running order (note: excluding driver and propulsion batteries) of not more than 450 kg (passenger transport) or 600 kg (goods transport); some sub-categories have limits on maximum design speeds (see below).

Further quadricycle sub-categories are listed in Table 2.1. Note that these contain 'car-like' vehicles with an enclosed occupant compartment as well as vehicles without a compartment and with straddle seating. The most relevant vehicles for this review are the potentially 'car-like' sub-categories L6e-BP, L6e-BU, L7e-A2, L7e-CP and L7e-CU.

[3] Regulation (EU) 168/2013: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02013R0168-20201114

Table 2.1 Quadricycle sub-categories according to Regulation (EU) 168/2013

Category	Name	Max. mass	Compartment type	Max. seat number	Seating type	Max. engine power	Max. speed
Light quadricycles (L6e)							
L6e-A	Light on-road quad	425 kg	Not specified	2	Not specified	4 kW	45 km/h
L6e-BP	Light quadri-mobile for passenger transport	425 kg	Enclosed compartment	2	Not specified	6 kW	45 km/h
L6e-BU	Light quadri-mobile for utility purposes	425 kg	Enclosed compartment	2	Not specified	6 kW	45 km/h
Heavy quadricycles (L7e)							
L7e-A1	A1 on-road quad	450 kg	Not specified	2	Straddle	15 kW	Not specified
L7e-A2	A2 on-road quad	450 kg	Not specified	2	Non-straddle	15 kW	Not specified
L7e-B1	All-terrain quad	450 kg	Not specified	2	Straddle	Not specified	90 km/h
L7e-B2	Side-by-side buggy	450 kg	Not specified	3	Non-straddle	15 kW	Not specified
L7e-CP	Heavy quadri-mobile for passenger transport	450 kg	Enclosed compartment	4	Non-straddle	15 kW	90 km/h
L7e-CU	Heavy quadri-mobile for utility purposes	600 kg	Enclosed compartment	2	Non-straddle	15 kW	90 km/h

The maximum dimensions of L-category vehicles are generally 4,000 mm in length, 2,000 mm in width and 2,500 mm in height. L6e-B and L7e-C vehicles are shorter (at 3,000 mm and 3,700 mm, respectively) and narrower (at 1,500 mm).

Authors' note: Additional topics of interest for steering group

ATVs, including side-by-sides, can be categorised as heavy quadricycles (see Table 2.1 sub-categories L7e-B1, L7e-B1). However, some may also meet the definition of both category L and category T (agricultural and forestry vehicles). These vehicles can be approved based on Regulation (EU) 167/2013.[4] T-category approval usually limits vehicles to a registration as agricultural or forestry vehicle (see section 2.1.4). Some ATVs may be too highly powered to meet L-category definitions, which then requires a T-category approval. ATVs intended never to be used on the road can also be approved as 'machinery',[5] but they cannot then be registered as a road vehicle.

Electric cycles, including those with three or four wheels for freight delivery, are classified under sub-category L1e-A (Powered cycle). To fall into this sub-category, vehicles must:

- be designed to pedal and be equipped with an auxiliary propulsion with the primary aim to aid pedalling
- cut off auxiliary propulsion at a vehicle speed ≤ 25 km/h
- have an engine power ≤ 1 kW.

[4] Regulation (EU) 167/2013: http://data.europa.eu/eli/reg/2013/167/2019-04-18

[5] Directive 2006/42/EC: http://data.europa.eu/eli/dir/2006/42/2019-07-26

2.1.3 Type approval

The technical requirements for type approval of L-category vehicles are also defined within Regulation (EU) 168/2013 and are therefore harmonised across the EU. Annex II of the regulation provides an overview of the applicability of requirements across the various sub-categories. Detailed technical requirements and test procedures are specified in supplementary legislation, namely:

- Commission Delegated Regulation (EU) No 134/2014[6] (environmental and propulsion unit performance requirements); note that vehicle category L also includes quadricycles propelled by internal combustion engines
- Commission Delegated Regulation (EU) No 44/2014[7] (vehicle construction and general requirements)
- Commission Delegated Regulation (EU) No 3/2014[8] (functional safety requirements).

The EU specifies a range of technical requirements for L6e and L7e quadricycles; however, it should be noted that the minimum safety level required is considerably lower compared to passenger cars or vans. Relevant safety requirements for quadricycles include:

- audible warning devices (horns)
- braking
- electrical safety
- glazing, wipers and washers
- lighting
- rollover protective structures (mandatory for L7e-B2 only)
- safety belts (mandatory for L7e-A2, L7e-B2 and L7e-C and all L6e/L7e fitted with body work)
- steer-ability and cornering properties
- vehicle structure integrity
- devices to prevent unauthorised use
- electromagnetic compatibility
- external projections.

In some of these areas, the requirements set out are considerably lower than for passenger cars. Notably:

- The braking requirements allow for lower mean fully developed deceleration levels (4.4 m/s^2 (L6e) or 5.0 m/s^2 (L7e) compared to 6.43 m/s^2 (car)) and do not require systems such as brake assist, anti-lock braking or electronic stability control.
- Certain quadricycles with bodywork – in particular, light ones – may be fitted with lap belts instead of the more effective three-point safety belts.

More detail on the requirements is available in the technical annexes of the delegated regulations listed above.

It should further be noted that L-category safety requirements do not contain aspects relating to the prevention of collisions (such as advanced emergency braking systems, lane-keeping assistance or

[6] Commission Delegated Regulation (EU) No 134/2014: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02014R0134-20180320

[7] Commission Delegated Regulation (EU) No 44/2014: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02014R0044-20180320

[8] Commission Delegated Regulation (EU) No 3/2014: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02014R0003-20161016

intelligent speed assistance), protection of occupants in collisions (such as frontal impact, side impact or protective steering), pedestrian protection requirements going beyond the regulation of external projections, or requirements for seat belt reminders. More information on quadricycle safety requirements, including a comparison to passenger cars, can be found in TRL reports by Edwards et al. (2014) and Benders et al. (2022).

2.1.4 Vehicle registration and taxation

There is no EU-wide law governing vehicle registration, so member states set their own rules. Only the contents and format of the registration documents are harmonised via Council Directive 1999/37/EC.[9]

As a general rule, most quadricycles need to be registered to be used on-road. Documents that typically need to be submitted for registration include a Certificate of Conformity to prove type approval compliance, proof of roadworthiness for used vehicles, proof of ownership and proof of insurance cover. Under certain preconditions (eg, vehicle has reverse gear and trailer hitch; vehicle has no passenger seats; registered keeper owns agricultural land), quadricycles can be registered as agricultural or forestry vehicles, which allows on-road use but only in connection with agricultural/forestry activities.

In the **UK**, quadricycles must be registered, insured and taxed before road use. Fully electric vehicles must be taxed, but the annual rate is reduced to zero (ie, no payment is required currently). The vehicles must be fitted with front and rear licence plates.

In **Germany**, vehicle registration requirements are governed by the *Verordnung über die Zulassung von Fahrzeugen zum Straßenverkehr.*[10] Light quadricycles (L6e) are not registered[11] and not taxed. Users need to purchase an insurance licence plate, which allows using the vehicle on-road and provides proof of insurance for up to one year. Heavy quadricycles (L7e) need to be registered, fitted with full licence plates, and the keeper must have third-party insurance. EVs are exempt from paying tax until 2030. After that date, vehicles will be taxed based on their weight, with a 50% reduction of tax compared to identical-weight commercial vehicles with a combustion engine.

In **France**, quadricycles must be registered, insured and taxed before road use. EVs are not exempt from annual taxation, but the rates are lower compared to combustion engine vehicles because the levy for polluting vehicles does not apply. Quadricycles must be fitted with one licence plate at the rear.

2.1.5 Usage restrictions

The use of roads by different vehicle types is regulated nationally. No restrictions apply explicitly for quadricycles, but vehicle-design-based restrictions apply for certain types of roads.

In the **UK**, vehicles must have a maximum design speed of at least 25 mph (ca. 40 km/h) to be used on motorways. For motorcycles there is an additional requirement of at least 4 kW power, but this does not apply to four-wheeled vehicles. Many quadricycles could therefore use motorways legally. No relevant restrictions apply to other road types.

To use **German** motorways or motor roads (*Kraftfahrstraße*, a road type indicated by a blue sign edged in white showing a white car silhouette; often a dual carriageway), vehicles must have a maximum design speed of more than 60 km/h. Category L6e vehicles, which are limited to 45 km/h by definition, cannot be

[9] Council Directive 1999/37/EC: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A01999L0037-20220324

[10] https://www.gesetze-im-internet.de/fzv_2011/index.html#BJNR013900011BJNE001304124

[11] https://www.kba.de/SharedDocs/Glossareintraege/DE/L/L_Fahrzeuge.html

used on these roads legally, but faster quadricycle models of category L7e may. No relevant restrictions apply to other road types.

In **France,** the usage rules are similar to Germany: Motorways and expressways (*voie express*, a road type indicated by a blue sign edged in white showing a white car silhouette; often a dual carriageway) are reserved to vehicles with a maximum design speed of at least 60 km/h. Some quadricycles of category L7e may therefore be used legally, but not those of category L6e.

2.1.6 Driver licensing

Driving licence categories in the EU are harmonised through Directive 2006/126/EC.[12] The UK currently continues to apply the harmonised EU categories after having left the EU. The relevant categories for quadricycles are summarised in Table 2.2. Member states must mutually recognise driving licences of all categories defined in the directive, but not all countries offer each category to their citizens. For instance, category B1 is not offered in Germany.

Table 2.2 EU driving licence categories relevant for quadricycles

Category	Vehicles covered
AM	2- and 3-wheel vehicles with a maximum design speed of not more than 45 km/h, as well as light quadricycles
A1	Light motorcycles with a cylinder capacity not more than 125 cubic centimetres and a power rating less than 11 kW
A2	Motorcycles with a power rating under 35 kW
A	Heavy motorcycles without power restrictions
B	Passenger vehicles weighing up to 3,500 kg and seating not more than eight passengers
BE	Vehicle of category B towing a heavy trailer of under 3,500 kg
B1	Quadricycles

The minimum age when a licence category can be acquired varies between countries. Table 2.3 summarises the minimum legal age to drive quadricycles in the European countries in scope. The table shows the licence category that grants the permission to drive at the youngest age. Generally, higher category A licences allow driving L6e vehicles, and full B licences allow driving light and heavy quadricycles.

Table 2.3 Minimum age to drive quadricycles on-road (years of age; licence category)

	UK	Germany	France
Light quadricycle (L6e)	16 (AM licence)	15 (AM licence)	14 (AM licence; persons born before 1988 without licence)
Heavy quadricycle (L7e)	17 (B1 or B licence)	17/18 (B licence with/without use restrictions)	16 (B1 licence)

[12] Directive 2006/126/EC: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02006L0126-20201101

2.1.7 Roadworthiness inspection

Minimum standards and minimum intervals for the roadworthiness inspection of road vehicles are harmonised through Directive 2014/45/EU,[13] but the application for quadricycles varies between countries as explained below. It should be noted that the directive does not require mandatory roadworthiness testing for L6e vehicles but only for 'L7e equipped with a combustion engine with a displacement of more than 125 cm^3'.

The **UK** requires a periodic roadworthiness inspection, or *MOT test*, for light and heavy quadricycles under the Road Traffic Act 1988.[14] The intervals prescribed (see Table 2.4) are identical to those for passenger cars.

Germany requires a periodic *Hauptuntersuchung* under the *Straßenverkehrs-Zulassungs-Ordnung (StVZO)*[15] for heavy quadricycles; light quadricycles do not have to undergo roadworthiness testing. The regular interval is the same as for passenger cars, but the first inspection must happen two years after first registration,[16] whereas cars only need to be inspected initially after three years.

France does not currently require a *contrôle technique* for quadricycles in the *Code de la route.*[17] In 2021, France issued an amendment to the relevant legislation that would have made regular roadworthiness inspections mandatory at the same interval as passenger cars (initially at four years, then every two years) starting from 2023. However, this amendment was later repealed in parts. Currently, French national legislation does not appear to be in line with the EU Directive; it is not clear how the national law will develop in the future.

Table 2.4 Roadworthiness inspection intervals for quadricycles (first inspection from date of registration; subsequent inspection interval)

	UK	Germany	France
Light quadricycle (L6e)	3 years, then every 1 year	not required	not required
Heavy quadricycle (L7e)	3 years, then every 1 year	2 years, then every 2 years	not required

2.2 Japan

2.2.1 Introduction

In Japan, four-wheeled lightweight EVs, referred to as quadricycles in Europe, fall into the micro-mobility and mini-car (motorised bicycle) classes of vehicle. In 2013, the Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT) recognised the concept of micro-mobility as a potential new category of vehicle that could be developed to help meet CO_2 emission targets and resolve problems associated with ageing and depopulation, such as the decline of public transportation systems in rural areas (MLIT, 2013).

[13] Directive 2014/45/EU: http://data.europa.eu/eli/dir/2014/45/2022-09-27

[14] Road Traffic Act 1988: https://www.legislation.gov.uk/ukpga/1988/52/part/II/crossheading/tests-of-vehicles-other-than-goods-vehicles-to-which-section-49-applies

[15] StVZO: https://www.gesetze-im-internet.de/stvzo_2012/anlage_viii.html

[16] https://www.adac.de/rund-ums-fahrzeug/reparatur-pflege-wartung/hu-und-au/hu-und-au/

[17] Code de la route: https://www.legifrance.gouv.fr/codes/section_lc/LEGITEXT000006074228/LEGISCTA000006159587/#:~:text=III.,les%20prestations%20de%20celui%2Dci.

Micro-mobility can be envisaged as filling the gap in needs between motorised two-wheeled vehicles and K cars. K cars are small, light motor vehicles that have regulated size limits, length ≤ 3.4 m, width ≤ 1.48 m, height ≤ 2.0 m, engine displacement ≤ 660 cm^3, and a voluntary engine power limit ≤ 47 kW. K cars are required to meet the same vehicle technical standards, including crash safety ones, as standard cars. They are popular because they are convenient to drive and have economic benefits, such as low purchase price and tax, and good fuel economy compared to standard cars. Because the area of micro-mobility is still evolving, the associated regulation is also still evolving. Circa 2010, the use of micro-mobility vehicles started with MLIT collaborating with local governments to perform demonstration trials. Following these trials, in 2013, MLIT established a certification scheme to allow local governments to instigate their own schemes to operate micro-mobility vehicles in defined areas (which do not include expressways). More recently, circa 2020, regulation has been introduced to permit the type approval (designation) of micro-mobility vehicles. At present, regulations exist:

- to allow type approval of micro-mobility vehicles (which includes defined safety requirements) for general use on the road (excluding expressways)
- for the certification of micro-mobility vehicles to permit their use in specific local government schemes that operate in defined areas (which do not include expressways) to help solve regional transportation issues. Note that vehicle certification includes additional specific safety requirements. Also, it is interesting to note that since the introduction of regulation to permit type approval of micro-mobility vehicles, these schemes are generally aimed at improving the transportation system and no longer run for the purpose of demonstration of micro-mobility alone.

Two main acts control the approval and use of micro-mobility vehicles:

- Road Transportation Vehicle Act – a law concerning the approval of vehicles, administered by MLIT
- Road Traffic Act – a law concerning the use (driving) of vehicles, administered by the National Police Agency.

2.2.2 Vehicle categorisation

According to the Road Transportation Vehicle Act, micro-mobility is classified into three categories according to their size and power rating (Table 2.6). Two of these categories – ‘micro-mobility type-approved (designated) vehicle’ and ‘micro-mobility certified scheme vehicle’ – are sub-categories of the K car category, and the other is ‘Class 1 motorised bicycle (mini-car)’,[18] a category for low-powered micro-mobility (rated power output ≤ 0.6 kW or engine displacement ≤ 50 cm^3).

The categories ‘micro-mobility type-approved (designated) vehicle’ and ‘Class 1 motorised bicycle (mini-car)’ are type-approved vehicles that can be purchased by the general public and used freely on public roads (with the exception of expressways according to traffic laws) in a similar manner to private cars. In contrast, vehicles within the ‘micro-mobility certified scheme vehicle’ category cannot be purchased by the general public for use on public roads and can only be used for the purposes and within the defined operational areas of the scheme for which they have been certified by MLIT. Part of the scheme certification process involves the introduction of measures to ensure that safety levels are appropriate and thus, because some of these measures, such as speed limitation, may reduce operational domain risks, vehicle safety levels may not be as stringent as for equivalent type-approved vehicles.

[18] The term ‘bicycle’ is used in the category description because the category was originally intended for small low-powered two-wheelers (eg, mopeds). However, even though low-powered micro-mobility have three or four wheels, they are included in this category because of their low power (and size).

Additional points to note:

- Whilst the maximum dimensions and speed of the type-approved micro-mobility categories (namely the mini-car and micro-mobility car) are restricted compared to standard K cars (namely, length ≤ 2.5 m cf. ≤ 3.4 m, width ≤ 1.3 m cf. ≤ 1.48 m, speed ≤ 60 km/h cf. no limit), for certified scheme micro-mobility cars, relaxed K car restrictions or motorcycle restrictions apply, which allows more freedom provided the scheme safety requirements can be met.
- Around 2020, to help reduce the number of accidents involving small go-karts (four-wheeled, low height-profile vehicles without occupant compartment; with engine displacement ≤ 50 cm^3, so categorised as motorised bicycles) driven on public roads, mainly by foreign tourists, the regulations for motorised bicycles (mini-cars) were updated to include additional technical requirements to improve safety. These updates are detailed in Table 2.5 below. Note that the conspicuity requirements were mainly aimed to improve the safety of karts given their low height, whereas the other technical requirements such as seat belt fitment, head restraint, steering mechanism, and wheel shielding were aimed at all mini-cars.

Table 2.5 Revision of regulatory requirements for Class 1 motorised bicycles (mini-cars)

Description of additional requirements	Scope
Conspicuity: vehicle shall have the structure with specified area visible from the front, back, left and right at a height of 1 m or more from the ground	Three-wheeled or four-wheeled motorised bicycles with a seat height of less than 500 mm from the ground (excluding those with a straddle seat).
Night-time conspicuity: vehicle shall have tail lights mounted near the maximum height of the structure	
Seat belt: vehicle shall be equipped with a two- or three-point seat belt	Motorised bicycles with three or four wheels (excluding those with straddle seats)
Head restraint: vehicle shall be equipped with a head restraint	
Steering mechanism shall be designed to absorb energy when impacted	Motorised bicycle with three or four wheels (excluding handlebar type)
Shielding of rotating parts: wheels must not protrude beyond the vehicle body	Motorised bicycle with three or four wheels

Table 2.6 Classification of micro-mobility

	Class 1 motorised bicycle (mini-car)	K car (light motor vehicle)			Standard car
		Micro-mobility (certified scheme car)	Micro-mobility (type-approved car)		
Maximum speed	60 km/h	Scheme dependent	60 km/h	N/A	N/A
Operational area restrictions	Yes (not expressways)	Yes (scheme-defined area only)	Yes (not expressways)	No	No
Max no. of seats	1	2	4[b]	4	9
Max load	90 kg	N/A	N/A	N/A	N/A
Rated power output[a]	≤ 0.6 kW or displacement ≤ 50 cc	0.6 kW–8.0 kW	> 0.6 kW	> 0.6 kW	> 0.6 kW
Length	≤ 2.5 m	≤ 3.4 m	≤ 2.5 m	≤ 3.4 m	≤ 12 m (≤ 4.7 m)
Width	≤ 1.3 m	≤ 1.48 m	≤ 1.3 m	≤ 1.48 m	≤ 2.5 m (≤ 1.7 m)
Height	≤ 2.0 m	≤ 2.0 m	≤ 2.0 m	≤ 2.0 m	≤ 3.8 m (≤ 2.0 m)
Vehicle examples	 Toyota iRoad  Toyota auto-body coms (1 occupant)	 Nissan New mobility concept (Renault Twizy)  Honda MC-β  Toyota auto-body coms (2 occupants)	 Toyota C+pod		

[a] 'Rated power output' is measured according to TRIAS 99-017-02 (based on JIS C 4034-1, IEC 60034-1); power output is measured over 1 hour of normal use of the vehicle. Note that in Europe, the 'maximum continuous rated power' measure is used. This is the maximum power over 30 minutes (UN Regulation No. 85 – Rev.1; Regulation (EU) No 168/2013).

[b] Practically, due to the vehicle's limited size, max number of seats is usually two.

2.2.3 Approval and certification

The technical requirements for the three micro-mobility categories described above are detailed in the relevant sections below.

2.2.3.1 Micro-mobility type-approved (designated) vehicle

This category was introduced around 2020 with technical requirements based on those for standard K cars but with changes made to allow for the smaller vehicle size and different operational domain.

Differences include:

- maximum dimensions: length 2.5 m, width 1.3 m, height 2.0 m (K car max length 3.4 m, width 1.48 m, height 2.0 m)
- not permitted to drive on expressways (unlike K cars)
- maximum speed: 60 km/h; sign displayed on rear of vehicle (Figure 2.1) to indicate maximum speed to other traffic (K car max speed self-imposed by manufacturers ca. 140 km/h)

Figure 2.1 Sign to show vehicle maximum speed

- frontal impact:
  - full-width test (UN ECE R137), impact speed can be reduced to 40 km/h (from 50 km/h)
  - Offset Deformable Barrier test (UN ECE R94), impact speed can be reduced to 40 km/h (from 56 km/h)
- side impact:
  - pole side impact (UN ECE R135), not required (because fitment of electronic stability control mandatory).

Similarities include:

- maximum seating capacity: four, but note that two seats are realistic due to dimensional limitations
- occupant restraint (UN ECE R16) – applied *mutatis mutandis* (ie, with necessary changes)
- lighting
- braking
- energy absorbing steering mechanism (UN ECE R12) – applied *mutatis mutandis* (ie, with necessary changes)
- side (lateral) impact (UN ECE R95)
- rear impact
  - safety of electric power train in a rear-end collision (UN ECE R153)
- in-use electrical safety (UN ECE R100) and electrical shock protection checks in impact tests
- fuel tank safety (UN ECE R34)
- hydrogen safety (UN ECE R134) – applied *mutatis mutandis* (ie, with necessary changes)
- pedestrian protection (UN ECE R127)
- advanced emergency braking system (AEBS) (UN ECE R152).

In summary, the technical requirements for micro-mobility type-approved vehicles are similar to those for K cars but with some significant changes to the crash test requirements on the basis of the vehicle's small size and its lower speed operational domain and some small changes to a number of requirements necessary to apply the relevant regulations.

2.2.3.2 Class 1 motorised bicycle (mini-car)

Although they can be four-wheeled vehicles, the technical requirements for mini-cars are based on those of motorised bicycles, which must have an engine displacement of ≤ 50 cm^3 or a rated power output ≤ 0.6 kW. On this basis, they include requirements for:

- maximum dimensions: length 2.5 m, width 1.3 m, height 2.0 m
- maximum speed: 60 km/h (note: sign to show vehicle maximum speed not required)
- maximum seating capacity: 1
- maximum load capacity: 90 kg.

Relevant safety requirements include:

- braking
- lighting
- vehicle body
- seat belts
- head restraints
- protective steering mechanism.

It should be noted that, unlike the micro-mobility type-approved vehicle category described above, the safety requirements for mini-cars do not include aspects relating to:

- the protection of occupants in collisions (such as frontal impact or side impact)
- pedestrian protection requirements that go beyond the usual regulation of external projections
- requirements for seat belt reminders.

2.2.3.3 Micro-mobility certified scheme vehicle

In 2013, MLIT established a micro-mobility certification scheme to allow local governments to use micro-mobility vehicles on public roads and assure safety as a top priority. Only local governments, councils organised by local governments, or organisations authorised by local governments are permitted to apply to set up a scheme. The application shall be submitted to the Director General of the District Transport Bureau, who has jurisdiction over use of micro-mobility in the local area, and include:

- a description of the area of vehicle operation
- measures to be taken to ensure traffic safety (eg, education of users and staff, prevention of driving outside operational area, response to emergencies such as an accident or wrong entry onto expressway)
- items for vehicle regulatory reductions and associated justification.

Before the introduction of regulation to allow the type-approval of micro-mobility vehicles, schemes were often instigated to trial the potential use of micro-mobility. The idea was that these demonstrative trials would investigate the use of micro-mobility to provide a convenient means of transportation in local communities over relatively short distances whilst obtaining technical data related to micro-mobility, creating successful cases, fostering public understanding, and increasing social acceptance.

The scheme requirements were based on the deregulation certification system based on Article 55-1 of the Safety Regulations for Road Vehicles (1951, Ministry of Transport Ordinance No. 67). The developed scheme permits micro-mobility with prescribed limited vehicle size and performance and the relaxation of some of the regulations to the extent that safety and environmental performance are not compromised under the following conditions:

1. The vehicle must not travel on national expressways or limited expressways.[19]
2. The vehicle must operate in areas where measures have been taken to ensure safe and smooth traffic flow.

The basic requirements for vehicles eligible for use within a certification scheme are:

- the length, width, and height of the vehicle are within the maximum dimensions for K cars (length ≤ 3.4 m, width ≤ 1.48 m, height ≤ 2.0 m)
- capacity of two occupants or fewer (three occupants or fewer in the case of a vehicle equipped with two child restraint systems)
- rated power output of 8 kW or less (125 cc or less for internal combustion engines).

The technical requirements for certified scheme vehicles are based on those for K cars but upon application can be reduced as follows:

- Exemptions for following items:
  - flammability of interior materials (Article 20, Paragraph 4)
  - seat attachment strength, seatback impact absorption (Article 22, Paragraphs 3 and 4)
  - seat belt installation strength,[20] seat belt reminder (Article 22-3, Paragraphs 2 and 4)
  - seat space, seat dimensions (Article 22, Paragraphs 1 and 2)
  - child restraint system (partial regulations such as ISOFIX) (Article 22-5)
  - equipped with fall prevention devices at entrances (Article 25, Paragraph 3)
  - door retention (Article 25, Paragraph 4)
  - windscreen strength (Article 29, Paragraph 2).
- If the width of the vehicle is ≤ 1.3 m, the requirements for the following items can be replaced with those for motorcycles:
  - lighting device[21] (Articles 32 to 41-5)
  - motor (double axle return spring) (Article 8, Paragraph 3)
  - running system (performance of light alloy wheels) (Article 89, Paragraph 3 of the Detailed Notification)
  - locking device (Article 92, Paragraph 3 of the Detailed Notification)
  - braking device (Article 93, Paragraphs 2 and 3 of the detailed notice).
- If the vehicle's maximum speed is ≤ 30 km/h, the following items can be exempted:
  - impact absorption of instrument panel (Article 20, Paragraph 5)

[19] Automobile limited expressways as defined in Article 48-4 of the Road Act (Act No. 180 of 1952), national expressways as defined in Article 4-1 of the Highway Act (Act No. 79 of 1957), and roads with a speed limit exceeding 60 km/h as defined in Article 22-1 of the Road Traffic Act (Act No. 105 of 1960).

[20] This does not exempt the obligation to equip seat belts.

[21] To permit this for light signalling devices, the vehicle's length must also be ≤ 2.5 m, as well as width ≤ 1.3 m (Article 41 of the Safety Regulations).

  - seat belt equipment and strength (Article 22-3, Paragraphs 1 and 3)
  - head restraint of front seat (Article 22-4)
  - impact absorption of sun visor (Article 45, Paragraph 3).
- On the basis that sales volumes are low (Article 1-3), the following crash test related items can be exempted:
  - impact absorption of steering mechanism (Article 11, Clause 2)
  - prevention of fuel leakage from fuel system (Article 15, Paragraph 2)
  - high-voltage safety after a collision (Article 17-2, Paragraph 4)
  - occupant protection (full frontal, offset frontal, and side impact) and pedestrian protection (head and legs) in a collision (Article 18, Paragraphs 2 to 5)
  - occupant protection in a collision (side impact) (Article 100, Paragraph 13 of the Detailed Notification).[22]

Additional technical requirements for certified vehicles, some of which help offset exemptions, include the following:

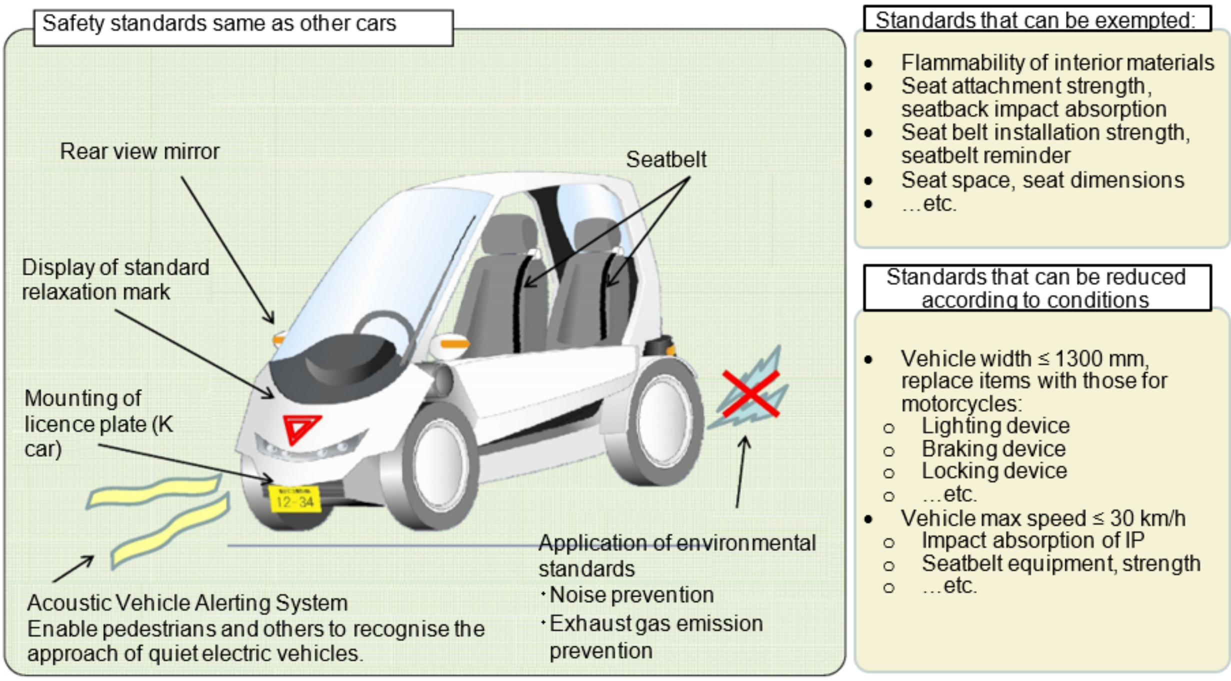
- The vehicle must be equipped with an acoustic vehicle alerting system that alerts pedestrians and others of the vehicle approaching.
- A deregulation mark must be displayed on the front and rear of the vehicle.

Also, it is recommended that certified vehicles be equipped with accident-prevention devices such as speed warning devices and collision warning.

A summary of the requirements is shown in Figure 2.2 below. It should be noted that type-approved (designated) micro-mobility vehicles are also permitted for use within a certified scheme. Mini-cars can also be used, provided the certified scheme requirements can be satisfied.

[22] In cases where the side impact structural requirements cannot be met, the regulations can be relaxed on the condition that safety measures are taken with side impact beams.

Figure 2.2 Summary of technical requirements for micro-mobility certified scheme vehicles



2.2.4 Vehicle registration

All three categories of micro-mobility vehicles are required to be notified[23] to the national or local government for use on the public road in Japan according to the Road Transportation Vehicle Act. 'Micro-mobility type-approved (designated) vehicle' and 'micro-mobility certified scheme vehicle' are K car sub-categories and thus are notified as K cars and shall display the appropriate licence plate at the front and rear of the vehicle. The 'Class 1 motorised bicycle (mini-car)' category is based on motorised bicycles that have low power (engine displacement of ≤ 50 cm^3 or a rated power output ≤ 0.6 kW), such as mopeds. Thus, they are notified to the municipality as motorised bicycles and shall display the appropriate licence plate at the rear.

2.2.5 Driver licensing

Under the Road Traffic Act (a law for safe driving on roads, administered by the National Police Agency), a micro-mobility vehicle (ie, micro-mobility type-approved (designated) vehicle or micro-mobility certified scheme vehicle) is classified as a standard motor vehicle. Thus, a standard driving licence is required to drive a micro-mobility vehicle. Note that the minimum age for a standard car driving licence is 18 years old.

In a similar manner, the 'mini-car' category is also classified as a standard motor vehicle in the Road Traffic Act. Thus, a standard motor vehicle driving licence is also required to drive mini-cars. Wearing a seat belt is mandatory for a mini-car occupant under the Road Traffic Act.

[23] Standard cars are registered at the national Land Transport Branch Office, but K cars are inspected at the Light Vehicle Inspection Association to obtain a vehicle inspection certificate and licence plate. This process is called 'notification' instead of registration. For this reason, while standard cars are referred to as 'registered vehicles', K cars are referred to as 'notified vehicles'.

2.2.6 Roadworthiness inspection

The requirements for periodic roadworthiness inspection are determined on the basis of the vehicle's category in the Road Transportation Vehicle Act. Therefore:

- Micro-mobility type-approved (designated) vehicles and certified scheme vehicles require periodic roadworthiness inspection as for K cars (and regular passenger cars), with first inspection at 3 years and every 2 years thereafter.
- Class 1 motorised bicycle (mini-car) vehicles do not require roadworthiness inspection as they belong to the 'Class 1 motorised bicycle (mini-car)' category.

2.2.7 Tax and insurance

According to the category of mini-cars and micro-mobility in the Road Transportation Vehicle Act, the vehicle tax and compulsory liability insurance for mini-cars are the same as the 'Class 1 motorised bicycle (mini-car)' category, while those for micro-mobility (type-approved/certified scheme) are the same as for K car category (Table 2.7).

Table 2.7 Tax and insurance of micro-mobility

	Mini-car (Class 1 motorised bicycle)	Micro-mobility (K car)	Small car (personal use) (Engine disp.: 1.0–1.5 L)
Motor vehicle tax (every year)	¥3,700 (≈ NZ$45)	¥10,800 (≈ NZ$131)	¥30,500 (≈ NZ$370) (1.0–1.5 L)
Motor vehicle weight tax (every year)[a]	¥0	¥3,300 (≈ NZ$40)	¥8,200 (≈ NZ$100) (< 1 ton) ¥12,300 (≈ NZ$149) (1–1.5 ton) (¥4,100 (≈ NZ$50) per 0.5 ton)
Motor vehicle tax (environmental excise) (at the time of vehicle acquisition)	¥0	EV, plug-in hybrid vehicle: ¥0 Other vehicles: 0–2% of the acquisition price, depending on the degree of achievement of fuel efficiency against the fuel efficiency standards in FY2030	EV, plug-in hybrid vehicle, clean diesel car: ¥0 Other vehicles: 0–3% of the acquisition price, depending on the degree of achievement of fuel efficiency against the fuel efficiency standards in FY2030
Compulsory automobile liability insurance (for 36-month contract)	¥10,590 (≈ NZ$130)	¥26,760 (≈ NZ$325)	¥27,180 (≈ NZ$330)

[a] For electric micro-mobility vehicles, the motor vehicle weight tax is reduced to zero until the vehicle's second roadworthiness inspection, which is when it is five years old.

2.3 USA

In the USA, equivalent vehicles to quadricycles in Europe and micro-mobility in Japan are classified as low-speed vehicles (LSVs). Electric versions of LSV are also known as neighbourhood electric vehicles (NEVs).

An LSV is defined as a four-wheeled motor vehicle, other than an ATV, that is capable of reaching speeds of at least 20 mph (ca. 32 km/h) but not greater than 25 mph (ca. 40 km/h), has a gross vehicle weight rating of less than 3,000 pounds (ca. 1,361 kg), and meets the safety standards in Title 49 of the US Code of Federal Regulations, § 571.500. These standards include requirements for:

- maximum speed 25 mph (ca. 40 km/h)
- lighting (headlamps, front and rear turn signal lamps, tail lamps, stop lamps, reflectors)
- mirrors and rear visibility
- parking brake
- windshield that conforms to Federal Motor Vehicle Safety Standard (FMVSS) No. 205
- seat belts (Type 1 or 2) that conform to FMVSS No. 209
- alert sound that conforms to FMVSS No. 141
- vehicle identification number.

The precise rule details vary by state, but in general an LSV may only operate on secondary highways with a posted speed limit of up to 35 mph (ca. 56 km/h) but may cross a highway with posted speed limits over 35 mph at an intersection. An LSV must be registered and licensed with the Department of Motor Vehicles in the appropriate state in the same manner as a passenger vehicle and is subject to the same insurance requirements applicable to other motor vehicles. LSV drivers are required to possess a car driving licence. The minimum age at which this can be obtained varies by state between 16 and 18 years old. Homemade low-speed vehicles, retrofitted golf carts,[24] or any other similar vehicles do not qualify as LSV.

2.4 Summary and comparison

Table 2.8 provides a comparative overview of the main regulation and enforcement aspects concerning four-wheeled lightweight EVs in Europe, Japan and the USA. Note that for some aspects differences exist between vehicle sub-categories. In order to limit the complexity of this overview, the table shows the values for the sub-categories considered most ‘car-like’ (eg, those featuring an enclosed occupant compartment). More detail can be found in the preceding report sections. Points to note include the following.

- Japan, for its type-approved micro-mobility category, is the only region that has safety standards along the lines of those required for passenger cars, including requirements for crashworthiness and VRU impact protection. The level of these standards, together with the fact that major vehicle manufacturers such as Toyota make these vehicles, suggests that it is possible to enforce requirements for crashworthiness and VRU impact protection without making these micro-mobility vehicles as heavy, inefficient, and expensive as a standard passenger car and hence negating the advantages of them.
- It is interesting to note the different ways in which Europe, Japan and the USA choose to regulate and enforce the different safety aspects, both in terms of focus and amount for each aspect – the main aspects being the vehicle categorisation (size, mass, power, max. speed and seating capacity), safety standards, and usage restrictions in terms of roads that can be driven on.
- The USA regulates four-wheeled lightweight EVs far less than either Europe or Japan, with the main restrictions covering only their gross mass, top speed, and the roads on which they can be driven. As for all other regions, the USA has requirements for lighting, fitment of seat belts, registration, insurance and driver licensing. Interestingly, for pedestrians it does require fitment of an acoustic alert, which is not required in other regions with the exception of Japan for larger micro-mobility categories. Also, the limitation for top speed is the most restrictive (lowest) compared to other regions, which may to some extent, combined with usage restrictions, help to compensate for other aspects where requirements are lower.
- Europe, for its heavy quadricycles (L7e) category, is the only region that does not restrict usage on higher-speed roads (motorways/expressways).

[24] Note that the maximum speed of golf carts is 20 mph (ca. 32 km/h).

Table 2.8 Regulation and enforcement – comparative overview

	Europe (EU-wide)		Japan			USA
	Light quadricycle (L6e)	Heavy quadricycle (L7e)	Micro-mobility (type-approved)	Micro-mobility (scheme)	Mini-car	LSV
Vehicle categorisation						
Dimensions (L × W × H)	3.0 × 1.5 × 2.5 m	3.7 × 1.5 × 2.5 m	2.5 × 1.3 × 2.0 m	3.4 × 1.48 × 2.0 m	2.5 × 1.3 × 2.0 m	N/A
Max. mass	425 kg (incl. driver, excl. batteries)	450 kg (incl. driver, excl. batteries)	N/A	N/A	N/A	1,361 kg (gross weight)
Max. continuous power[a]	6 kW	15 kW	N/A	N/A	N/A	N/A
Rated power output[b]	N/A	N/A	> 0.6 kW, < 8 kW	< 8 kW	≤ 0.6 kW	N/A
Max. speed	45 km/h	90 km/h	60 km/h	Scheme dependent	60 km/h	40 km/h
Max. no. of seats	2	2–4	4	2	1	N/A
Safety standards						
Occupant protection	Safety belts	Safety belts	Safety belts and energy absorbing steering mechanism (UN ECE R16, R12)	Safety belts	Safety belts	Safety belts
Crashworthiness (tests)	None	None	Front, side and rear impact	Scheme dependent	None	None
VRU protection	External projections	External projections	Impact protection (UN ECE R127) Avoidance: AEBS and acoustic alert	Acoustic alert	None	Acoustic alert
Registration and taxation						
Registration required	yes (except Germany)	yes	yes	yes	yes	yes
Insurance required	yes	yes	yes	yes	yes	yes
Taxed	no (except France)	no (except France)	yes	yes	yes	yes

	Europe (EU-wide)		Japan			USA
	Light quadricycle (L6e)	Heavy quadricycle (L7e)	Micro-mobility (type-approved)	Micro-mobility (scheme)	Mini-car	LSV
Usage restrictions						
Motorways	not allowed (except UK)	allowed	not allowed	not allowed	not allowed	not allowed
Expressways/motor roads	not allowed (except UK)	allowed	not allowed	not allowed	not allowed	not allowed
Driver licensing						
Driving licence	required	required	required	required	required	required
Min. age	14–16 (country dependent)	16–17 (country dependent)	18	18	18	16–18 (state dependent)
Roadworthiness inspection						
Periodic test	not required (except UK)	required (except France)	required	required	not required	not required

[a] Maximum continuous power is measured according to UN Regulation No. 85 – Rev. 1; Regulation (EU) No 168/2013; the vehicle's maximum continuous power output for 30 minutes is measured.

[b] Rated power output is measured according to TRIAS 99-017-02 (based on JIS C 4034-1, IEC 60034-1); power output is measured over 1 hour of normal use of the vehicle. A rated power output value of 8 kW is equivalent to a max. continuous power of approximately 15 kW.

3 Number of quadricycles (current and future) and benefits/costs

3.1 Literature review

A literature review of national and local government policy, including environmental drivers and targets, and manufacturer announcements on expected production and sales targets, was performed to gather information on potential influencing factors and expectations for the future uptake of quadricycles. The literature review was conducted by searching science databases including Science Direct, Transport Research International Documentation, and Google Scholar. In addition to academic sources, news sources were identified for information related to manufacturing announcements and market trends related to quadricycles. Key search terms were selected based on their relevance to the study. Search terms used include ‘quadricycle’, ‘L-category vehicle’, ‘powered light vehicle’, ‘L6e’, ‘L7e’, ‘microcar’, ‘benefit’, ‘cost’, ‘uptake’, and ‘registration numbers’. The search terms were tested to determine which ones returned the most relevant results. Identified sources were reviewed for relevance to the literature review. Identified information was collected and organised by source into tables in Appendix A, which provide additional detail to the summarised information below. Twenty-nine sources were identified and their content reviewed for inclusion in this report.

3.1.1 Benefits

L6e and L7e category vehicles have numerous benefits. They can:

- provide environmental and energy benefits
- improve accessibility for older people and people living with disabilities
- provide last mile connectivity
- provide better quality of service and increased coverage when compared to public transit, especially in areas with low density.

3.1.1.1 Environmental and energy benefits

The L-category vehicle sector has many EVs (Hutchinson, 2018). In 2021, 100% of new L6e-category vehicles and 19% of new L7e-category vehicles registered in the UK were electric (Department for Transport, 2022a). Some authors claim that small electric vehicles (SEVs), by the very nature of being carbon neutral or zero emission, support climate protection (Ewert et al., 2022). L6e-category vehicles such as the Citroën Ami (launched in the UK in 2022) are fully electric. The Ami can travel up to 80 km on a 3.5-hour charge. Greater travel distances on shorter charge cycles promote the independence and reliability of quadricycle use.

In a report by the Low Carbon Vehicle Partnership (Davies & Nieuwenhuis, 2018), the authors posit that for L-category vehicles, the primary objective with regard to air quality has to be to maintain or reduce the contribution of these vehicles to greenhouse gas (GHG) emissions from road transport comparative to vehicles in other categories. Thus, under this paradigm, the shift from M_1-category vehicles (passenger cars) to L-category vehicles presents a net benefit or at least is climate neutral. Other authors, however, consider the GHG emission benefits in a more scientific way, showing that conventionally sized EVs consume more energy and occupy more space than is needed for the kind of trips they are often used to make. Such trips can be easily done with vehicles of a reduced size and weight and consume significantly less energy (Honey et al., 2014).

It is advantageous to use SEVs as they present a form of mobility that is accessible, affordable and efficient. They are a clean transportation mode that promotes good quality air and reduced noise pollution (Department for Transport, 2022a). L-category vehicles also use significantly less energy in the use phase of their life cycle. This can be accounted for by their lower vehicle mass compared to conventional vehicles (Hutchinson, 2018). A study into the influence of microcars on the traffic network determined that an increase in the proportion of microcars at speeds of 40 to 45 km/h on arterial roads resulted in higher fuel efficiency and lower emissions. These vehicles have a lower power requirement at the suggested speeds (Mu & Yamamoto, 2013).

L-category vehicles are made using lightweight and often recyclable materials, although there are currently no legal requirements for recyclability of L-category vehicles in Europe. Additionally, the process used to make L-category vehicles is simple. This is because the market is dominated by small young companies, the use of new materials provides for different production methods, and the moral imperative to recycle calls for the process of disassembling vehicles to be simple (Hutchinson, 2018). L-category vehicles are often small in relation to conventional vehicles. Their small size provides for easier manoeuvrability, particularly in large cities, which often experience congestion (Karaca et al., 2018). Vehicles such as the microcar from Citroën are marketed as ‘agile and compact’. They are touted as being well suited to navigate busy streets with limited parking spaces (GreenFleet, 2021).

Private vehicles are often parked, and thus parking spaces account for a large area, especially in cities where land is often scarce (Honey et al., 2014). Transport infrastructure takes up a large portion of the total area, particularly in cities. With rising populations in cities, there is pressure on land availability (Ewert et al., 2022). Microcars such as those in the L6e and L7e category are often shorter and narrower and retain their manoeuvrability in traffic jams. SEVs present a viable solution to reduce the land use pressure in cities as they require fewer parking spaces compared to conventional vehicles. In the case of powered two-wheelers, five can occupy the same parking space as one conventionally sized vehicle. Increased adoption of L-category vehicles would reduce the pressure and burden of land use caused by the need for parking by stabilising the requirement for additional parking spaces (Santucci et al., 2016). It should be noted that infrastructure may have to adapt to maximise these benefits, such as reducing the size of parking spaces.

In highly motorised countries such as Japan and the USA, the occupancy of conventional cars has dropped. On average in the USA it was 1.38 person-kilometre per vehicle-kilometre, while in Japan it was 1.39 person-kilometre per vehicle-kilometre in 2009. On average, car occupancy is estimated at less than 2. Given the low occupancy of conventional cars, the introduction of microcars into the traffic flow would reduce congestion without affecting occupancy. As conventional cars typically have a capacity of up to 5 occupants and an actual occupancy of 2 or less, the introduction of microcars with a smaller physical body could help to improve congestion (Tanveer et al., 2022). It should be noted that the shift from conventional cars to microcars is not without its hurdles. For there to be widespread adoption, these vehicles need to prove that they are reliable, attractive, and cost effective to the consumer.

3.1.1.2 Improving accessibility for older people and people living with disabilities

Compared to other European countries, France has a relatively well-developed lightweight vehicle segment. In the past, ‘light’ and ‘heavy’ quadricycles could be driven in France without a licence, when their top speed was limited to 45 km/h. Older people were drawn to this vehicle category because of the lack of licence requirement. These vehicles allowed for older people to retain a sense of independence and mobility even in their later years. France has now enacted a licensing requirement where people born after 1 January 1988 are required to acquire a licence after 7 hours of driver training under an approved driving school (Hutchinson, 2018). As mentioned in section 2.2.1 above, MLIT is considering micro-mobility vehicles as part of a potential solution to improve accessibility for older people. Microcars offer accessibility benefits for older people and people living with disabilities (Tanveer et al., 2022).

3.1.1.3 Providing last mile connectivity

Microcars are well suited for short and medium distance trips due to their light weight and manoeuvrability, particularly in urban centres. In the commercial sector, powered light vehicles can provide last mile connection for deliveries. These trips are typically done by carbon fuel powered vehicles like vans (Hutchinson, 2018).

3.1.1.4 Providing better quality of service and increased coverage when compared to public transit, especially in areas with low density

Many urban centres have taken a car-centric approach in the development of transportation systems. This has led to negative impacts on personal mobility, particularly walking, cycling and mobility of people living with a disability. Large urban sprawl of many cities, particularly in the USA, limits walking and cycling (Honey et al., 2014). The use of L6e and L7e category vehicles can bridge this gap by providing personal mobility. Microcars offer improved quality of service compared to public transport for people living in areas with poor or irregular public transport service (Tanveer et al., 2022).

3.1.2 Costs

While many benefits exist with L-category vehicles, one must also reflect on their associated costs. These include:

- crash safety concerns of L-category vehicles
- manufacturing challenges and selling price of L-category vehicles.

3.1.2.1 Safety concerns of L-category vehicles

In contrast to M-category vehicles, EU regulations do not currently cover crashworthiness of L-category vehicles and do not require active safety systems to reduce the likelihood of collisions. Regulations in place only cover functional safety (Bastien & Davies, 2018). In a literature review of crash data of microcars, Rui and Yamamoto (n.d.) concluded that reviews which analyse the historical statistical USA crash data showed that vehicles of a smaller size reduce the crash rate. Additionally, medium-sized vehicles were found to have the highest crash rate. However, smaller vehicles were found to increase the occupant rate of fatality or risk of injury due to their build (ie, smaller size and lighter weight). In contrast, for pedestrians, Honey et al. (2014) stated that a benefit of microcars was their ‘decreased aggressiveness in the event of a crash, particularly with pedestrians, due to the weight reduction’ (p. 142). It should be noted that in theory the lower mass ratio between a microcar and a pedestrian compared to a conventional car and a pedestrian should offer some benefit to the pedestrian, but this is likely to be very small unless the microcar–pedestrian mass ratio is small, say microcar 2 or 3 times the mass of the pedestrian. Furthermore, in practice other factors such as the vehicle stiffness and impact kinematics will also have a substantial effect on the pedestrian’s injury risk, which could negate and possibly reverse any mass ratio benefit.

3.1.2.2 Manufacturing challenges and selling price of L-category vehicles

Many L-category manufacturers are small. They lack adequate funds and large-scale operations for development. This could be mitigated by the entry of larger manufacturers into the sector (Hutchinson, 2018). Manufacturers face significantly higher costs for small series runs compared to mass production. When discussing the price of SEVs, it bears distinguishing the difference in the vehicle types. SEVs can appear to be more expensive compared to e-scooters, bicycles, and cars from the second-hand market (Benders et al., 2022). The Twizy 45 from Renault, for example, costs €7,450 (≈ NZ$13,400), and the Twizy 80 costs €8,240 (≈ NZ$14,800). This cost varies based by the country of sale. Purchase bonuses for acquiring EVs exist in some countries, directly impacting the purchase price and purchase decision (Renault

Group, 2020). An electric quadricycle launched in the UK called the ‘me’ costs £11,499 (≈ NZ$23,478; Adams, 2020). The purchase price of SEVs can negatively affect a consumer’s decision to purchase (Benders et al., 2022).

For SEVs to have wider market appeal, an attractive price is needed. Here enters the dilemma faced by manufacturers. For example, to offer a vehicle with higher safety standards that is safer and of a higher quality, the cost needs to be reflected. SEVs carry fewer people and luggage and appear as more expensive. Despite this, compared to new battery electric cars, SEVs are still relatively cheaper. However, this may not be the case when compared to cars with internal combustion engines, which are still available for purchase, although their future phase out has been legislated for in some countries and is being debated in others. Currently, the pricing schemes are not favourable for SEVs in numerous countries. Some of the challenges faced by SEVs include high speed limits within city limits, limited advantages in fewer lanes or parking, lack of incentives and few models available in the market (Benders et al., 2022).

3.1.3 Influencing factors for future uptake of quadricycles

There are several factors that affect the future uptake of quadricycles, which indicate or affect their future uptake. Four key areas were identified as impacting the future uptake of quadricycles:

- manufacturing trends
- government policy – EU policy
- consumer and market trends
- lobby action.

3.1.3.1 Manufacturing trends

There are promising manufacturing trends in the microcar space. News reports indicate that Kia planned to launch an electric quadricycle/microcar in partnership with Arrival, a UK-based start-up working in the commercial EV space. This launch would involve offering a microcar similar to the Citroën Ami (Natarajan, 2021). In addition, the Citroën family, which includes the Ami, expanded with the company head indicating that there would be additional microcar models released in the future (Natarajan, 2022). In 2019, a UK-based start-up was reported to have launched a small range of electric quadricycles with a 93-mile (ca. 150 km) range and a top speed of 48 mph (ca. 77 km/h; Holding, 2019). These positive reports bode well for the future supply of L-category vehicles.

In 2019, there were reports that Daimler would do away with their microcar because it was not profitable at the time. They reported a drop in sales in previous years, particularly in the USA where only 1,276 sales of Smart were reported in 2018. Sales in Europe were better, where 97,346 vehicles were sold despite targets of 200,000 (Gauthier, 2019). In 2019, Geely, a Chinese automotive manufacturer, acquired a 50% stake in the Smart City Car brand from Daimler (Wilkinson, 2020). Together, Daimler and Geely formed a joint venture with the intent to become a leader in small urban vehicle manufacturing. Assembly of new models of the Smart vehicle was scheduled to begin in 2022 (Liu et al., 2019). This is despite speculation that the line would be scrapped and manufacture of this vehicle cease due to low sales.

In the passenger car market, it can be seen that some small vehicle models are being taken out of production. This can be explained by factors such as cost sensitivity, emissions, and safety regulations. These should also be considered in establishing regulations for L-category vehicles.

3.1.3.2 Government policy – EU policy

Government regulation of L-category vehicles is a patchwork and not uniform from country to country. There is a variation of vehicle types that can be found in different regions based on the prevailing regulations. The

EU has established regulations on the classification of vehicles into the various sub-categories of the L-category based on size and weight. Despite this, there still exists a large disparity in the regulation of L-category vehicles compared to those in the M_1 category. There is a lack of evidence on which to base policy. Additionally, there is limited accident data related to L-category vehicles (Davies & Nieuwenhuis, 2018). This presents a challenge to formulate a uniform approach to regulating vehicles in this category.

Some progress has been made on this challenge in terms of crashworthiness standards for L-category vehicles in the EU. Despite the lack of accident data, Davies and Bastien (2021) have proposed an approach to assess the crashworthiness of smaller and lighter vehicles based on an understanding of the current M_1 category vehicle crash test requirements and fundamental parameters that control a vehicle's crashworthiness performance, such as vehicle compartment strength. The approach proposed a focus on the assessment of the vehicle's structural performance capability on the basis that occupant compartment integrity (ie, maintaining survival space) is crucial for occupant protection. The assessment could be made using an appropriate Mobile Deformable Barrier test.

To help mitigate climate change, the UK government has legislated a commitment to 'net zero greenhouse gas emission by 2050'. To meet this commitment requires decarbonising the transport sector within the UK. To help achieve this, the government has proposed to end sales of new non-zero emission vehicles in the L6e and L7e category by 2030. This gradual phase out of non-zero emission vehicles in the L-category is set to shape the future of these vehicles. Manufacturers will have to plan their production runs accordingly and prepare for this transition as is already the case for M_1 vehicles.

Comparatively, in the EU, the European Commission has adopted ambitious targets of cutting carbon emissions by 55% by 2030. Achieving this target will also require an increase in the use of EVs (European Commission, 2020a). It should be noted that while quadricycles may fit well with this ambition and planning, they are not explicitly mentioned in the EU programme.

3.1.3.3 Consumer and market trends

Electric L7e vehicles accounted for 'over 18.58% of UK market sales of L7e category vehicles in 2021' (Department for Transport, 2022a, p. 18). It is expected that there will be a launch of 'a wide range of new electric quadricycles into the UK market, highlighting this technology is already available, affordable and practical' (p. 18).

3.1.3.4 Lobby action

The USA demonstrated a possible model for pushing for L-category vehicles and other vehicles for environmental optimisation. Grassroots action of various communities pressured regulators to accommodate EVs even though they fell out of existing legislation. Residents of Palm Desert, California, were able to successfully lobby to have golf carts permitted on certain roads despite there being limitations in place for where golf carts could be used (ie, on roads with no more than 26 mph (ca. 42 km/h) speed limits within 1.6 miles (ca. 2.6 km) of a golf course) (Davies & Nieuwenhuis, 2018).

3.1.4 Discussion and summary

In the context of the growing climate crisis and increased awareness of the need for clean and sustainable mobility, electric quadricycles may be a promising mobility solution. Sustainable transport modes and multi-modal solutions will also need to be integrated into clean mobility solutions (European Commission, 2020b). Electric L6e and L7e vehicles fit well with this ambition, as they promote public transport use and last mile connectivity. Japan is considering the use of quadricycles as part of the efforts to decarbonise transport and promote mobility of older people and people living with disabilities. The UK is planning on transitioning all quadricycles for road use to zero emission in the coming years.

The safety of quadricycles is under debate. Existing European regulations do not cover the crash safety and safety features of quadricycles as they do for conventional vehicles, and the requirements set out for aspects covered by regulation, such as brake performance, are often less stringent. With an increase in use and demand for quadricycles, such regulations may need to be introduced in the future. Due to their lightweight build and relatively small size, valid concerns exist on the crash safety of these vehicles. Note that this review has identified no indication of imminent plans to strengthen European quadricycle safety regulation.

Some manufacturers have released promising quadricycle production reports, and new microcar models are entering the market, indicating that manufacturers recognise the economic potential of these vehicles. However, other manufacturers are reported to have pulled out of this market because it was not profitable. Ultimately, consumer and market trends coupled with legislative and regulatory frameworks will shape the quadricycle markets. Note that this review has identified no specific European policies to actively expand the uptake of quadricycles.

3.2 Identification of quadricycles by make/model in the UK

A list of makes and models of quadricycles in the UK was identified (see Appendix B). This was required to enable analysis of the registration and collision data for the UK because neither of these data sets have specific identifiers for quadricycles. Therefore, it was necessary to identify them by make (manufacturer) and model. The steps taken to develop the list were as follows:

1. A list of quadricycle (L6e and L7e) makes and models in Germany published by the Kraftfahrt-Bundesamt (2022) was identified and retrieved.
2. Vehicle licensing (registration) statistics data by vehicle make/model from the Department for Transport (2022b) were identified and retrieved.
3. As a first filter, the German quadricycle list was matched to the UK licensing data in order to identify quadricycle makes and models in the UK fleet.
4. As a second filter, expert review of the UK licensing data make and model list was used to identify remaining quadricycles by, for example, identifying manufacturers (makes) that produce mainly quadricycles (REVA, AIXAM, Microcar and LIGIER) and specific known quadricycle makes/models (Citroën Ami) and including appropriate makes/models.

While performing step 4, it was noticed that there were many vehicle models described as ‘quad’ or ‘quad bike’ that were not quadricycles but mostly ATVs. A list of makes/models to identify this category of vehicles called ‘quads’ was also developed (see Appendix B).

In the list of quadricycle makes and models, 169 models were identified from 12 manufacturers. In comparison, for ‘quads’ 132 models were identified from 34 manufacturers.

3.3 Vehicle registration data analyses

3.3.1 UK

In the UK, a motor vehicle is required to be registered in order to use it on a public road. A registered vehicle is issued with an identification (number) plate, associated with a vehicle keeper (legal owner), and entered onto the Driver and Vehicle Licensing Agency (DVLA) registration database. The vehicle keeper is responsible for ensuring that annual road tax associated with the vehicle is paid and that the vehicle is insured and has a valid MOT (roadworthiness certificate) if appropriate. These vehicles are identified in the

DVLA registration database as 'licensed' vehicles. If a vehicle keeper does not wish to use a vehicle on a public road for a period of time and intends to keep it off the public road – for example, on a driveway, in a garage or on private land – they can make a Statutory Off-Road Notification (SORN). Vehicle keepers may choose to do this because, for example, they do not wish to insure the vehicle and/or pay road tax or they wish to salvage parts from it before it is scrapped. These vehicles are identified in the DVLA registration database as 'SORN' vehicles. To be removed from the registration database, a vehicle has to be scrapped or exported. Vehicles can only be scrapped at an authorised treatment facility that will inform the DVLA that it has been scrapped. If a vehicle is exported, the vehicle keeper should also inform the DVLA.

The vehicle licensing (registration) statistics data by vehicle make/model from the Department for Transport was interrogated, using the lists generated as described in section 3.2 above, to identify the number of registered quadricycles and quads in the UK.

Figure 3.1 shows the number of registered quadricycles, licensed and SORN, by quarter from 2014 to 2022. The data suggests that at the end of 2022 quarter 3, a total of 6,674 quadricycles were registered, consisting of 3,342 licensed vehicles and 3,332 SORN quadricycles.[25] The chart also shows that from 2014 to 2022 the total number of registered quadricycles has remained relatively constant, but the number of quadricycles licensed for use on the road has fallen by about 40%, with many quadricycles registered as off the road (ie, SORN).

Note that the average number of licensed quadricycles (3,994) over the period from 2014 quarter 3 to 2021 quarter 4 was calculated for use in the collision analysis in section 4.1 for the purpose of estimating the KSI casualty rate per licensed vehicle.

Figure 3.1 Number of registered quadricycles in the UK, from 2014 quarter 3 to 2022 quarter 3

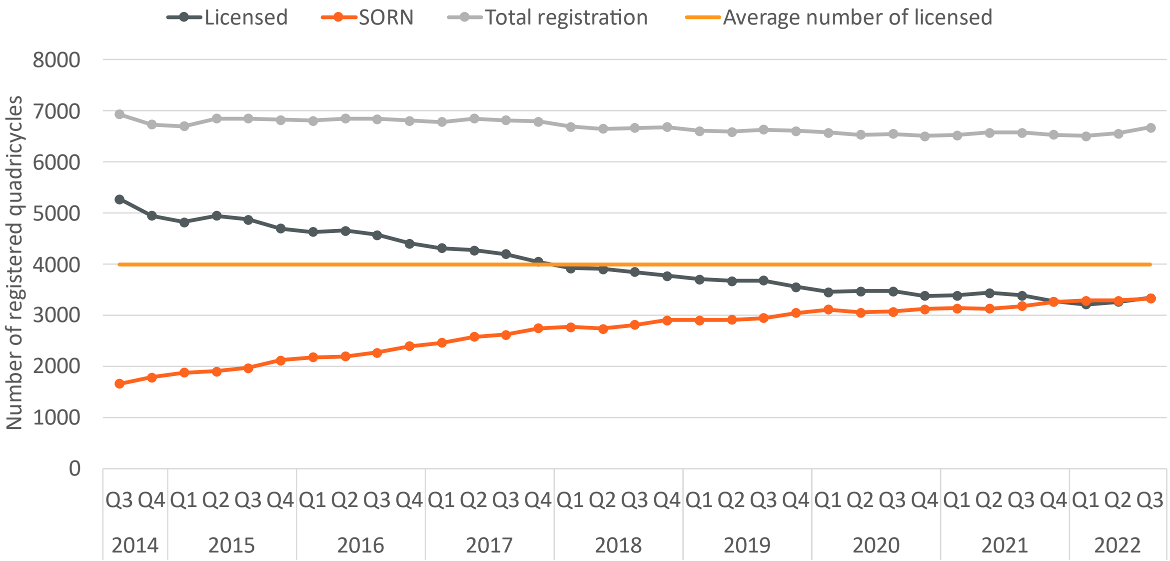
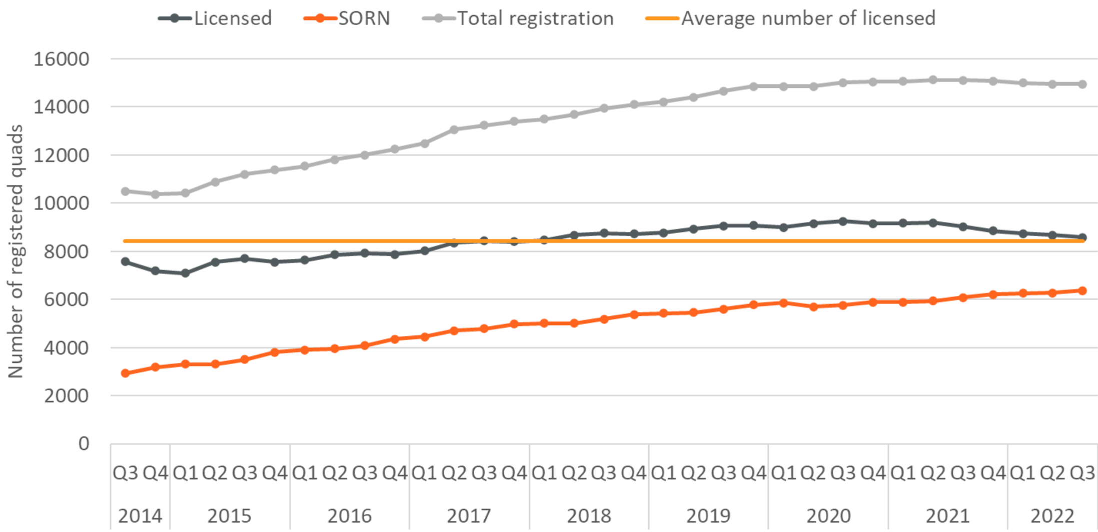


Figure 3.2 shows the number of registered quads, licensed and SORN, by quarter from 2014 quarter 3 to quarter 3 2022. In 2022 quarter 3, there were 14,955 quads registered, consisting of 8,582 licensed and

[25] Because the number of quadricycles in the UK vehicle fleet appeared very low in comparison to Germany (~6,384 cf. 102,016) a sanity check was performed. This was to calculate the number of Ford Fiestas (Britain's favourite car) in the vehicle fleet using the same data set used to calculate the number of quadricycles. The numbers we found were 1.46 million licensed and 1.55 million registered Fiestas. This was found to agree with the number of 1.5 million quoted by other sources such as Statista (2023) and Fleet World (Middleton, 2023).

6,373 SORN quads. Note that in a similar manner as for quadricycles, the average number of licensed quads (8,440) over the period from 2014 quarter 3 to 2021 quarter 4 was calculated for use in the collision analysis in section 4.1 for the purpose of estimating the KSI casualty rate per licensed vehicle.

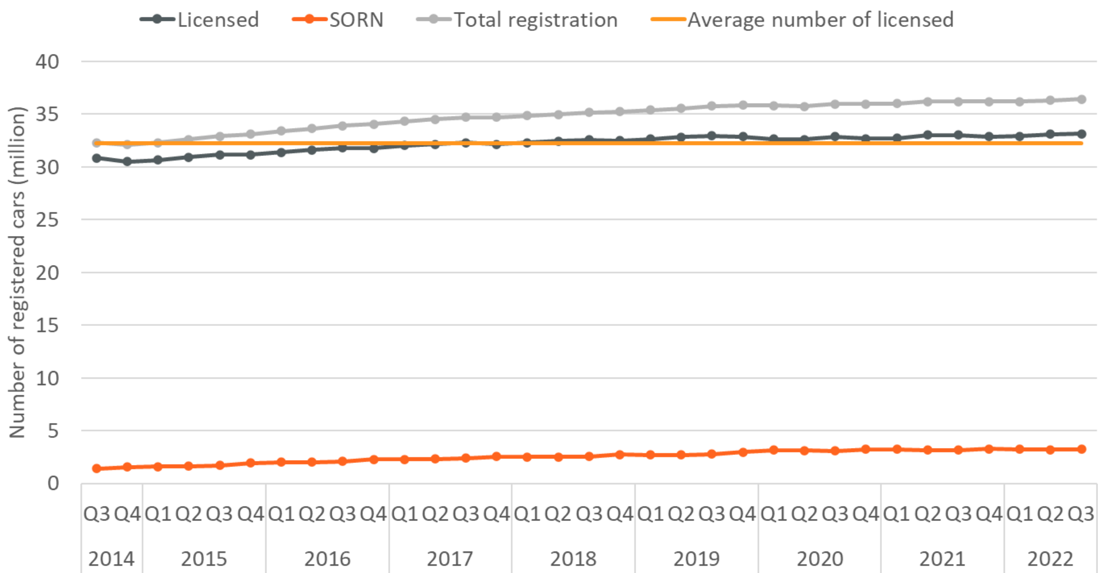
Figure 3.2 Number of registered quads in the UK, from 2014 quarter 3 to 2022 quarter 3



The chart also shows that the number of registered quads has risen by about 40% from 2014 to 2022, but that increase is mainly made up of SORN quads, which should not be used on public roads.

Figure 3.3 shows the number of registered cars, licensed and SORN, by quarter from 2014 to 2022. Note that the average number of licensed cars over the period from 2014 to the end of 2021 was calculated for use in the subsequent collision analysis. The value calculated was 32.2 million licensed cars per year on average. It should be noted that some quadricycle models were also classified into 'car' in the registration data, meaning the figure includes some quadricycles. However, because the number of quadricycles was very small compared to the number of cars, it should not affect the estimation of the collision analysis much.

Figure 3.3 Number of registered cars in the UK, from 2014 quarter 3 to 2022 quarter 3



3.3.2 Germany

Vehicle numbers for Germany are collated and published by the Kraftfahrt-Bundesamt.[26] The published data sets aggregate L6e and L7e quadricycles into the category *Leichtes vierrädriges Kraftfahrzeug*. Table 3.1 provides numbers for new vehicles entering the fleet and total fleet size for the last 10 years. The numbers are visualised in Figure 3.4 and Figure 3.5.

Note:

- Separate numbers for light and heavy quadricycles are not published.
- The numbers include both vehicles with an electric drivetrain and those with an internal combustion engine.
- The numbers include both car-like vehicles with occupant compartment and those with straddle seating and handlebar steering.

Table 3.1 Number of quadricycles (L6e and L7e) in Germany, by year, new vehicles entering fleet (throughout given year) and total fleet size (on 1 January of given year), 2012–2022

Year	New L6e/L7e vehicles[a]	Fleet size L6e/L7e[b]
2012	11,659	111,974
2013	7,926	116,339
2014	6,871	117,066
2015	6,462	117,856
2016	7,114	118,325
2017	3,011	118,054
2018	1,995	116,582
2019	1,355	113,374
2020	1,228	109,274
2021	892	105,760
2022	*not yet published*	102,016

[a] Source: Kraftfahrt-Bundesamt, Report FZ 26 for given year: https://www.kba.de/DE/Statistik/Produktkatalog/produkte/Fahrzeuge/fz26_n_uebersicht.html

[b] Source: Kraftfahrt-Bundesamt, Report FZ 25 for given year: https://www.kba.de/DE/Statistik/Produktkatalog/produkte/Fahrzeuge/fz25_b_uebersicht.html

[26] Kraftfahrt-Bundesamt website: https://www.kba.de/

Figure 3.4 Number of new L6e/L7e vehicles entering German fleet, 2012–2021

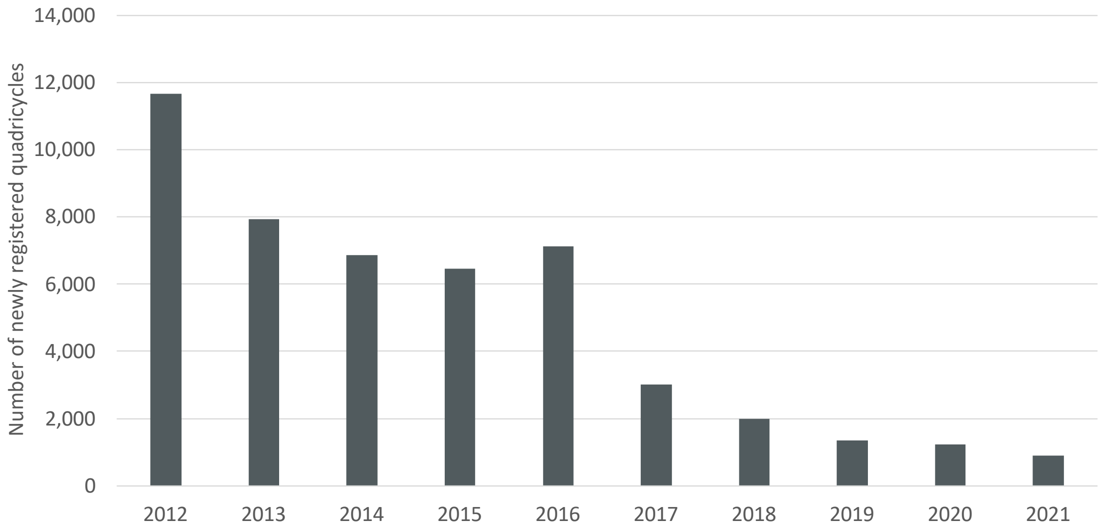
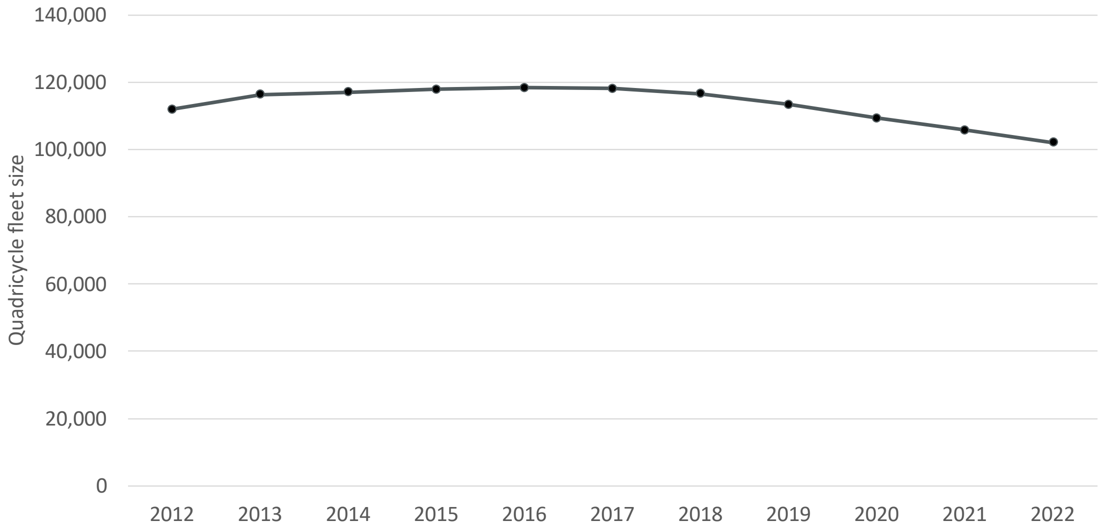


Figure 3.5 Total fleet size of L6e/L7e vehicles in Germany, 2012–2022



3.3.3 France

Vehicle numbers for France are collated in a database called *Répertoire statistique des véhicules routiers* with data coming from the *Système d'immatriculation des véhicules* of the *Ministère de l'Intérieur*. The database is not publicly accessible, and the numbers published by the interior department do not allow disaggregating quadricycles from two- or three-wheelers and are therefore not useful for the present study.

The *Ministère de la Transition écologique*, however, published relevant numbers on new *voiturettes* entering the fleet, which were last updated in 2020 (Table 3.2, Figure 3.6). Voiturettes are car-like L6e vehicles, which feature an occupant compartment and are speed limited to 45 km/h with a maximum power of 4 kWh.

Note:

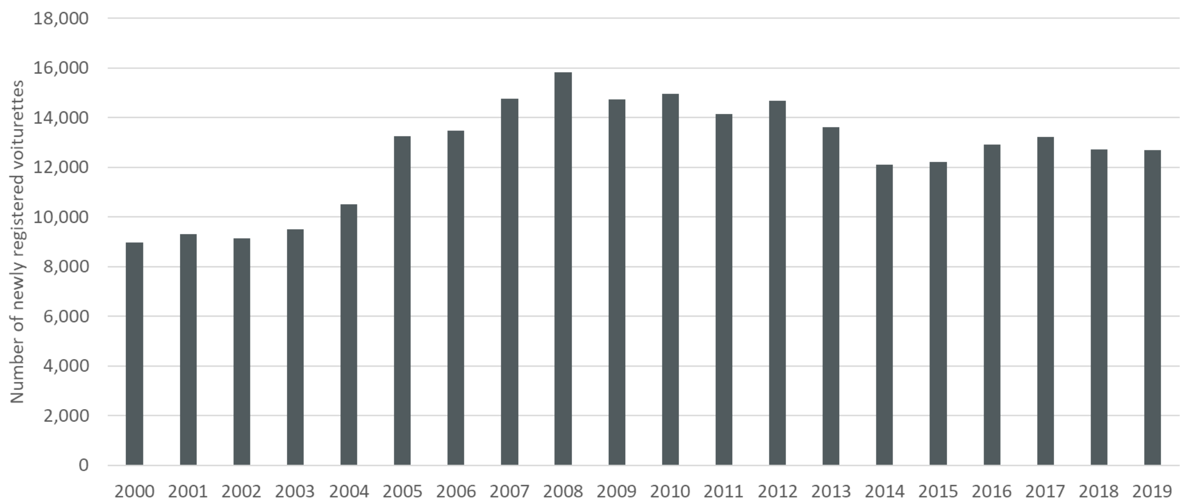
- The numbers include both vehicles with an electric drivetrain and those with an internal combustion engine.
- We requested additional data on fleet size but received no response within the project timescales.

Table 3.2 Number of new voiturettes (car-like L6e vehicles) entering French fleet, 2000–2019

Year	New voiturettes[a]	Year (cont'd)	New voiturettes (cont'd)
2000	8,977	2010	14,943
2001	9,291	2011	14,142
2002	9,147	2012	14,684
2003	9,511	2013	13,603
2004	10,499	2014	12,088
2005	13,247	2015	12,211
2006	13,465	2016	12,899
2007	14,757	2017	13,231
2008	15,821	2018	12,714
2009	14,715	2019	12,689

[a] Ministère de la Transition écologique, Fichier 0.I.F.1: https://www.statistiques.developpement-durable.gouv.fr/donnees-2020-sur-les-immatriculations-des-vehicules

Figure 3.6 Number of new voiturettes (car-like L6e vehicles) entering French fleet, 2000–2019



3.3.4 Discussion and summary

The vehicle registration data analysis covered three European countries: the UK, Germany and France. The numbers identified allowed the following conclusions:

- UK: Fleet size of quadricycles in use (ie, without SORN) showed a declining trend from the beginning of the available data range in 2014, reducing from ca. 5,000 to ca. 3,000 in 2022.
- Germany: Fleet size of L6e/L7e vehicles was relatively stable between the beginning of the data range in 2012 and 2017, with vehicle numbers between ca. 112,000 and 118,000, but showed a declining trend from 2017 with a reduction to ca. 102,000 in 2022. New registrations also dropped sharply from 2017 and fell from a peak of ca. 12,000 in 2012 to ca. 1,000 in 2021.
- France: Total fleet size of relevant vehicles could not be identified from available data. New registrations of car-like L6e vehicles (45 km/h max. speed) rose year-by-year from the year 2000 to a peak of almost 16,000 in 2008; numbers then decreased slightly to ca. 13,000 new registrations in 2019.

- Data between countries was not easily comparable due to reporting differences and gaps in data. It can be observed that the total fleet size can be expected to be largest in France, followed by Germany and then the UK, which had by far the smallest fleet of L6e/L7e vehicles.
- The new registration numbers in France are much higher than in Germany (particularly when considering that the French data only represents a sub-group of L6e vehicles). Also, they were more stable over time, showing only a small reduction during the last decade.
- The European approval requirements for L-category vehicles (Regulation (EU) 168/2013) entered into force in 2016. It could be speculated that this may have contributed to sales declining around that time.
- The sustainability and cost-of-operation benefits of L6e/L7e vehicles compared to passenger cars might be assumed to have led to increasing vehicle numbers in recent years, but none of the data identified would indicate such a trend. Indeed, the opposite trend is seen in the UK and Germany with sharp decreases, while France shows relatively stable numbers over the last decade.

4 Collisions and casualties

4.1 UK

4.1.1 Stats19 collision data

Stats19 is a database of injury collisions for Great Britain reported to and by the police. The police record data including the collision circumstances, the vehicles involved and the resultant casualties. The data is collated by the Department for Transport. Comparisons with death registration statistics show that very few, if any, road accident fatalities are not reported to the police. However, research has shown that a considerable proportion of non-fatal casualties are not known to the police and are therefore not included in Stats19. However, Stats19 is the most complete and reliable source of information on road casualties covering the whole of Great Britain.

From 2016 onwards, figures on the severity of injury have been affected by a large number of police forces changing their reporting systems. It is likely that the recording of injury severity is more accurate for forces using these new reporting systems. This has had a large impact on the number of serious injuries recorded in 2016 onwards compared with 2015. Some of these serious injuries may previously have been classified as slight injuries, which means that serious injury figures for 2016 onwards are not comparable to previous years and to each other. The Department for Transport has calculated adjustment factors for each collision and casualty from 2005, which adjust the severity of each casualty to match the more recent system. These factors were used to give an estimate of the number of casualties or collisions in the analyses reported below.

The vehicle make and model is appended to the vehicle part of the collision data by the Department for Transport based on matching the recorded vehicle registration number with DVLA data on licensed vehicles. This is not available for all vehicles; for example, self-reported collisions or vehicles that failed to stop are unlikely to have this vehicle registration number reported. In this analysis, make and model of quadricycle or quad bike were used to identify related collisions and casualties in the Stats19 database. It should be noted that around 90% of vehicles have make and model recorded, which means that a small percentage of relevant collisions and casualties were not identified for the analysis performed.

4.1.2 Analysis of collisions involving quadricycles

Collisions involving quadricycles for the eight years from 2014 to 2021 were identified for analysis using the quadricycle make/model list developed previously (see section 3.2). Collision-based and casualty-based analyses were performed.

4.1.2.1 Collision-based analysis

Figure 4.1 shows the number of collisions involving quadricycles in the UK from 2014 to 2021 broken down into two categories: pedestrian involved, and pedestrian not involved. It is seen that the total number of collisions involving quadricycles over the period was 123, with 14 of them involving pedestrians. For the years 2020 and 2021, the number of collisions was much lower than for previous years; the most likely reason for this being the COVID-19 pandemic and associated decreased traffic levels.

Figure 4.1 Number of collisions involving quadricycles in the UK, 2014–2021

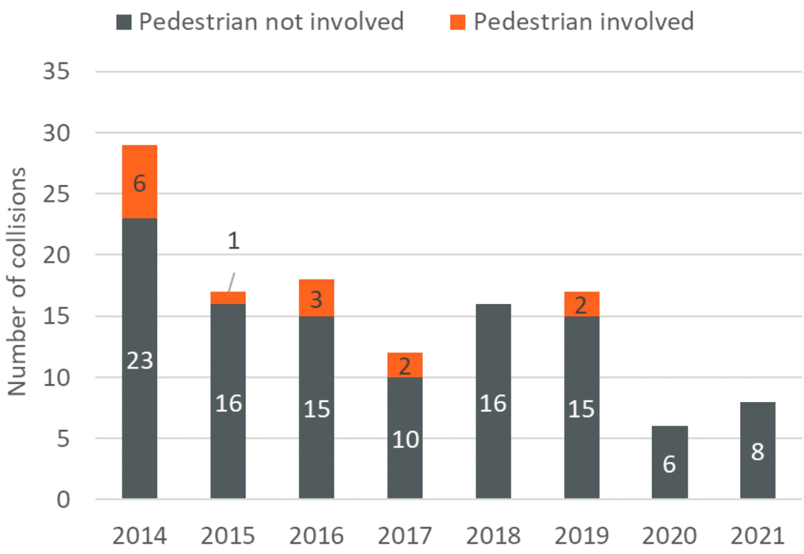
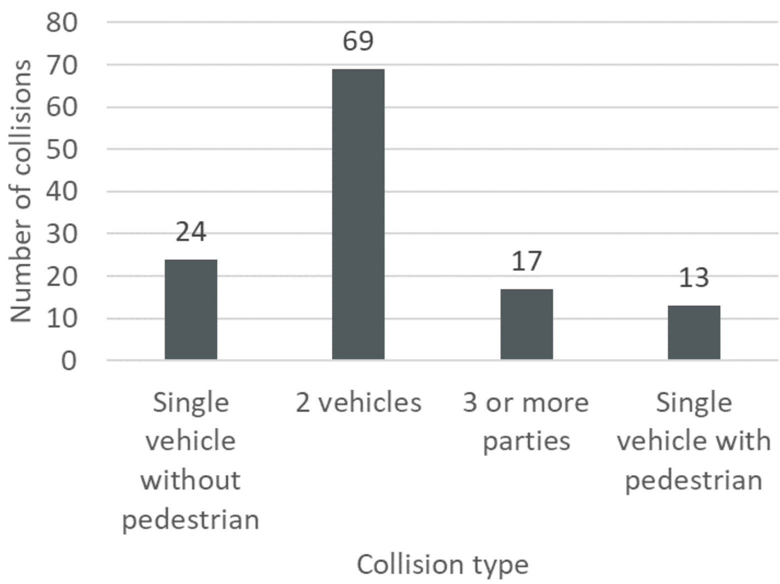


Figure 4.2 shows quadricycle collisions (2014–2021) by collision type: single vehicle without pedestrian, 2-vehicle collision, 3 or more parties, and single vehicle with pedestrian. Two-vehicle collisions are seen to be the most frequent. Note that one pedestrian-involved collision incident involved another party as well as the quadricycle (ie, 3 or more parties).

Figure 4.2 Number of collisions involving quadricycles in the UK, by collision type, 2014–2021



Note that the data analysed does not allow to draw conclusions on the impact of different road types or speed limits on the risk of quadricycle operation.

4.1.2.2 Casualty-based analysis

Figure 4.3 shows the 153 casualties associated with the 123 collisions involving quadricycles broken down by injury severity and pedestrian involvement; 15 in 'pedestrian involved' collisions and the remainder (138) in ‘pedestrian not involved’ collisions. Of the 153 casualties, 103 were quadricycle occupants. These only occurred in ‘pedestrian not involved’ type collisions.

Figure 4.3 Number of casualties in collisions involving quadricycles in the UK, by pedestrian involvement and injury severity, 2014–2021

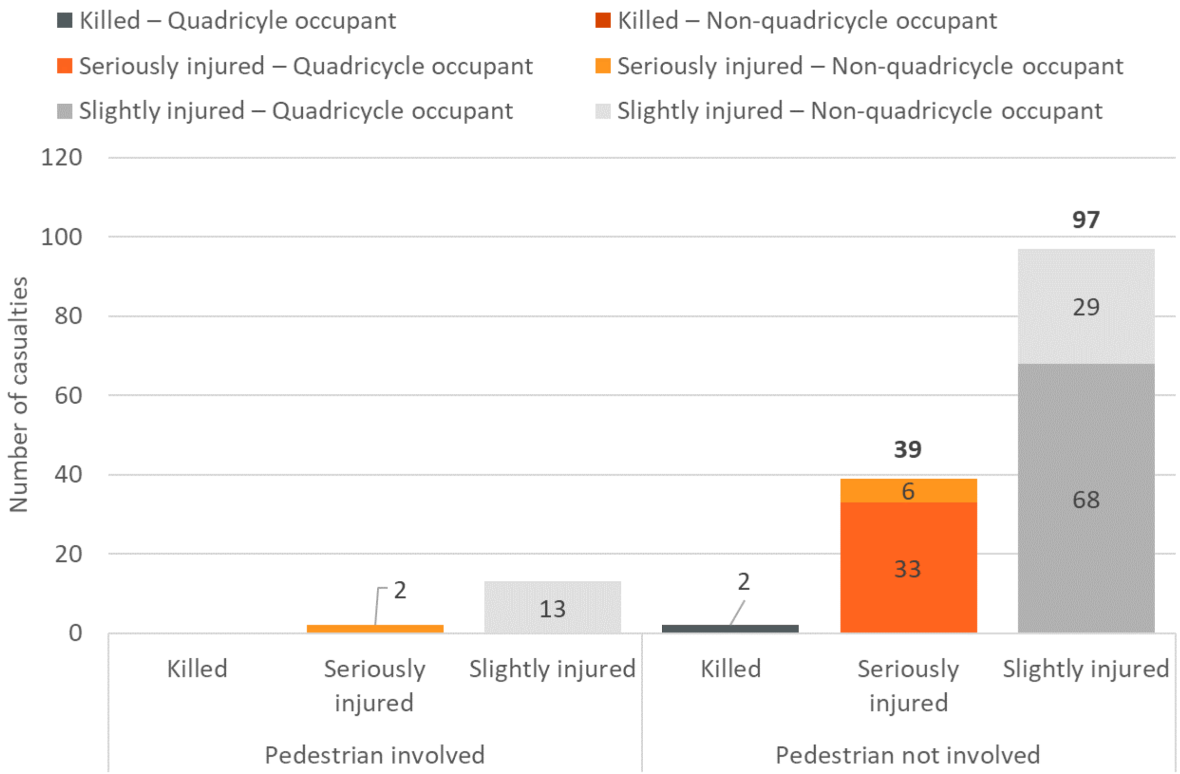


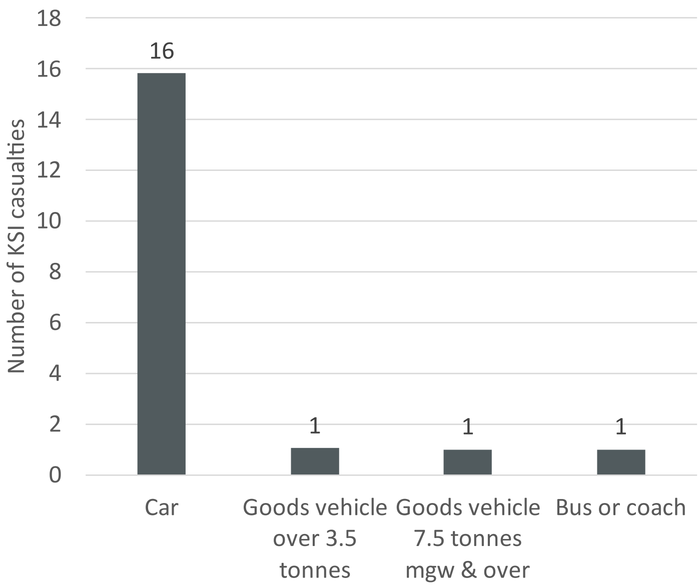
Table 4.1 shows the 103 quadricycle occupant casualties by injury severity and collision type, in collisions (with no pedestrians involved) involving quadricycles, from 2014 to 2021. It is seen that there were 35 KSI casualties, with about half involved in two-vehicle collisions and most of the other half involved in single-vehicle collisions such as impacting an object and/or rollover.

Table 4.1 Number of quadricycle occupant casualties in collisions involving quadricycles in the UK, by collision type and injury severity, 2014–2021

	Single vehicle without pedestrian	2-vehicle collision	3 or more parties	Total
Killed	0	1	1	**2**
Seriously injured	11	18	4	**33**
Slightly injured	18	37	13	**68**

For the 19 KSI quadricycle occupant casualties in the two-vehicle collisions, Figure 4.4 shows the quadricycle impact partner, which was a car in most cases.

Figure 4.4 Quadricycle occupant KSI casualties in two-vehicle collisions in the UK, by impact partner



To provide an indication of the difference in safety in terms of injury risk for car, quadricycle and motorcycle users, KSI casualty rates per year and per million licensed vehicles were calculated using the following equation:

$$\text{KSI casualty rate} = \left(\frac{\text{Average number of occupant/user casualties per year for 2014–2021}}{\text{Average number of licensed vehicles for 2014–2021}}\right) \times 1{,}000{,}000 \qquad \text{(Equation 4.1)}$$

Table 4.2 shows the data sources and values used for the calculation.

Table 4.2 Data source and values used for quadricycle occupant/user KSI casualty rate calculation

Parameter	Quadricycle		Motorcycle		Car	
	Data source	Value	Data source	Value	Data source	Value
Average number of occupant/user casualties per year	Table 4.1	4.375	Reported casualties data table RAS0201[a]	5,468	RAS0601[b]	25,563
Average number of licensed vehicles	Figure 3.1	3,994 for UK = 3,608 (adjusted for GB)[c]	Vehicle licensing data table VEH0101[d]	1,289,970 (data for GB)	Figure 3.3	32,200,000 for UK = 31,076,696 (adjusted for GB)[c]

[a] RAS0201: Road user type, numbers and rates. https://www.gov.uk/government/statistical-data-sets/reported-road-accidents-vehicles-and-casualties-tables-for-great-britain

[b] RAS0601: Government statistical data set – reported road collisions, vehicles and casualties tables for Great Britain: Collisions and casualties by vehicle and road user type involved. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1106323/ras0601.ods

[c] df_VEH0120_GB: All registered vehicles in Great Britain; from 1994 Quarter 4 (end December). https://www.gov.uk/government/statistical-data-sets/vehicle-licensing-statistics-data-files
Note that the Stats19 data set only covers road traffic accidents that occur in Great Britain, and not in Northern Ireland. Therefore, when analysing this data set, it is necessary to adjust the number of licensed vehicles from the UK to Great Britain here.

[d] VEH0101: Vehicles at the end of the quarter by licence status and body type: Great Britain and United Kingdom https://www.gov.uk/government/statistical-data-sets/vehicle-licensing-statistics-data-tables

Table 4.3 shows the values calculated for quadricycles, motorcycles and cars, which show the KSI casualty rate of quadricycle occupants to be substantially higher than car occupants but substantially lower than motorcycle users. At face value, the KSI casualty rate indicates the injury risk when using a vehicle category. However, these results should be treated with caution because, inter alia:

- the exposure metric used (per million licensed vehicles) does not consider how much the vehicles are used (which is why a rate per billion miles travelled is usually used for this type of calculation) or where they are used
- the low numbers of quadricycle casualties and licensed quadricycles make the result sensitive to small changes.

In summary, the difference in KSI casualties per million licensed vehicles indicate a higher injury risk for occupants of quadricycles compared to cars (+47%) but a lower risk compared to motorcycles (−71%). These results should be treated with caution, because, inter alia, the low numbers of quadricycle casualties and licensed vehicles make the results sensitive to small changes. To illustrate, had there been 11 fewer quadricycle KSI casualties in the 8-year period studied, then the rate would look identical to cars.

Table 4.3 KSI casualties per year per million licensed vehicles in the UK, by vehicle type, 2014–2021

Vehicle type	KSI casualties per year per million licensed vehicles
Quadricycle	1,213
Motorcycle	4,239
Car	823

4.1.3 Analysis of collisions involving quads

Collisions involving quads for the eight years from 2014 to 2021 were identified for analysis using the same methodology as quadricycles in the previous section. Collision-based and casualty-based analyses were performed.

4.1.3.1 Collision-based analysis

Figure 4.5 shows the number of collisions involving quads in the UK from 2014 to 2021, broken down into two categories: pedestrian involved, and pedestrian not involved. It is seen that the total number of collisions involving quads over the period was 76, with three of them involving pedestrians. In comparison, there were 123 collisions involving quadricycles over the same period (Figure 4.1).

Figure 4.5 Number of collisions involving quads in the UK, 2014–2021

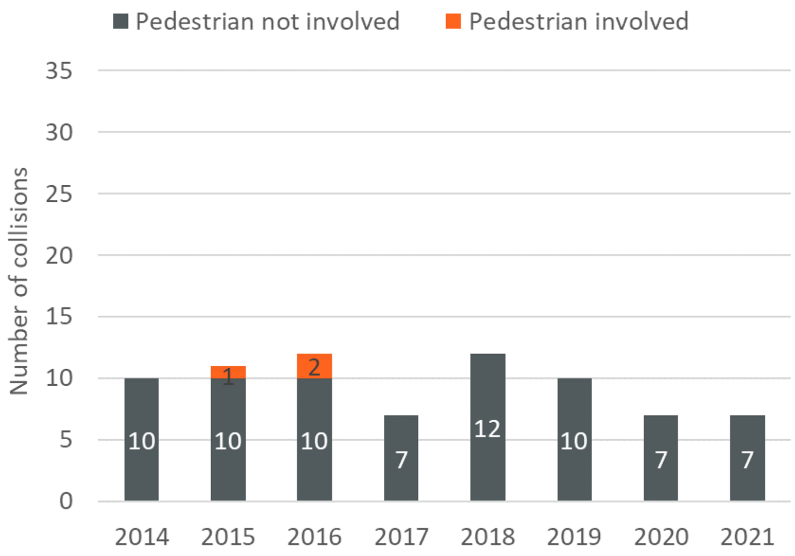
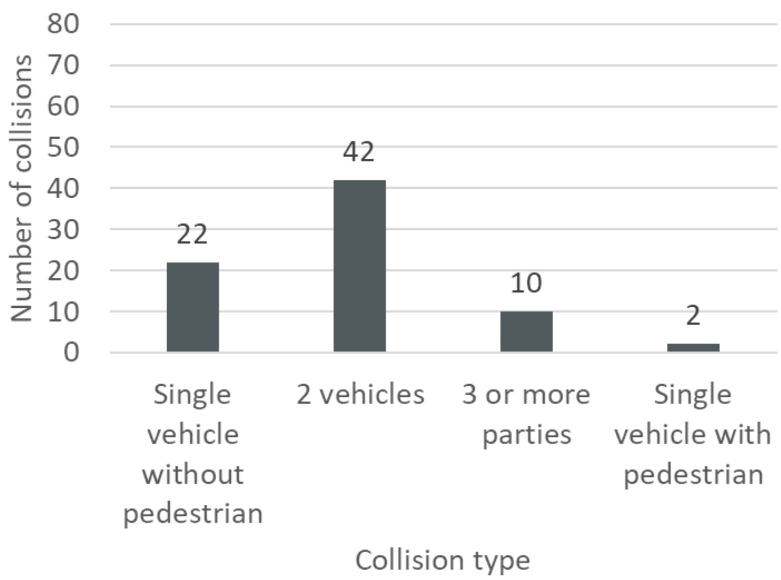


Figure 4.6 shows quads collisions (2014–2021) by collision type: single vehicle without pedestrian, 2-vehicle collision, 3 or more parties, and single vehicle with pedestrian. Two-vehicle collisions were seen to be the most frequent, which was similar to quadricycles, as per Figure 4.2.

Figure 4.6 Number of collisions involving quads in the UK, by collision type, 2014–2021



Note that the data analysed does not allow to draw conclusions on the impact of different road types or speed limits on the risk of quadricycle operation.

4.1.3.2 Casualty-based analysis

Figure 4.7 shows the 96 casualties associated with the 76 collisions involving quads broken down by injury severity and pedestrian involvement. Of the 96 casualties, the majority (79) were quad occupants/users. These casualties only occurred in 'pedestrian not involved' type collisions. Compared to quadricycles, the most noticeable difference was the difference in the ratio of slightly to seriously injured casualties, with a much bigger ratio for quadricycles. A potential explanation for this difference is that, whereas most quadricycles have seat belts fitted, many quads are quad bikes with straddle type seating and therefore 'occupants/users' are much more likely to be unrestrained and thus sustain more serious injuries in lower severity collisions.

Figure 4.7 Number of casualties in collisions involving quads in the UK, by pedestrian involvement and injury severity, 2014–2021

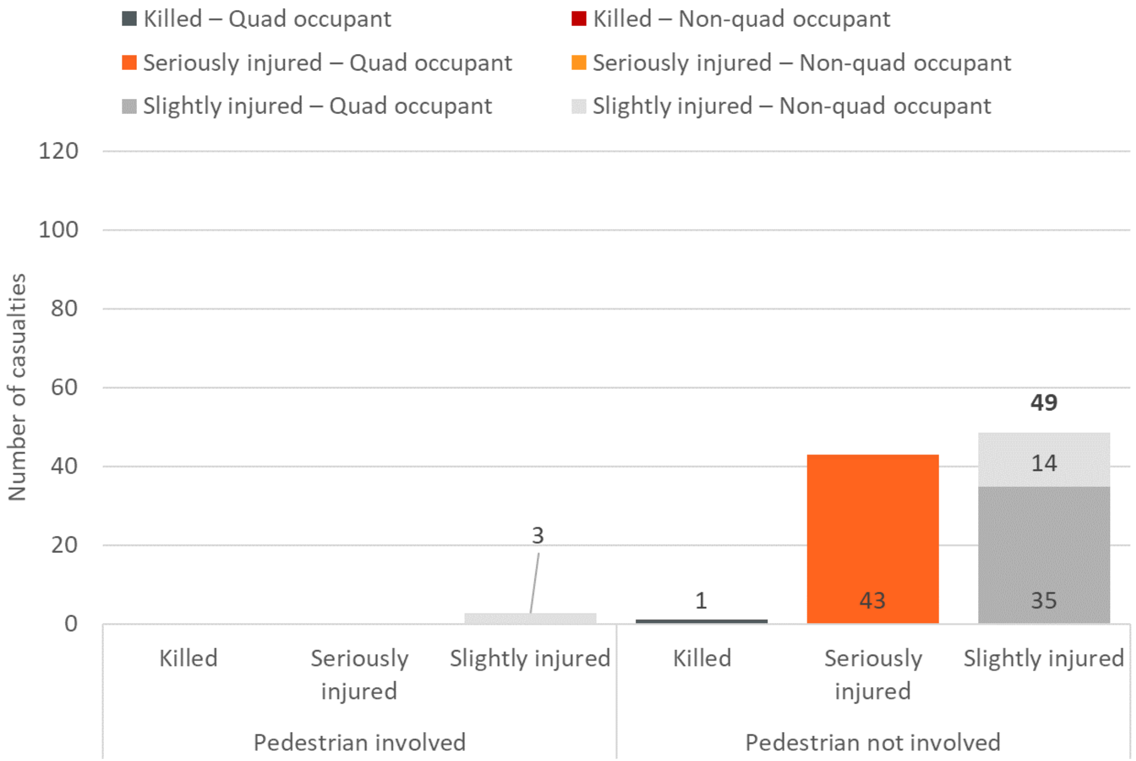


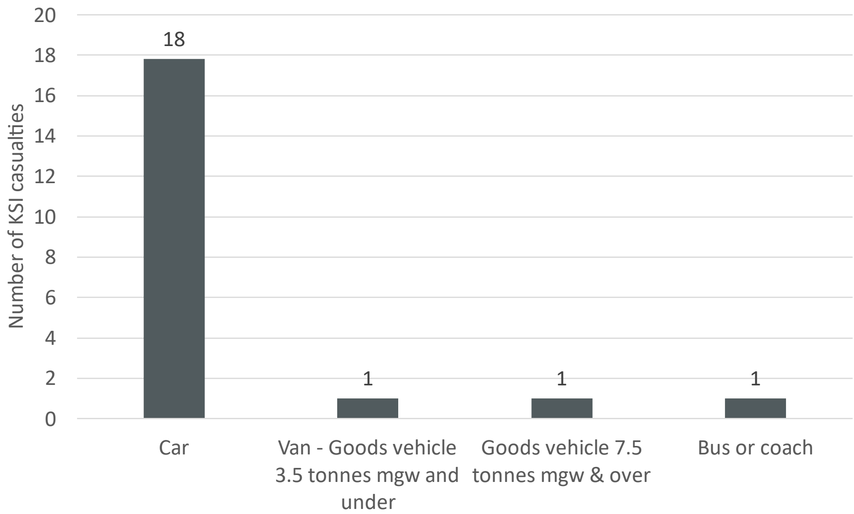
Table 4.4 shows the 79 quad occupant casualties by injury severity and collision type, in collisions (with no pedestrians involved) involving quads, from 2014 to 2021. It is seen that there were 44 (43+1) KSI casualties, with about half involved in two-vehicle collisions and most of the other half involved in single-vehicle collisions. This is similar to the distribution for quadricycles, as shown in Table 4.1.

Table 4.4 Number of quad occupant/user casualties in collisions involving quads in the UK, by collision type and injury severity, 2014–2021

	Single vehicle without pedestrian	2-vehicle collision	3 or more parties	Total
Killed	1	0	0	**1**
Seriously injured	16	21	6	**43**
Slightly injured	8	23	4	**35**

For the KSI quad occupant casualties in the two-vehicle collisions, Figure 4.8 shows the quad impact partner, which was a car in most cases.

Figure 4.8 Quad occupant KSI casualties in two-vehicle collisions in the UK, by impact partner



To provide an indication of the difference in safety in terms of injury risk for car and quad occupants, KSI casualty rates per year and per million licensed vehicles were calculated using the same methodology mentioned in section 4.1.2.2.

Table 4.5 shows the data sources and values used for the calculation.

Table 4.5 Data source and values used for quad occupant/user KSI casualty rate calculation

Parameter	Quad		Car	
	Data source	Value	Data source	Value
Average number of occupant/user casualties per year	Table 4.1	5.5	RAS0601[a]	25,563
Average number of licensed vehicles	Figure 3.1	8,440 for UK = 8,208 (adjusted for GB)	Figure 3.3	32,200,000 for UK = 31,076,696 (adjusted for GB)

[a] RAS0601: Government statistical data set – reported road collisions, vehicles and casualties tables for Great Britain: Collisions and casualties by vehicle and road user type involved. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1106323/ras0601.ods

Table 4.6 shows the values calculated for quads and cars. It shows a slightly lower KSI casualty rate for quad occupants, indicating a lower injury risk than both car occupants (823) and quadricycle occupants (1,213). However, it should be noted that these results should be treated with caution because, inter alia:

- the metric used (per million licensed vehicles) does not consider how much the vehicles are used, which is why a rate per billion miles travelled is usually used for this type of calculation
- the different operating environments of these vehicle types – quads are more likely to be used on rural roads to a greater extent compared to cars and quadricycles
- the low numbers of quad casualties and licensed quads make the results sensitive to small changes.

This result is contrary to conventional wisdom, which would expect quad users to have a much higher injury risk than car users if they were operated in a similar environment because of the much lower level of user protection. Therefore, to a large extent this result demonstrates that the KSI casualty rate metric is only valid for comparison of vehicle types used in a similar environment in a similar way and hence is not appropriate for comparing quads and cars.

Table 4.6 KSI casualties per year per million licensed vehicles in the UK, by vehicle type, 2014–2021

Vehicle type	KSI casualties per year per million licensed vehicles
Quad	670
Car	823

4.2 Germany

4.2.1 Destatis collision data

Collision data for Germany is published by Destatis, the German federal statistical office. The published casualty data sets[27] aggregate four- and three-wheeled vehicles: Light quadricycles and light tricycles are reported as one group (categories L6e and L2e), and heavy quadricycles and heavy tricycles as another (L7e and L5e).

Note:

- Data was not published before 2015.
- Separate numbers for four- and three-wheeled vehicles are not published.
- The numbers include both car-like vehicles with occupant compartment and those with straddle seating and handlebar steering.
- Data on collision numbers or collision types is not available for the vehicles of interest. Hence this report is restricted to casualty-based analysis.

4.2.2 Casualty numbers

Table 4.7 and Table 4.8 provide overall numbers of killed, seriously injured, and slightly injured casualties among occupants of light and heavy tricycles and quadricycles on German roads from 2015 to 2021. The numbers of KSI casualties over time are visualised in Figure 4.9. It can be observed that casualty numbers remained largely stable over this time period in a band of over 200 and under 250 KSI casualties (with an expected dip in the first years of the COVID-19 pandemic). The contribution of heavy quadricycles/tricycles to these casualty numbers is substantially higher than that of light quadricycles/tricycles.

[27] Source: Destatis, Report Verkehrsunfälle Kraftrad- und Fahrradunfälle im Straßenverkehr for given year: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Verkehrsunfaelle/_inhalt.html#

Table 4.7 Light quadricycle and tricycle (L6e and L2e) occupant casualties in Germany, all collisions, by year and severity, 2015–2021

Year	Killed	Seriously injured	Slightly injured
2015	1	51	191
2016	4	69	174
2017	1	55	133
2018	6	63	154
2019	2	55	183
2020	3	52	177
2021	7	68	178

Table 4.8 Heavy quadricycle and tricycle (L7e and L5e) occupant casualties in Germany, all collisions, by year and severity, 2015–2021

Year	Killed	Seriously injured	Slightly injured
2015	7	176	265
2016	10	142	259
2017	3	151	252
2018	14	148	259
2019	12	153	224
2020	6	129	239
2021	6	132	245

Figure 4.9 Number of KSI casualties in light (L6e/L2e) and heavy quadricycles and tricycles (L7e/L5e) in Germany, 2015–2021

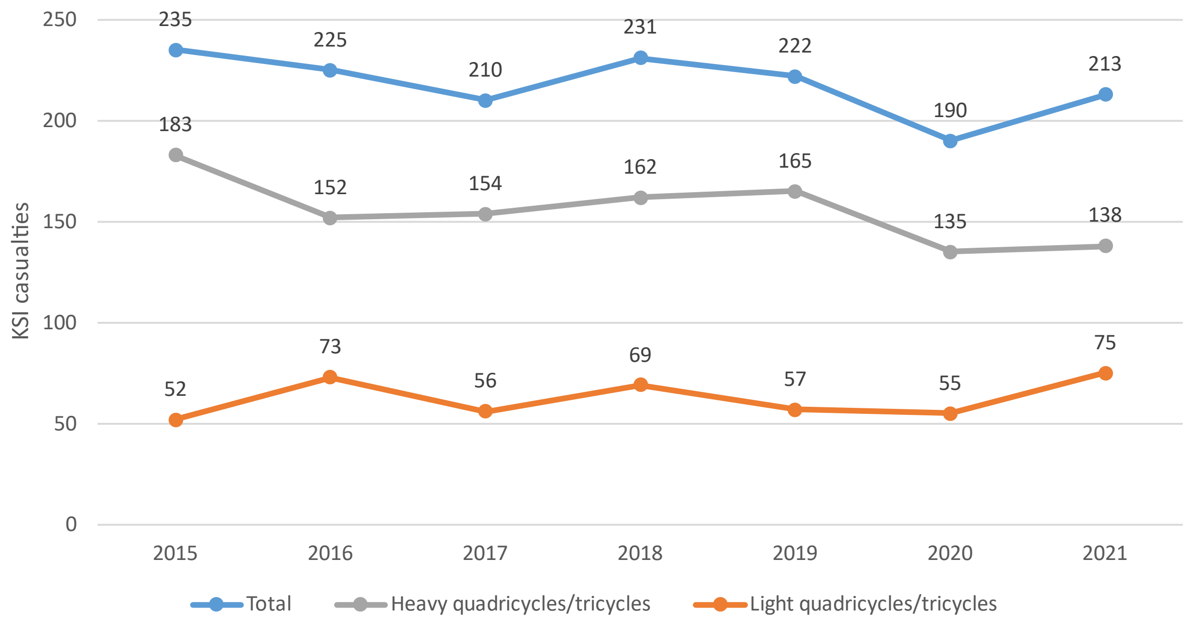


Table 4.9 to Table 4.12 split the above numbers further into casualties that occurred in urban areas and casualties that occurred outside urban areas (including motorways). The numbers of KSI casualties are visualised in Figure 4.10. It is observed that urban and extra-urban collisions each account for about half of KSI casualties.

Table 4.9 Light quadricycle and tricycle (L6e and L2e) occupant casualties in Germany, collisions in urban areas, by year and severity, 2015–2021

Year	Killed	Seriously injured	Slightly injured
2015	0	37	138
2016	1	47	134
2017	0	29	85
2018	3	43	106
2019	2	32	137
2020	3	31	122
2021	4	39	129

Table 4.10 Heavy quadricycle and tricycle (L7e and L5e) occupant casualties in Germany, collisions in urban areas, by year and severity, 2015–2021

Year	Killed	Seriously injured	Slightly injured
2015	0	87	187
2016	4	72	164
2017	0	73	167
2018	4	64	183
2019	4	78	155
2020	1	73	161
2021	4	58	148

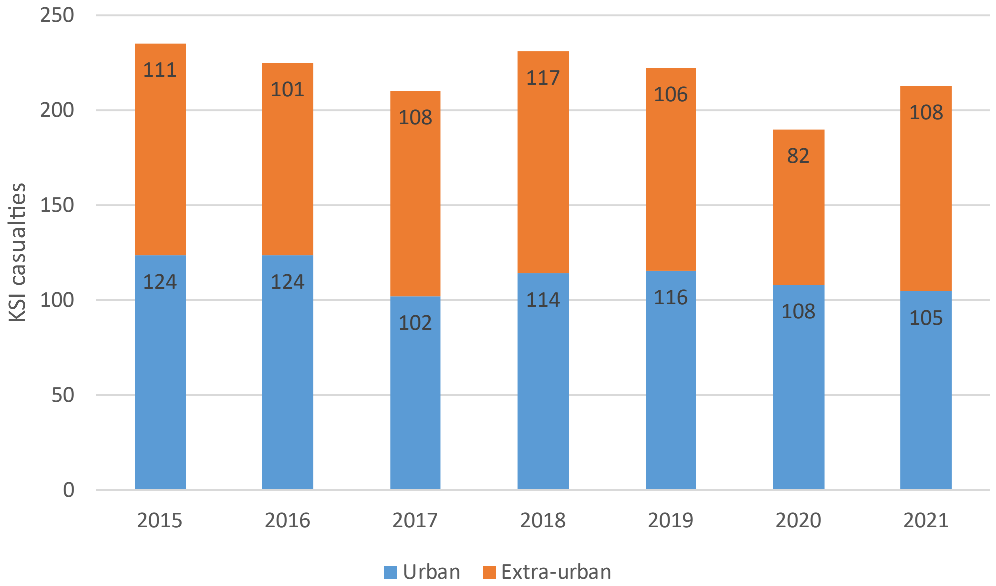
Table 4.11 Light quadricycle and tricycle (L6e and L2e) occupant casualties in Germany, collisions outside urban areas (including motorways), by year and severity, 2015–2021

Year	Killed	Seriously injured	Slightly injured
2015	1	14	53
2016	3	22	40
2017	1	26	48
2018	3	20	48
2019	0	23	46
2020	0	21	55
2021	3	29	49

Table 4.12 Heavy quadricycle and tricycle (L7e and L5e) occupant casualties in Germany, collisions outside urban areas (including motorways), by year and severity, 2015–2021

Year	Killed	Seriously injured	Slightly injured
2015	7	89	78
2016	6	70	95
2017	3	78	85
2018	10	84	76
2019	8	75	69
2020	5	56	78
2021	2	74	97

Figure 4.10 Number of KSI casualties inside and outside urban areas in Germany, occupants of light (L6e/L2e) and heavy (L7e/L5e) quadricycles and tricycles combined, 2015–2021



4.2.3 Casualty rates compared to passenger cars and motorcycles

The best available exposure metric to determine a casualty rate is the vehicle fleet size, because data on distance travelled is not available for quadricycles in Germany.

The fleet size reported for Germany in section 3.3.2 aggregates L6e and L7e vehicles but does not contain L2e or L5e vehicles that are included in the casualty numbers reported above. However, fleet sizes in a suitably aggregated way are also published by the German federal statistical office: For the group of heavy quadricycles and tricycles (L7e and L5e), full fleet size data is available; for light quadricycles and tricycles (L6e and L2e), data is only published up to the year 2016. Fleet size and casualty data for passenger cars (M_1) is also published by the German federal statistical office.

Average fleet sizes:

- L6e/L2e: 33,694.5 vehicles[28] (average, years 2015–2016)
- L7e/L5e: 152,088.4 vehicles[29] (average, years 2015–2021)
- All L-category vehicles (mostly motorcycles)[30]: 6,215,171 vehicles (average, years 2015–2016)
- M_1: 45,875,136.7 vehicles[31] (average, years 2015–2021).

Average annual number of KSI casualties:

- L6e/L2e: 62.5 KSI casualties (average, years 2015–2016)
- L7e/L5e: 155.6 KSI casualties (average, years 2015–2021)
- All L-category vehicles (mostly motorcycles)[32]: 13,449.5 KSI casualties (average, year 2015–2016)
- M_1: 28,565.3 KSI casualties[33] (average, years 2015–2021).

Table 4.13 shows the KSI casualty rate relative to the vehicle fleet size for the vehicles in scope compared to passenger cars. This indicates higher injury risks for occupants of light and heavy quadricycles compared to passenger cars in Germany. The same limitations as outlined for the UK analysis apply (see section 4.1.2.2).

Table 4.13 KSI casualties per year per million licensed vehicles in Germany, by vehicle type

Vehicle category	KSI casualties per year per million licensed vehicles
Light quadricycles and tricycles (L6e and L2e)	1,855
Heavy quadricycles and tricycles (L7e and L5e)	1,023
Light two-, three- and four-wheelers (L, ≈ motorcycles)	2,164
Passenger cars (M_1)	623

4.3 France

4.3.1 ONISR collision data

Collision data for France is published by the French Road Safety Observatory (ONISR), an inter-ministerial government organisation. The published casualty data[34] is limited to the group of voiturettes (ie, car-like L6e vehicles as described in section 3.3.3).

[28] Source: Destatis, Report Verkehrsunfälle Kraftrad- und Fahrradunfälle im Straßenverkehr for given year: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Verkehrsunfaelle/_inhalt.html#

[29] Source: Destatis, Report Verkehrsunfälle Kraftrad- und Fahrradunfälle im Straßenverkehr for given year: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Verkehrsunfaelle/_inhalt.html#

[30] Source: Destatis, Report Verkehrsunfälle Kraftrad- und Fahrradunfälle im Straßenverkehr 2021: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Verkehrsunfaelle/_inhalt.html#

[31] Source: Destatis, Report Verkehrsunfälle Zeitreihen 2021: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Verkehrsunfaelle/_inhalt.html#_5ygkjuujg

[32] Source: Destatis, Report Verkehrsunfälle Kraftrad- und Fahrradunfälle im Straßenverkehr for given year: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Verkehrsunfaelle/_inhalt.html#

[33] Source: Destatis, Report Verkehrsunfälle Zeitreihen 2021: https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Verkehrsunfaelle/_inhalt.html#_5ygkjuujg

[34] Source: ONISR, Annual data tables for given year: https://www.onisr.securite-routiere.gouv.fr/en/data-tools/annual-tables

Notes:

- Data from the tables was extracted to cover Metropolitan France (ie, excluding overseas territories).
- Numbers for other vehicle sub-categories (ie, L7e and rest of L6e except voiturettes) are not published.
- Data on collision numbers or collision types is not available for the vehicles of interest. Hence this report is restricted to casualty-based analysis.

4.3.2 Casualty numbers

Table 4.14 provides the overall numbers of killed, seriously injured, and slightly injured casualties among occupants of voiturettes on French roads. The number of KSI casualties over time is visualised in Figure 4.11. It is seen that the number of casualties rose to a peak in the year 2015 and has reduced since, with COVID-19 affecting the numbers for 2020 and 2021.

Table 4.14 Voiturette (car-like L6e vehicle) occupant casualties in France, drivers and passengers, by year and severity, 2011–2021

Year	Killed	Seriously injured	Slightly injured
2011	26	130	200
2012	28	104	198
2013	29	123	174
2014	24	129	191
2015	25	160	173
2016	30	141	162
2017	27	115	124
2018	26	96	162
2019	17	110	368
2020	18	76	186
2021	14	90	216

Figure 4.11 Number of KSI casualties in voiturettes (car-like L6e vehicles) in France, 2011–2021

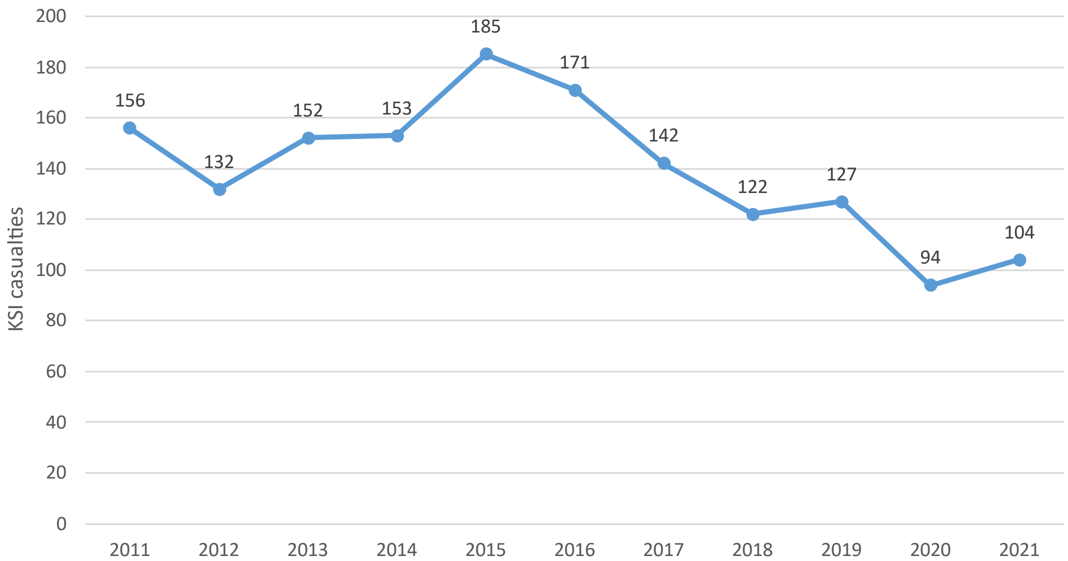


Table 4.15 and Table 4.16 split the above numbers further into driver casualties and passenger casualties. The numbers of KSI casualties are visualised in Figure 4.12. Typically, approximately three quarters of KSI casualties are drivers and one quarter passengers.

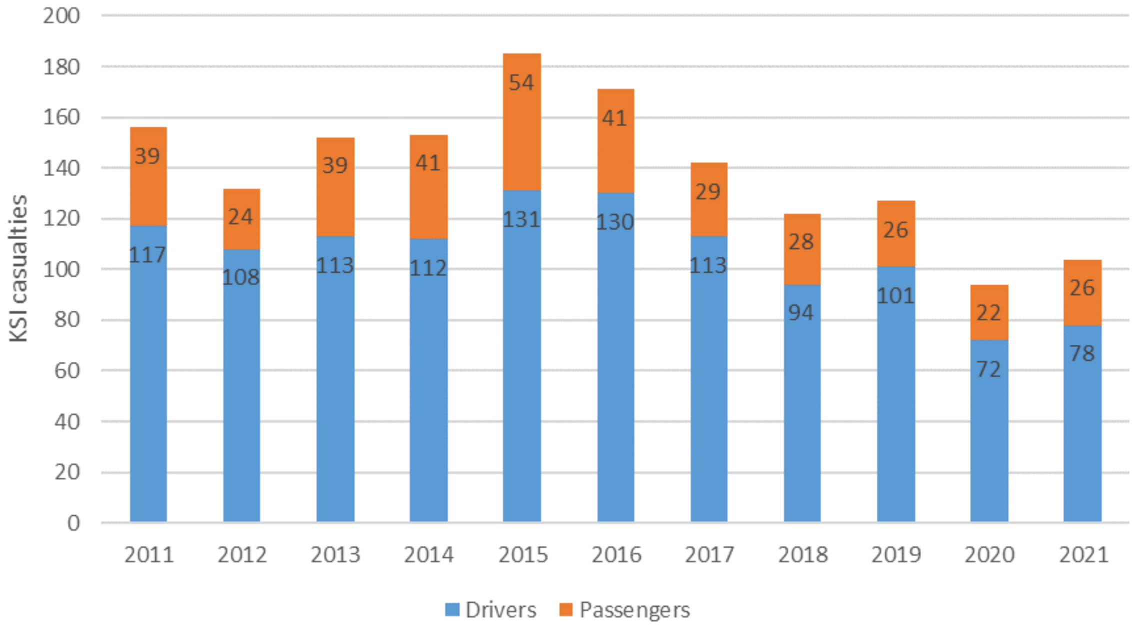
Table 4.15 Voiturette (car-like L6e vehicle) occupant casualties in France, drivers only, by year and severity, 2011–2021

Year	Killed	Seriously injured	Slightly injured
2011	21	96	147
2012	21	87	145
2013	24	89	124
2014	19	93	137
2015	21	110	128
2016	25	105	118
2017	21	92	91
2018	21	73	123
2019	14	87	252
2020	17	55	123
2021	11	67	166

Table 4.16 Voiturette (car-like L6e vehicle) occupant casualties in France, passengers only, by year and severity, 2011–2021

Year	Killed	Seriously injured	Slightly injured
2011	5	34	53
2012	7	17	53
2013	5	34	50
2014	5	36	54
2015	4	50	45
2016	5	36	44
2017	6	23	33
2018	5	23	39
2019	3	23	116
2020	1	21	63
2021	3	23	50

Figure 4.12 Number of killed and seriously injured drivers and passengers in voiturettes (car-like L6e vehicles) in France, 2011–2021



4.3.3 Casualty rate compared to passenger cars

Distance travelled or fleet size would be suitable exposure metrics to compare casualty rates with passenger cars, but neither are available for voiturettes in France.

To allow any comparison, the voiturette fleet size was approximated from the annual new registrations: The average age of a passenger car when scrapped is ca. 14 years,[35] which serves as an upper estimate. The average useful life of a voiturette is expected to be somewhat shorter than a car; in the absence of data, 10 years was used as a plausible value for a lower boundary. Upper and lower bounds for the fleet size were then calculated by summing the new registrations for the preceding 14 and 10 years (see section 3.3.3), respectively. Note that the results involve a high level of uncertainty. Fleet size and casualty data for passenger cars (M_1) is published by Statista and ONISR, respectively. The required data for motorcycles was not available for comparison.

Fleet sizes:

- Voiturettes: 135,230 to 192,520 vehicles (range of approximated fleet size for year 2019; the latest year when all data required for this task was available)
- M_1: 38,246,432 vehicles[36] (year 2019).

Annual number of KSI casualties:

- Voiturettes: 127 KSI casualties (year 2019)
- M_1: 9,456 KSI casualties[37] (year 2019).

[35] Source: https://www.smmt.co.uk/industry-topics/sustainability/average-vehicle-age/; data for France or other vehicle categories not available.

[36] Source: Statista, Nombre total de voitures particulières immatriculées en France de 2011 à 2022: https://fr.statista.com/statistiques/472580/voitures-particulieres-immatriculees-france/

[37] Source: ONISR, Annual data table 2019: https://www.onisr.securite-routiere.gouv.fr/en/data-tools/annual-tables

Table 4.17 shows the KSI casualty rate relative to the vehicle fleet size for the vehicles in scope compared to passenger cars. This indicates higher injury risks for occupants of voiturettes compared to passenger cars in France. The same limitations as outlined for the UK analysis apply (see section 4.1.2.2).

Table 4.17 KSI casualties per year per million licensed vehicles in France, by vehicle type, 2019

Vehicle category	KSI casualties per year per million licensed vehicles
Voiturettes (car-like L6e vehicle)	Approximately 660 to 939[a]
Passenger cars (M_1)	247

[a] Fleet size data for voiturettes estimated with high degree of uncertainty.

4.4 Discussion and summary

In the UK, 4 quadricycle occupants and 6 quad occupants were killed or seriously injured on average per year over the last eight years. In Germany, an average of 218 occupants of light and heavy tricycles and quadricycles were killed or seriously injured per year. In France, 140 occupants of car-like light quadricycles were killed or seriously injured on average per year.[38] In all three countries, quadricycles only contribute a small fraction to all road deaths and serious injuries, which were ca. 33,000, 67,000 and 31,000 per annum for the UK, Germany and France, respectively.[39]

For Germany and France, the countries with higher overall KSI casualty numbers, the development over time was analysed. In both countries, a certain reduction in 2020 and 2021 was observed, which is likely due to the COVID-19 pandemic. In the period before that, KSI casualty numbers in Germany remained relatively stable. In France numbers peaked in 2015 and reduced by almost a third by 2019, potentially partly attributable to a shrinking fleet because annual new registrations also reduced by about 20% since 2008.

Detailed information on accidentology was sparse for the vehicle categories of interest. In the UK, the majority of quadricycle collisions (more than half) involved one other vehicle, followed by single-vehicle collisions (some of which involved a pedestrian), and collisions involving two or more other parties forming the smallest group. In Germany, collisions involving heavy quadricycles/tricycles were substantially more frequent in absolute numbers than light quadricycles/tricycles. However, the difference in fleet size between these groups was even larger, resulting in a lower casualty rate for heavy quadricycles/tricycles (see following paragraphs). Urban and extra-urban collisions contributed about equally to the number of KSI casualties. In France, only the split between drivers and passengers is known: Approximately three quarters of KSI casualties were drivers, which is in line with expectation under the assumption that single occupancy is arguably the main mode of operation.

To allow a comparison of the injury risk for quadricycle occupants, passenger car occupants and motorcycle users, KSI casualty rates per year and per million licensed vehicles were analysed. These results should be treated with caution because:

- the exposure metric used (per million licensed vehicles) does not consider how much the vehicles are used or where they are used

[38] These numbers cannot be compared directly because they relate to different sub-groups of the L6e and L7e vehicle categories.

[39] The time periods of published data for quadricycles vary between countries. Where numbers for different vehicle categories are quoted for comparison, they relate to the same time period as the data that was available for the vehicles in scope.

- the low numbers of quadricycle casualties and licensed quadricycles make the results sensitive to small changes.

For the UK, the casualty rates were 823 KSI casualties per million cars compared to 1,213 KSI casualties per million quadricycles, indicating a 47% higher casualty rate for quadricycles. In Germany, the difference in casualty rates between cars and quadricycles was even larger, with a 64% higher rate for heavy quadricycles/tricycles (1,023) and a 198% higher rate for light quadricycles/tricycles (1,855) compared to cars (623). In France, the picture for light quadricycles was similar to the other countries: The casualty rate among occupants of car-like light quadricycles was approximately 660 to 939 KSI casualties per million vehicles, which is 167% to 280% higher compared to passenger cars (247).

Data for motorcycles was available for the UK and Germany, indicating casualty rates of 4,239 and 2,164, respectively. Compared to motorcycles, quadricycles therefore had a 71% lower casualty rate in the UK. In Germany, heavy quadricycles/tricycles had a 53% lower casualty rate, and light quadricycles/tricycles 14% lower.

No data was available on distance travelled for quadricycles, but the assumption that they travel less far than cars, on average, appears justified. Taking this into account, the fact that travelling speeds are lower, and noting the caveats above – in particular, that operating environments were assumed to be similar – the estimated casualty rates indicated that the safety performance of quadricycles is worse than that of passenger cars. This allows us to conclude that there is a risk of total casualty numbers increasing, potentially substantially, if significant numbers of road users change from cars to quadricycles and quadricycle safety standards remain at current EU levels. To investigate further the magnitude of this risk and the likelihood of it actually materialising, further research is required that takes into account factors such as usage patterns and driver demographics.

5 Summary of findings

5.1 Regulation and enforcement

Europe, Japan and the USA were found to diverge in their approaches to vehicle categorisation, pre-deployment safety regulation and controls, and associated enforcement mechanisms for four-wheeled lightweight EVs. The focus and amount of regulation for each aspect differ widely with regard to vehicle categorisation (size, mass, power, max. speed and seating capacity), occupant and VRU protection standards, and usage restrictions in terms of roads that can be driven on.

Japan, for its type-approved micro-mobility category, is the only region that has safety standards along the lines of those required for passenger cars, including requirements for crashworthiness and VRU impact protection. It is interesting to note that the level of these standards, together with the fact that major vehicle manufacturers such as Toyota make these vehicles, shows that it is possible to enforce requirements for crashworthiness and VRU impact protection without making these micro-mobility vehicles as heavy, inefficient, and expensive as a standard passenger car and hence negating the advantages of them. Europe, for its heavy quadricycles (L7e) category, is the only region that does not restrict usage on higher-speed roads (motorways/expressways).

The USA regulates lightweight EVs far less than either Europe or Japan, with the main restrictions covering only their gross mass, top speed, and the roads on which they can be driven. As for all other regions, the USA has requirements for lighting, fitment of seat belts, registration, insurance and driver licensing. Interestingly, for pedestrians it does require fitment of an acoustic alert, which is not required in other regions with the exception of Japan for larger micro-mobility categories. Also, the limitation for top speed is the most restrictive (lowest) compared to other regions, which may to some extent, combined with usage restrictions, help to compensate for other aspects where requirements are lower.

5.2 Number of quadricycles (current and future) and benefits/costs

The literature review found that four-wheeled lightweight electric quadricycles are considered a promising mobility solution in the context of the growing climate crisis and increased awareness of the need for clean and sustainable mobility. Sustainable transport modes and multi-modal solutions will also need to be integrated into clean mobility solutions. Lightweight EVs fit well with this ambition, as they promote public transport use and last mile connectivity. Japan is considering the use of quadricycles as part of the efforts to decarbonise transport and promote mobility of older people and people living with disabilities. The UK is planning on transitioning all quadricycles for road use to zero emission in the coming years.

The safety of quadricycles is under debate. Existing European regulations do not cover the crash safety and safety features of quadricycles as they do for conventional vehicles. With an increase in use and demand for quadricycles, such regulations may need to be introduced in the future. Due to their lightweight build and relatively small size, valid concerns exist on the crash safety of these vehicles.

Some manufacturers have released promising production reports, and new microcar models are entering the market, indicating that manufacturers recognise the economic potential of these vehicles. However, other manufacturers are reported to have pulled out of this market because it was not profitable.

The current and historical fleet size data analysed for the UK, Germany and France cannot easily be compared between countries due to reporting differences and gaps in data. However, it can be observed that the total fleet size can be expected to be largest in France, followed by Germany and then the UK, which has by far the smallest fleet of quadricycles.

The sustainability and cost-of-operation benefits of quadricycles compared to passenger cars might be assumed to have led to increasing vehicle numbers in recent years, but none of the data identified would indicate such a trend. Indeed, the opposite trend is seen in the UK and Germany with sharp decreases, while France shows relatively stable numbers over the last decade. Ultimately, it appears that consumer and market trends coupled with legislative and regulatory frameworks will shape the future markets for four-wheeled lightweight EVs.

5.3 Collisions and casualties

The collision and casualty data analysed for the UK, Germany and France showed that in all three countries, quadricycles only contribute a small fraction to overall road deaths and serious injuries, which is to be expected given the small vehicle fleet size compared to passenger cars and other vehicles.

Detailed information on accidentology was sparse for the vehicle categories of interest. In the UK, most quadricycle collisions (more than half) involved one other vehicle, followed by single-vehicle collisions (some of which involved a pedestrian), and collisions involving two or more other parties forming the smallest group. In Germany, collisions involving heavy quadricycles/tricycles were substantially more frequent in absolute numbers than light quadricycles/tricycles. However, the difference in fleet size between these groups was even larger, resulting in a lower casualty rate for heavy quadricycles/tricycles (see following paragraphs). Urban and extra-urban collisions contributed about equally to the number of KSI casualties. In France, only the split between drivers and passengers was known: Approximately three quarters of KSI casualties were drivers, which is in line with expectation under the assumption that single occupancy is arguably the main mode of operation.

To allow a comparison of the injury risk for quadricycle occupants and passenger car occupants, KSI casualty rates per year and per million licensed vehicles were analysed. These results should be treated with caution because:

- the exposure metric used (per million licensed vehicles) does not consider how much the vehicles are used or where they are used
- the low numbers of quadricycle casualties and licensed quadricycles make the results sensitive to small changes.

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Appendix A: Benefits and costs of quadricycles

Table A.1 Benefits of quadricycles

<table>
<tr><th>Source</th><th>Category</th><th>Benefits</th></tr>
<tr><td>Davies & Nieuwenhuis, 2018</td><td>Low Carbon Vehicle Partnership report</td><td>
While the question of the crash safety of quadricycles exists, they make up a small segment of the motorised vehicle market, with about 320,000 quadricycles on European roads and 20,000 new ones sold annually, most of which are in France, where 10,704 were sold in 2016. These numbers are relatively small compared to the 13 million new M_1 vehicles, 800,000 new motorcycles and 400,000 new mopeds.
Many L-category vehicles are electric, making the shift from M_1-subcategory vehicles to L-category vehicles climate neutral or with a net benefit.
L-category vehicles support the decongestion of urban areas because they are smaller than conventional vehicles. Additionally, they are better for the environment and have lower operating costs. More developed L-category vehicle markets like France and to a smaller degree Italy have established markets for these vehicles as well as of the supplying industries.
</td></tr>
<tr><td>Hutchinson, 2018</td><td>Low Carbon Vehicle Partnership report</td><td>
Powered light EVs require significantly less energy in the use phase of their life cycle compared to M-category vehicles. The materials used to make them also ‘offer lower embodied energy’ (p. 2).
L-category vehicles, while excluded from EU regulations on recyclability, are made using lighter and recyclable materials.
There’s greater flexibility in the manufacture of powered L-category vehicles as there is not as much pressure to innovate compared to M-category vehicles. This is due to powered light vehicles being lighter and having smaller engines.
Powered light vehicles are of commercial benefit primarily as in last mile delivery as an alternative to fossil fuel cars. TNT, a Brussels based delivery company, established a mobile depot system where parcels could be filled and dropped off at points within the city selected for strategic interest. After which, electric covered tricycles could deliver the parcels all over the city. This change is estimated to result in 900 km less of van movement in the city per week. This has a positive impact on GHG emissions and noise pollution.
</td></tr>
<tr><td>Department for Transport, 2022a</td><td>Department for Transport report (UK)</td><td>
L-category vehicles present a form of mobility that is accessible, affordable, and efficient. They are a clean transportation mode that promotes good air quality and reduces noise pollution and congestion. They are relatively small and promote the use of public transport as well as the availability of active transport modes like cycling and walking infrastructure.
The UK Department for Transport has set the ambition to decarbonise L-category vehicles. By doing so the positive benefits of reducing noise and toxic pollution can be realised. The UK has set legally binding carbon reduction targets, of which decarbonising transport is an element.
New L-category vehicle registrations from 2019, 2020 and 2021 show the following: There is an increase (for L7) in the percentage of vehicles that are electric, showing a positive trend in environmentally friendly vehicle fleets.

<table>
<tr><th></th><th colspan="3">2019</th><th colspan="3">2020</th><th colspan="3">2021</th></tr>
<tr><th></th><th>Tot</th><th>Elec</th><th>Elec%</th><th>Tot</th><th>Elec</th><th>Elec%</th><th>Tot</th><th>Elec</th><th>Elec%</th></tr>
<tr><td>L6</td><td>4</td><td>4</td><td>100%</td><td>2</td><td>2</td><td>100%</td><td>10</td><td>10</td><td>100%</td></tr>
<tr><td>L7</td><td>750</td><td>120</td><td>16%</td><td>958</td><td>168</td><td>17.54%</td><td>888</td><td>165</td><td>18.58%</td></tr>
</table>
Adapted from Table 4 of Department for Transport, 2022a, p. 17</td></tr>
</table>

Source	Category	Benefits
		• L6e and L7e vehicles are often better placed for zero-emission technology compared to L3e vehicles as they have the capacity to 'hold a larger battery and do not have to be moved by hand, i.e. taken off a kickstand and manoeuvred by hand' (p. 18). Some are even 'all-terrain or heavy on-road vehicles though with energy and powertrain requirements specifically tailored to their duty cycles and use requirements' (p. 18). The larger battery capacity increases the possible travel radius on a single charge of these vehicles, improving their reliability.
Ewert et al., 2022	Book	• Small electric vehicles (SEVs) by their carbon neutral or zero emission nature have the potential to support climate protection, the efficient use of land and mitigating the impacts of pollution, particularly in cities. • SEVs provide a reduction in land usage, particularly for stationary traffic. Land use attributable to transport infrastructure represents a large segment of the total area. With increasing populations (particularly in cities) and scarcity of space, this presents a growing challenge. Smaller vehicles occupy less space on the road and require smaller parking spaces. There is thus the potential for land savings with adoption of SEVs. This is, however, theoretical. • SEVs are also lightweight and consume less energy. • Uptake of SEVs promotes improved air quality, which worsens with increased population growth and number of motorised vehicles. • In comparison to EVs, SEVs cost less to acquire and operate.
Renault Group, 2020	Company website	• Renault's Twizy microcar is easy to recharge as it plugs into a household socket – 3.5 hours are sufficient to charge the battery for a range of 80 km. • It is sized between a large moped and a small electric car. Due to its small size it doesn't obstruct traffic and is easy to park (a standard parking space fits 3 of these vehicles).
GreenFleet, 2021	News article	• Citroën launched the Ami, a zero-emission quadricycle, in the UK in 2022. The Ami is a 100% electric zero-emission vehicle that uses a 5.5 kWh battery that can be recharged in 3 hours. It has a 46-mile range, and its top speed is 28 mph (ca. 45 km/h). • The Ami is a relatively small vehicle measuring 2.41 m in length. It is agile and compact, well suited for navigating busy streets with limited parking spaces. It fits a driver, passenger and one luggage item. This vehicle comes with various personalisation options that owners can take up.
Adams, 2020	News article	• Vehicle manufacturer Smart has an L-category vehicle offering that has the alibility to recharge using public rapid charging facilities. This makes it possible for it to charge from 10% to 80% in less than 40 minutes. The short charging period reduces wait times for vehicle users before they can make their next trip.
Kazmierski, 2019	News article	• While not referring specifically to L6 and L7 category vehicles, it is worth noting that UK-based delivery company DPD has launched the use of cargo bikes in UK, Ireland, Spain and Germany for package delivery. This is significant as continued uptake and use cases for L-category vehicles for both commercial and personal use bring consumer awareness to the vehicle category. • DPD has touted these cargo bikes as being environmentally friendly and highly manoeuvrable particularly in urban settings. The cargo bikes can deliver closer to the delivery addresses and carry a day's worth of packages. A company spokesperson is quoted as saying, 'We know that the environment and climate change matter more than ever to our clients and the feedback we get when we share our EV vision with them is really positive.'
Weiss, 2020	News article	• Bio-mechanical electric hybrid vehicles can replace vans and cars in urban environments without any loss in operational efficiency. Improvements to current offerings are, however, necessary.
Santucci et al., 2016	Journal article	L- category vehicles: • make more efficient use of land (five L6e or L7e category vehicles can occupy a parking space for one car)

Source	Category	Benefits
		• are shorter and narrower and can remain mobile in a traffic jam (more so for L1e–L3e category vehicles, which are not within the scope of this project).
Karaca et al., 2018	Conference proceeding	• Microcars have many advantages due to their small size and relatively slow speed. They offer users personal freedom as they can drive with significantly less traffic, parking woes, less GHG emissions and lower overall operating costs. Compared to motorcycles they offer the added protection from weather conditions as well as the stability of a conventional car. • An increase in microcars in cities can lead to improved air quality. Due to their small size and manoeuvrability, microcars can decrease traffic jams and air pollution caused by conventionally sized cars. It is expected that the world will turn to electric mobility to combat the rising problem of pollution and depleting fossil fuels. It is imperative now more than ever to find solutions to the growing mobility challenges. Public transport is limited by fixed departure times and a 'limited network bounded by stops' (p. 7). Microcars offer a flexible alternative to public transport.
Mu & Yamamoto, 2012	Journal article	• A study was carried out on the characteristics of traffic where microcars were present in the traffic flow. The study conducted an analysis by implementing cellular automata simulation model. It determined that where microcars were present, there was a relief to some extent of traffic congestion. The study found that high-density traffic saw smoother and faster movement with increase in microcars in traffic.
Mu & Yamamoto, 2013	Journal article	• A study was conducted to determine the influence of microcars in traffic. From the results it can be inferred that an increase in proportion of microcars at a lower desired speed results in higher fuel efficiency and fewer emissions. This is because at a lower speed the vehicle power requirement is lower. • When conducting the analysis from the perspective of both the environment and travel efficiency, the study proposes finding a balance. The authors suggest setting a desirable speed of between 40 and 45 km/h to achieve fuel efficiency while still not negatively impacting travel efficiency.
Mu & Yamamoto, 2019	Journal article	A study funded by the Environment Research and Technology Development Fund of the Japanese Ministry of the Environment investigated the impact to safety of microcars present in traffic flow. A microcar here is defined as a 'two-seater two-door lightweight vehicle and less than 3 m long' (p. 218). The study made use of the TCA model in their analysis. The model took into consideration 'the number of lane changes, the number of decelerations, the speed distribution, and the instantaneous power per unit mass (VSP [vehicle-specific power]) from the simulations' (p. 219). The study determined the following: • When considering lane changes, where traffic was composed of either conventional cars or microcars exclusively, lane changes occurred less frequently. Where the two vehicle types are combined in free flow on a highway, an increase in the number of microcars lane changing occurred less often. With regard to safety, it was determined that microcars may negatively impact traffic safety where the density of traffic is less than 30 veh/km/lane (ie, when there is free-flowing traffic). However, on arterial roads even at this density, microcars do not have a negative influence. The implication here being microcars may be dangerous for use on highways due to the frequent lane changes that occur. • When looking at how many decelerations occur as an aspect of safety, the study found that microcars were hazardous in free-flowing traffic in highways but not on traffic on arterial roads. • When looking at speed variation as an aspect of safety, the study found that microcars pose a safety disadvantage on highways. • An analysis of emissions considering VSP showed that there were fewer emissions on arterial roads compared to highways where there were more emissions of HC, NO and NO_x under free-flow conditions. • The size of microcars compared to conventional cars also potentially poses a traffic safety concern. The size of microcars may impact crash risk as roads are

Source	Category	Benefits
		designed with conventional vehicles in mind. Some design elements that may impact crash risk such as driver's eye level arise due to the size of microcars.
Tanveer et al., 2022	Research article	• On average, car occupancy is estimated at less than 2. Given the low occupancy of conventional cars (which can hold up to 5 people), introduction of microcars (which can hold up to 2 people) into the traffic flow would reduce congestion without affecting occupancy. • Microcars are smaller than conventional cars. The weight difference would decrease the aggressiveness of a crash with pedestrians in comparison to a conventional car. • Microcars offer accessibility benefits for older people and people living with disabilities. Additionally, it offers last mile connectivity for mass transit users. • Microcars offer improved quality of service compared to public transport, particularly in areas that are less dense.
Honey et al., 2014	Journal article	• Private vehicles spend a large amount of time parked. '…the US requires an area the size of Connecticut for parking and the world would waste a paved area the size of England for parking if the world's vehicle ownership levels reached those of the US' (p. 141). It is estimated that drivers cruising for parking spots in the USA account for 8% of all traffic. Large areas allocated to parking generate 'dead spaces', which lead to the sprawl of communities. Three microcars can occupy the space of one conventionally sized car.
Benders et al., 2022	European Commission report	• L-category vehicles, while outnumbered by M- and N-category vehicles (goods and passenger vehicles) in the UK, occupy less space on the road and are lighter and smaller in size. Thus, they align with concerns related to transport externalities around road transport such as reducing energy consumption, decongesting cities and communities, and improving air quality.

Table A.2 Costs of quadricycles

Source	Category	Costs/Challenges
Hutchinson, 2018	Low Carbon Vehicle Partnership report	• The L-category market is filled with small vehicle manufacturers that have inadequate funds for development. Entry of larger vehicle manufacturers could benefit the industry by pushing the boundaries of what is possible in this vehicle sector.
Bastien & Davies, 2018	Low Carbon Vehicle Partnership report	• Crash safety of L-category vehicles is not currently covered in EU regulations. The regulations currently in place cover functional safety but not crash testing, as is done for M-category vehicles.
Department for Transport, 2022a	Department for Transport report	• L-category vehicles account for 3.3% of UK licensed vehicles and contribute to 0.4% of the country's annual domestic GHG transport emissions. On the whole, road vehicles account for 91% of the domestic annual GHG emissions.
Benders et al., 2022	European Commission report	• When discussing the cost in terms of price of SEVs, it bears distinguishing the difference in the vehicle types. SEVs can appear to be more expensive compared to e-scooters, bicycles, and cars from the second-hand market. The purchase price of SEVs can negatively affect a consumer's decision to purchase. SEVs carry fewer people and less luggage and appear as more expensive. Despite this, compared to new cars, battery electric vehicles – in particular, SEVs – are still relatively cheaper. • Manufacturers face significantly higher costs for small series runs compared to mass production. For SEVs to have wider market appeal, an attractive price is needed. Here enters the dilemma faced by manufactures – for example, to offer a vehicle with higher safety standards that is safer and of a higher quality, the cost needs to reflect this.

Source	Category	Costs/Challenges
		• Currently, the pricing schemes are not favourable for SEVs in numerous countries. Some of the challenges faced by SEVs include high speed limits within city limits, limited advantages in fewer lanes or parking, lack of incentives and few models available in the market. • SEVs can thus appear as relatively expensive with limited benefits to people who would otherwise use them.
Renault Group, 2020	Company website	• Renault Group offers two quadricycle models: the Twizy 45, which costs €7,450 (≈ NZ$13,400), and the Twizy 80, which costs €8,240 (≈ NZ$14,800). The costs vary based on country. In many countries, there are incentives such as bonuses, Value Added Tax discounts or cancellation and other tax benefits of buying electric cars. These benefits should not be overlooked when looking at the purchase price of quadricycles.
Adams, 2020	News article	• Running costs for the Smart EQ Fortwo mini-car are 10.3–14.1 miles per pound with electric motor home charging and 5.6–7.6 miles per pound with electric motor public charging. 'Low figures relate to the least economical version; high to the most economical. Based on WLTP [Worldwide Harmonised Light Vehicle Test Procedure] combined fuel economy for versions of this car made since September 2017 only, and typical current fuel or electricity costs.'
Holding, 2019	News article	• Micro Electric launched three quadricycles in 2019 in the UK. The 'me' costs £11,499 (≈ NZ$23,189). Two other variants are offered with lead acid batteries. A second variant that is termed 'Low speed' costs £7,999 (≈ NZ$15,435), and a 'High Speed' model costs £9,999 (≈ NZ$19,294).
Lieven et al., 2011	Journal article	• A study of market potential of electric cars investigated 14 EV types including microcars. The study considered microcars whose cost was between €8,000 and €15,000 (≈ NZ$14,796 and NZ$27,723). The study found that there was a high price barrier for micro/city cars that result from 'proportion of the vehicle prices regarding conventional vehicles and EVs. In this category, EVs may be up to three times more expensive than the same vehicle with a conventional motor' (p. 242). • Where more expensive versions are under consideration, this proportion declines. In the compact and midsize car range, the price barriers are lower. In this category, EVs have more potential than microcars. 'Not all of these vehicles are used for long-distance trips, and as the price proportion is lower, there will be a higher probability for EV purchases (up to 11.9% in the executive class)' (p. 242).

Table A.3 Influencing factors of future uptake of quadricycles

Source	Category	Factor
		Consumer and manufacturing trends
Natarajan, 2021	News article	• Kia has indicated that it intends to launch an electric quadricycle/microcar in partnership with Arrival, a UK-based start-up working in the commercial EV space. This launch would involve offering microcars like the Citroën Ami.
Gauthier, 2019	News article	• Reports indicate that Daimler could do away with its microcar as it appears to have not been profitable. The sales of its vehicles were dropping in recent years in the USA (1,276 units sold in 2018), which has been attributed in part to its choice to only sell electric cars. The company did better in Europe with more sales (97,346) but was never able to reach its targets (200,000). • While this paints a negative picture, the future of Smart is not bleak. There are indications Daimler has been in talks with Beijing Automobile International Corporation (BIAIC) and Geely about a potential partnership.

Source	Category	Factor
Natarajan, 2022	News article	• The Citroën family expanded in May 2021 with the company's head of design hinting there could be different versions in the future.
GreenFleet, 2021	News article	• News reports indicate that 12,000 customers have registered their interest in a zero-emission microcar named the Ami by Citroën. This vehicle was set to launch in spring of 2022. • The vehicle, while adapted to the UK market, is left-hand drive. This is not without its benefits. A left-hand drive allows for a kerbside exit when parking.
Holding, 2019	News article	• Micro Electric, a start-up, launched a small range of electric quadricycles. The company developed three all electric vehicles with up to a 93-mile (ca. 150 km) range on a 10kWh battery. The top speed is denoted as 48 mph (ca. 77 km/h).
Weiss, 2020	News article	• 'EAV has announced a family of urban cargo vehicles that includes a tractor-trailer and refrigerated quadricycles. Now the British company is teaming up with Finnish electric drive hardware/software specialist Revonte in further evolving its pedal-assist electric drive platform around the unique needs of urban cargo delivery.'
Government/EU policy		
European Commission, 2020b	European Commission report	• The EU proposes setting in place stricter emission targets to meet set climate goals. Based on existing policy frameworks, the 2050 goals will not be met. • The European Commission proposes setting a 55% emission reduction target by 2030, which would set the EU on track to achieve climate neutrality. To achieve this, the European Commission will need to support EU companies to deploy low-carbon solutions in their operations. In addition, mobility will need to shift to zero emission by replacing conventional vehicles with zero emission ones as well as promoting the development of public transport. Sustainable transport modes and multi-modal solutions will also need to be integrated into clean mobility solutions. Electric L6 and L7 vehicles fit very well with this ambition as they promote public transport use and last mile connectivity.
Davies & Nieuwenhuis, 2018	Low Carbon Vehicle Partnership report	• There is a paucity of evidence on which to base policy. There is limited data on accident figures related to L-category vehicles. • 'Based on the available accident data, figures compiled by the UK Transport Research Laboratory for Austria, France and UK show that whilst there was a higher indicated fatality risk (between 10 and 14 times that of passenger car occupants), the data was ambiguous in identifying problems as the data was not disaggregated by quadricycle type, making the safety risk of different types of quadricycle difficult to determine (TRL CPR383). Based on accident data alone, the question is whether these vehicles require legislating at a European level, or whether national or local solutions are more appropriate' (pp. 8–9). • There is a variation of vehicle types that can be found in different regions based on the prevailing regulations. • There is a lack of a unified definition of L-category vehicles at a global level. EU regulations define L-category vehicles based on weight, power and speed for regulatory purposes. As a direct consequence of this lack of a unified classification of lightweight vehicles, the technical standards of these vehicles is not uniform. A national-level unified categorisation of these vehicles would not have as great an impact to manufacturing costs and economies of scale as would a global one. Different categorisations in different markets would negatively impact this market segment and would undoubtedly lead to increased costs to manufacturers and consumers.

Source	Category	Factor
		• Several recent actions by the EU show a trend towards EU-wide regulations on L-category vehicles, with notable examples of 2002/24/EC – Regulation (EU) 168/2013, which provides detailed technical requirements and test procedures for the environmental and propulsion unit performance for the approval of vehicles in the L-category. This regulation repeals previous directives covering the categorisation of such vehicles. Despite Regulation (EU) 168/2013 coming into force, there remains an essential difference in the regulation of L-category vehicles compared to that of passenger cars. L-category vehicles are often used in urban centres with an increased potential to interact with pedestrians, increasing the potential of conflicts. Occupants of these vehicles are also in potential danger should a traffic crash occur due to the reduced size of the microcars. • Government push towards reducing CO_2 emissions positively impacts uptake of L-category vehicles. • Future adoption of strict regulatory frameworks on L-category vehicles could bring about competitive advantage where these frameworks spread to other markets. Should this arise, companies that were operating in countries that set forth these regulations early would have 'early mover advantages' where this technology is concerned. • Case study France: France has put in place (as of 19 January 2013) a new class of driver licence for L-category vehicles (whereas a full licence is needed for L7 vehicles). People born after 1 January 1988 must have this licensing to operate this class of vehicles. There is no exam, but a theoretical and practical training is required and must be signed off by an approved driving school.
Department for Transport, 2022a	Department for Transport report (UK)	• The UK government has legislated a government commitment to end its contribution to climate change by making the commitment to 'net zero greenhouse gas emission by 2050'. Part of this requires decarbonising the transport sector within the UK. The government is committed to 'a phase out date of 2035, or earlier if a faster transition appears feasible, for the sale of new non-zero emission powered two and three wheelers (and other L-category vehicles)' (p. 4). • L-category vehicles are a growing sector in the UK with new licensed L-category vehicles increasing in 2021 to 5,800 from 2,400 in the previous year 2020. • The UK government has set out an EV infrastructure in the 2035 delivery plan, which details a vision for what is required to facilitate a transition to zero-emission vehicles and how the public and private sector can help achieve it. With suitable cable adjustments it is possible for some L-category vehicles to use the same charge points as electric M-vehicles while having shorter charging times due to their smaller batteries. • Electric L7 vehicles accounted for 'over 18.58% of UK market sales in 2021' (p. 18). It is expected that there will be a launch of 'a wide range of new electric quadricycles into the UK market, highlighting this technology is already available, affordable and practical' (p. 18). • The UK government proposed to end sale of new non-zero emission vehicles in the L6 and L7 category by 2030.
Davies & Bastien, 2021	Journal article	• In a crash involving two vehicles, the lighter one experiences a greater change in velocity compared to the heavier vehicle because 'for a collision between objects of dissimilar mass, conservation of momentum dictates that the change in the velocity of the lighter object will be greater than that of the heavier object' (p. 16). Therefore, there is a higher injury risk for the occupants of lighter vehicles such as microcars.

Source	Category	Factor
Benders et al., 2022	European Commission report	• Due to the need for SEVs to be lightweight, they are not equipped with extensive safety equipment. As crash testing is not mandated by regulation for these vehicles in many countries, they are equipped with only basic safety features. • A new UK powered light vehicle working group was established in 2019 to support the government's vision. The working group looks to advance the recommendations and discussion points from the Low Carbon Vehicle Partnership working group's work.
Santucci et al., 2016	Journal article	• 'According to the roadmap adopted by European Commission for next decade, one of the key goals is: no more conventionally fuelled cars in cities by 2050 and "the use of smaller, lighter and more specialised road passenger vehicles" is encouraged in order to achieve clean urban transport and commuting' (p. 3652). L-category vehicles present a feasible solution to this problem.
European Commission, n.d.	European Commission website	• The European Commission has the intermediate target of an at least 55% net reduction in greenhouse gas emissions by 2030. • EU-wide fleet emissions between 2020 and 2024 are set as 95 g CO_2/km for cars and 147 g CO_2/km for vans. The emission targets for 2025–2030 are even stricter. • These regulations do not currently apply to L-category vehicles, but it can be expected that once regulations catch up it would be the case to have similar strict emission targets. • The European Commission has incentive schemes for low-emission vehicles under a super credit system.
Consumer and market trends		
Davies & Nieuwenhuis, 2018	Low Carbon Vehicle Partnership report	• Increased consumer demand for L-category vehicles presents a concern as regulations in the areas of crash and environmental protection for L-category vehicles is not at par with that of passenger cars.
Benders et al., 2022	European Commission report	• Concerns around the safety of SEVs is seen as a stumbling block. • There are public concerns about a shift from active transport modes and public transport to SEVs despite there not being evidence of this.
Natarajan, 2022	News article	• Customer interest in the Citroën Ami has been soaring in the UK despite the vehicle's left-hand steering configuration.
Gordade, 2022	News article	• Popularity of electric cars and the various microcar models promotes the growth of the microcar market.
GreenFleet, 2021	News article	• Thousands of buyers expressed interest in the Ami zero-emission quadricycle ahead of its UK launch in spring 2022.
Lieven et al., 2011	Journal article	• 'Micro/city cars show response patterns similar to that of secondary cars. Range barriers are relatively low, but price barriers are the highest of all vehicle categories. This makes the consideration of an EV purchase unlikely. This is interesting in light of the multitude of micro cars forecast to come into the market in the near future' (p. 241).
Lobby action		
Davies & Nieuwenhuis, 2018	Low Carbon Vehicle Partnership report	• Possible model for pushing for L-category vehicles and other vehicles for environmental optimisation. In the USA, grassroots action of various communities pressured the USA and regulators to accommodate EVs even though they fell out of existing legislation. Residents of Palm Desert, California, were able to successfully lobby to have golf carts permitted on certain roads despite there being speed limitations in place for where golf carts could be used (ie, on roads with no more than 26 mph (ca. 42 km/h) speeds within 1.6 miles (ca. 2.6 km) of a golf course).

Appendix B: List of makes and models

Table B.1 List of makes and models of quadricycles

Make	Model
AEON	RA56-400
CFMOTO	CFORCE 1000
	CFORCE 450 L
	CFORCE 550
	CFORCE 600
	CFORCE 850XC
CITROEN	AMI
	AMI 6
	AMI 8
	AMI 8 CLUB
	AMI 8 CLUB CENTRIFUGAL
	AMI 8 CONFORT
	AMI 8 CONFORT CENTRIF
	AMI 8 LUXE
	AMI 8 LUXE CENTRIFUGAL
	AMI 8 SERVICE VAN
	AMI SUPER
	AMI SUPER CLUB
	MY AMI CARGO
	AMI SUPER SERVICE VAN
CPI	CRAB 100 (QUAD)
PAXSTER	PAXSTER
POLARIS	PHOENIX 200 (QUAD)
	PHOENIX 200 E
	PHOENIX 200 QUAD
	SAWTOOTH 200 (QUAD)
RENAULT	TWIZY CARGO
	TWIZY COLOUR
	TWIZY DYNAMIQUE
	TWIZY EXPRESSION
	TWIZY I DYNAMIQUE EV
	TWIZY I EXPRESSION EV
	TWIZY TECHNIC
	TWIZY URBAN

Make	Model
SMC	JP (QUAD)
	QUADZILLA 300 L (QUAD)
	QUADZILLA 300E XLC (QUAD)
	QUADZILLA 200E
	QUADZILLA STINGER 170E
	QUADZILLA STINGER 200E
	QUADZILLA STINGER 250E
	QUADZILLA SUV 200E
YAMAHA	YFM 350 R (QUAD)
AIXAM	400 SUPERLUXE AUTO
	500 E AUTO
	500 LUXE
	500 LUXE MINIVAN
	500 SL AUTO
	500 SUPER LUXE
	500 SUPER LUXE MINIVAN
	500 UT AUTO
	500.5 ECO
	500.5 LUXE
	500.5 LUXE MINIVAN
	500.5 SUPER LUXE
	500.5 SUPER LUXE MINIVAN
	A751 SUPER LUXE
	COUPE S
	CROSSLINE MINAUTO CVT
	CROSSLINE PACK
	CROSSLINE PREMIUM GT CVT
	CROSSLINE SUPER LUXE
	CROSSLINE SUPER LUXE D CVT
	CROSSOVER GT D CVT
	CROSSOVER GTR CVT
	MEGA 500L
	MEGA 500L DIESEL
	MEGA 500L ELECTRIC
	MEGA CITY ELECTRIC
	MEGA CITY+ AUTO
	MEGA MULTITRUCK 600D L A
	MEGA MULTITRUCK 600E A

Make	Model
	SCOUTY GTR
	500 ECO MINIVAN
	500 L AUTO
	MAC 500
	M-8 SXI CVT
	M-GO HIGHLAND CVT
	M-GO HSE CVT
	M-GO LX CVT
	M-GO PARIS CVT
	M-GO SE CVT
	M-GO SLX CVT
	M-GO SXI CVT
	MC1 DYNAMIC GSE CVT
	MC1 DYNAMIC HSE CVT
	MC1 DYNAMIC LX CVT
	MC1 DYNAMIC SE CVT
	MC1 DYNAMIC SLX CVT
	MC2 SE DYNAMIC CVT
	VIRGO ODYSSEY LX AUTO
	VIRGO ODYSSEY SLX AUTO
	VIRGO PREMIER LX AUTO
	VIRGO PRESTIGE HSE AUTO
	VIRGO PRESTIGE SE AUTO
LIGIER	AMBRA COUNTRY AUTO
	AMBRA GLX AUTO
	PULSE 3
REVA	G-WIZ

Table B.2 List of makes and models of quads

Make	Model
ADLY	ATV-300 (QUAD)
	ATV-300 XS (QUAD)
	ATV-320 (QUAD)
	ATV-500 S (QUAD BIKE)
	QUADZILLA 300E S (QUAD)
	QUADZILLA 300E U (QUAD)
AEON	COBRA 180 (QUAD)
	COBRA 2 REVO (QUAD)

Make	Model
	COBRA 220 (QUAD BIKE)
	GOES 220 (QUAD)
BAROSSA	CHEETAH 170 (QUAD)
	CHEETAH 250 (QUAD)
BASHAN	BS 200 S-3 (QUAD)
	BS 200 S-7 (QUAD)
BOMBARDIER	DS 250 (QUAD)
	OUTLANDER 650 (QUAD)
	OUTLANDER 800 (QUAD)
	OUTLANDER 800 MAX XT (QUAD)
	OUTLANDER MAX 650 (QUAD)
	OUTLANDER MAX 800 (QUAD)
	OUTLANDER MAX XT (QUAD)
	RALLY (QUAD)
	RENEGADE 800 EFI (QUAD)
BRP	OUTLANDER 400 HO (QUAD)
	OUTLANDER MAX 400 HO (QUAD)
	TRAXTER (QUAD)
CAN-AM	DS 450 X (QUAD)
	OUTLANDER 400 (QUAD)
	OUTLANDER 650 (QUAD)
	OUTLANDER 800 (QUAD)
	OUTLANDER MAX 400 (QUAD)
	OUTLANDER MAX 650 (QUAD)
	OUTLANDER MAX 800 (QUAD)
	OUTLANDER XT 800 (QUAD)
	RENEGADE 500 (QUAD)
	RENEGADE 800 (QUAD)
CPI	CRAB 100 (QUAD)
	XS 250 (QUAD)
DERBI	DXR 200 (QUAD BIKE)
	DXR 250 (QUAD BIKE)
DINLI	150 (QUAD)
	DL 901 (QUAD)
	DL801 (QUAD)
ETON	EXL 150 VIPER (QUAD BIKE)
	EXL 150 VIPER ST (QUAD)
	VXL 250 VECTOR (QUAD)

Make	Model
	VXL 250 VECTOR ST (QUAD)
GAS GAS	WILD E HP 450 (QUAD)
GO-KART	DF 500 GK (QUAD)
GOKA	GK 250-2D (QUAD)
	GK 650-2A (QUAD)
GSMOON	XY KD 260-2 (QUAD)
HONDA	TRX 250 TE (QUAD)
	TRX 250 TM (QUAD)
	TRX 350 FE (QUAD)
	TRX 350 FM (QUAD)
	TRX 350 TE (QUAD)
	TRX 350 TM (QUAD)
	TRX 420 FE (QUAD)
	TRX 420 FM (QUAD)
	TRX 420 TE (QUAD)
	TRX 420 TM (QUAD)
	TRX 500 FA (QUAD)
	TRX 500 FE (QUAD)
	TRX 500 FM (QUAD)
	TRX 680 FA (QUAD)
HYOSUNG	TE 450 RAPIER (QUAD)
JIANSHE	JS 250 ATV (QUAD)
KINROAD	XT 250 GK-7 RACER (QUAD)
	XT 250 GK-8 JEEP (QUAD)
KYMCO	KXR 250 RL (QUAD)
	MAXXER (QUAD)
	MXU 150 (QUAD)
	MXU 250 RL (QUAD)
	MXU 300 (QUAD)
	MXU 400 (QUAD)
	MXU 500 (QUAD)
LINHAI	P4W (QUAD)
LONCIN	LS2 (QUAD)
	LS2 CONQUEROR (QUAD BIKE)
	LS2 VARIANT 2A (QUAD)
MOTO ROMA	UQ 150 (QUAD)
	UQ 300 (QUAD)
MZ	EAGLE KX-150 (QUAD BIKE)

Make	Model
PGO	BR 200 (QUAD)
	BR 500 (QUAD)
POLARIS	ATP 330 (QUAD)
	HAWKEYE 300 E (QUAD)
	OUTLAW (QUAD)
	OUTLAW 525 E/S (QUAD)
	PHOENIX 200 (QUAD)
	PREDATOR 500 E (QUAD)
	RANGER 500 E (QUAD)
	SAWTOOTH 200 (QUAD)
	SCRAMBLER 500E (QUAD)
	SPORTSMAN 500 IE/6 (QUAD)
	SPORTSMAN 500E (QUAD)
	SPORTSMAN 800 E (QUAD)
	SPORTSMAN X2 (QUAD)
	SPORTSMAN X2 800 (QUAD)
	TRAILBLAZER 330 E (QUAD)
	TRAILBOSS 330E (QUAD)
QUADZILLA	300-2 (QUAD)
	320E 4X4 SUV (QUAD)
	CF 500 (QUAD)
	CF 500-2 (QUAD)
	CF 500-2A (QUAD)
	CF 500-A (QUAD)
SFMM	QUADZILLA XRV 250E (QUAD)
SKYGO	SG 125 ST-A (QUAD BIKE)
SMC	JP (QUAD)
	QUADZILLA 300 L (QUAD)
	QUADZILLA 300E XLC (QUAD)
	RAM 170E (QUAD)
	RAM 250E (QUAD)
	RAM QUADZILLA 250E (QUAD)
SYM	QUADLANDER (QUAD)
	TRACK RUNNER (QUAD BIKE)
TAIWAN GOLDEN BEE	BLADE 250 (QUAD)
	FBE BLADE 425 (QUAD)
XINLING	XL 150 A (QUAD)
	XL 250 (QUAD)

Make	Model
YAMAHA	YFM 350 R (QUAD)
ADLY	ATV-500 S (QUAD)
AEON	COBRA 220 (QUAD)
CPI	XT 50 5 (QUAD BIKE)
	XT 50 5 (QUAD)
DERBI	DXR 200 (QUAD)
	DXR 250 (QUAD)
DINLI	FACTORY (QUAD BIKE)
	FACTORY (QUAD)
ETON	EXL 150 VIPER (QUAD)
LONCIN	LS2 CONQUEROR (QUAD)
MZ	EAGLE KX-150 (QUAD)
SKYGO	SG 125 ST-A (QUAD)
SYM	TRACK RUNNER (QUAD)