SURFACE VEHICLE RECOMMENDED PRACTICE

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Taxonomy and Classification of Powered Micromobility Vehicles

RATIONALE

This document has been reviewed to comply with the SAE Five-Year Review policy and has been revised to update the references section and to add NOTES to the Classification System section.

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1. SCOPE

This technical report provides a taxonomy and classification of powered micromobility vehicles. These vehicles may be privately owned or be available via shared- or rental-fleet operations. This technical report does not provide specifications or otherwise impose minimum safety design requirements for powered micromobility vehicles.

NOTE 1: There may be powered micromobility vehicles designed for different purposes: (1) human transport; (2) vocational applications; and (3) goods delivery. This technical report only covers vehicles that are primarily designed for (1). Other categories may be covered in future SAE Technical Reports.

NOTE 2: This technical report is aimed only to define and describe powered micromobility vehicle types and classifications. It does not prescribe safe or appropriate classifications of vehicles, nor does it suggest where in the transportation system the vehicle should operate.

NOTE 3: For taxonomy specifically related to shared- or rental-fleet operations of micromobility vehicles, refer to SAE J3163.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J2358 Low-Speed Vehicles

SAE J3163 Taxonomy and Definitions for Terms Related to Shared Mobility and Enabling Technologies

SAE J3230/1 Kinematic Performance Metrics for Powered Standing Scooters

Goodsell, D. (1989). *Dictionary of automotive engineering*. SAE International.

2.1.2 Code of Federal Regulations (CFR) Publications

Copies of these documents are available online at https://www.ecfr.gov.

16 CFR § 1512.2 Definitions

49 CFR § 571.3 Definitions

2.1.3 Other Publications

NIOSH (1994). Applications manual for the revised NIOSH lifting equation. By Waters TR, Ph.D., Putz–Anderson V, Ph.D., Garg A, Ph.D. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94-110 (Revised 9/2021), https://doi.org/10.26616/NIOSHPUB94110revised092021.

State of California Vehicle Code, Section 312.5

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J213 Motorcycle Classifications

SAE J1451 A Dictionary of Terms for the Dynamics and Handling of Single Track Vehicles (Motorcycles, Scooters, Mopeds, and Bicycles)

Chang, A., Miranda-Moreno, L., Clewlow, R., and Sun, L. (2019). *Trend or fad? Deciphering the enablers of micromobility in the U.S.* SAE International.

2.2.2 Other Publications

Fang, K., Weinstein Agrawal, A., and Hooper, A. (2019). *How and where should I ride this thing? Rules of the road for personal transportation devices*. Project 1713. Mineta Transportation Institute.

3. DEFINITIONS

The definitions provided below are developed for use in the context of powered micromobility vehicles only. Existing definitions for other vehicle classes (e.g., motor vehicles) and fields may conflict with the definitions provided below.

3.1 ACCELERATOR

The hand or foot lever or switch that regulates the speed and output of a motor.

NOTE: Accelerator is also referred to as throttle.

3.2 BICYCLE

A vehicle with two or three wheels, solely human-powered, propelled by operable pedals (or a hand-driven equivalent) affixed to a mechanical propulsion system transmitted to one or more wheels, and has handlebars for steering and a saddle-like seat.

NOTE: A trike or tricycle is a three-wheeled bicycle.

3.3 BODY

The external structure of a vehicle that may include a roof, fairing, windscreen, fenders, doors, or other external components.

3.4 BRAKES

The energy conversion mechanism used to slow, stop, or hold a vehicle.

3.5 BRAKING SYSTEM

The combination of one or more brakes and the related mechanisms of operation and control.

3.6 CENTER COLUMN

The structural element used by the operator to control the vehicle; it may be used for steering and stability and may have handlebars, turn indicators, brake controls or other controls (such as a throttle), or information devices.

3.7 CURB WEIGHT

The weight of the base vehicle (standard equipment only), with all fluids filled to the maximum (e.g., fuel, coolant, etc.) and/or batteries without material or personnel load.

3.8 FOOT PLATFORM

A flat surface where the operator (and passenger) rests their feet, either while standing or seated; it typically accommodates the majority of the bottom surface of the feet of the operator (and passenger).

3.9 FOOTPEGS

Appendages to a vehicle only for the purpose of the operator (and/or passenger) resting their feet.

NOTE: Footpegs are also referred to as footrests.

3.10 HANDHELD CONTROL UNIT

A separate device used to control the speed and other aspects of the vehicle by the operator's hand and usually connected to the vehicle control system by wireless communication technologies (e.g., Bluetooth).

3.11 HANDLEBAR

The primary control for steering inputs; it also provides the operator (and passenger) stability support and functions as the mount for hand-operated controls and accessories.

3.12 HUMAN-POWERED

Describes a vehicle that may be propelled without motor assistance and solely through the means for human energy input.

3.13 INTERNAL COMBUSTION ENGINE

Engine in which energy is provided by combustion within a working chamber causing direct mechanical displacement of a piston, rotor, turbine, or other mechanical element.

NOTE: Definition is from Goodsell (1989).

3.14 LOW-SPEED VEHICLE

Refer to 49 CFR § 571.3 for definition of a low-speed vehicle.

NOTE: Information on low-speed vehicles can be found in SAE J2358.

3.15 MOTOR

A machine that converts electrical, chemical, or combustion energy into mechanical energy.

3.16 OPERABLE PEDALS

A pair of foot-operated levers affixed to a mechanical propulsion system that enables a vehicle to be propelled via human power.

3.17 OPERATOR

The person who is exercising balance, steering, braking, and speed control of the vehicle.

3.18 OPERATOR SEAT

The seat located directly behind the vehicle controls for the operator.

3.19 PASSENGER

A person who is transported on or in the vehicle but is not the operator.

3.20 POWERED VEHICLE

A vehicle that relies on full motor engagement for propulsion or partial motor engagement in addition to human power for propulsion.

3.21 REGULATORY AUTHORITY

A local, state, tribal, or federal governing authority, as applicable.

3.22 SELF-BALANCING MECHANISM

Elements to provide dynamic stabilization of a vehicle, achieved by a combination of sensors and gyroscopic devices inside the vehicle. A self-balancing mechanism turns a vehicle that is not statically stable to one that is stable when powered or in motion.

3.23 STATICALLY STABLE

The ability for a vehicle to remain upright and balanced while stationary and not powered with or without an operator and/or passenger.

3.24 TOP SPEED

Maximum speed when powered solely by the motor (with a fully charged battery) on a level surface.

NOTE: Top speed test procedures for powered micromobility vehicles may be developed in future SAE Technical Reports.

3.25 TRUCK ASSEMBLY

A component that includes the axle and attaches a pair of wheels to the base of a board.

4. POWERED MICROMOBILITY VEHICLE

A category of powered vehicles that have a curb weight of less than or equal to 500 pounds (227 kg) and a top speed of 30 mph (48 km/h) or less.

NOTE 1: The top speed of 30 mph is solely for the purpose of categorization. Powered micromobility vehicles should be operated at speeds deemed safe by local or state regulations and required by regulatory authorities. Each vehicle type and classification may have different top speeds and testing procedures.

NOTE 2: Powered micromobility vehicles are partially or fully powered by a motor. Thus, the class of powered micromobility vehicles excludes solely human-powered vehicles, such as a bicycle, skateboard, and roller skates.

NOTE 3: The vehicles covered in this technical report are primarily designed to be used on paved roadways and paths. The vehicles are not designed strictly for off-road (e.g., all-terrain vehicles) or non-land surfaces (e.g., vehicles for water or airborne usage).

NOTE 4: There may be powered micromobility vehicles designed for different purposes: (1) human transport; (2) vocational; and (3) goods delivery. This technical report only covers vehicles that are primarily designed for (1). Other categories may be covered in future SAE Technical Reports.

NOTE 5: The class of powered micromobility vehicles excludes motorcycles, mopeds and motor-driven cycles that exceed a curb weight of 500 pounds (227 kg) and/or a top speed of 30 mph (48 km/h).

NOTE 6: The class of powered micromobility vehicles excludes “low-speed vehicles” as defined in 49 CFR § 571.3.

NOTE 7: The class of powered micromobility vehicles excludes mobility aid devices primarily designed for use by persons with disabilities, such as powered wheelchairs and mobility scooters.

5. TAXONOMY OF POWERED MICROMOBILITY VEHICLE TYPES

5.1 Powered Bicycle

A wheeled vehicle that:

- Has operable pedals;
- Is steered by the operator using handlebars;
- Has a seat(s) for the operator (and passenger);
- Is powered partially or fully by a motor;
- Is manufactured primarily for transportation of not more than one person, except for specifically designed vehicles with multiple seats; and
- Is composed of two or three wheels held in a frame in the longitudinal direction of travel.

NOTE 1: Operable pedals are defined in 3.16.

NOTE 2: Speed may also be controlled manually by human power (e.g., pedaling to accelerate).

NOTE 3: This technical report does not address related devices, such as a motorized wheels or motor kits, that may turn a standard bicycle into a powered bicycle.

5.1.1 Electric Bicycle (E-Bike)

Refer to 16 CFR § 1512.2(a)(2) for definition of an e-bike.

5.1.1.1 Class 1: Pedal Assist

An e-bike that:

- Is equipped with an electric motor that provides assistance only when an operator is pedaling; and
- Has a motor that ceases to provide electrical assistance when the e-bike reaches the speed of 20 mph (32 km/h).

NOTE 1: Colloquial terms used are “class 1 e-bike,” “pedelec,” and “low-speed, pedal-assisted e-bike.”

NOTE 2: Definition is amended from State of California Vehicle Code, Section 312.5.

5.1.1.2 Class 2: Throttle on Demand

An e-bike that:

- Is equipped with an electric motor that may be used exclusively to propel the e-bike with a throttle; and
- Has a motor that ceases to provide electrical assistance when the e-bike reaches the speed of 20 mph (32 km/h).

NOTE 1: Colloquial terms used are “class 2 e-bike” and “low-speed, throttle-assisted e-bike.”

NOTE 2: Definition is amended from State of California Vehicle Code, Section 312.5.

5.1.1.3 Class 3: Speed Pedelec

An e-bike that:

- Is equipped with an electric motor that provides assistance only when an operator is pedaling;
- Has a motor that ceases to provide electrical assistance when the e-bike reaches the speed of 28 mph (45 km/h); and
- Is equipped with a speedometer.

NOTE 1: Colloquial terms used are “class 3 e-bike,” “speed pedelec,” and “speed pedal-assisted e-bike.”

NOTE 2: Definition is amended from State of California Vehicle Code, Section 312.5.

5.2 Powered Non-Self-Balancing Board

A wheeled vehicle that:

- Has neither a handlebar nor a center column;
- Is controlled by the operator using a handheld device or sensors on the foot platform for speed and is steered by the operator shifting their body and/or feet position;
- Has at least one foot platform for the operator to stand on;
- Is powered partially or fully by a motor;
- Is manufactured primarily for transportation of not more than one person;
- Is statically stable; and
- Has two trucks and at least three wheels.

NOTE 1: A colloquial term for powered non-self-balancing board with electric propulsion is “electric board” (e-board) or “electric skateboard” (e-skateboard).

NOTE 2: Speed may also be controlled manually by human power (e.g., operator kicking to accelerate or using foot or steering to decelerate).

5.3 Powered Self-Balancing Board

A wheeled vehicle that:

- May have a center column with handlebar;
- Is controlled by the operator manipulating controls on a center column and/or the operator distributing their weight for speed and steering;
- Has a foot platform or footpegs for the operator;
- Is powered solely by a motor;
- Is manufactured primarily for transportation of not more than one person;
- Is not statically stable and uses a self-balancing mechanism; and
- Has one wheel or two wheels in parallel.

NOTE: A colloquial term for some powered self-balancing board with a center column with a handlebar with electric propulsion is “electric personal assistive mobility device” (EPAMD).

5.4 Powered Skates

A wheeled vehicle that:

- Has two separate units, one for each foot of the operator to stand on;
- Is controlled by the operator distributing their weight by for speed and steering;
- Is powered solely by a motor; and
- Is manufactured primarily for transportation of not more than one person.

NOTE: A colloquial term for powered skates with electric propulsion is “electric skates” (e-skates).

5.5 Powered Seated Scooter

A wheeled vehicle that:

- Does not have operable pedals;
- Has a center column with a handlebar;
- Is controlled by the operator using the accelerator/throttle and brakes for speed and is steered with handlebar;
- Has a foot platform(s) and/or footpegs and seat(s) for the operator (and passenger);
- Is powered partially or fully by a motor;
- Is manufactured primarily for transportation of not more than one person, except for specifically designed vehicles with multiple seats; and
- Is composed of two or three wheels held in a frame in the longitudinal direction of travel.

NOTE: Operable pedals are defined in 3.16.

5.6 Powered Standing Scooter

A wheeled vehicle that:

- Has a center column with a handlebar;
- Is controlled by the operator using the accelerator/throttle and brakes for speed and is steered with handlebar;
- Has a foot platform for the operator (and passenger) to stand on;
- Is powered partially or fully by a motor;
- Is manufactured primarily for transportation of not more than one person, except for specifically designed vehicles; and
- Is composed of two or three wheels held in a frame in the longitudinal direction of travel.

NOTE 1: A colloquial term for powered scooter with electric propulsion is “electric scooter” (e-scooter) or “electric kick scooter.”

NOTE 2: Speed may also be controlled manually by human power (e.g., operator kicking to accelerate or using foot to decelerate).

6. CLASSIFICATION SYSTEM

6.1 Classification

The classification system consists of the micromobility vehicle type with descriptors of curb weight, vehicle width, top speed, and power source.

Table 1 - Classification system for powered micromobility vehicles

Name	Code	Description
Curb weight		
Ultra lightweight	WT1	Curb weight ≤ 50 pounds (23 kg)
Lightweight	WT2	50 pounds (23 kg) < curb weight ≤ 100 pounds (45 kg)
Midweight	WT3	100 pounds (45 kg) < curb weight ≤ 200 pounds (91 kg)
Midweight plus	WT4	200 pounds (91 kg) < curb weight ≤ 500 pounds (227 kg)
Vehicle width		
Standard-width	WD1	Vehicle width ≤ 3 feet (0.9 m)
Wide	WD2	3 feet (0.9 m) < vehicle width ≤ 4 feet (1.2 m)
Extra-wide	WD3	4 feet (1.2 m) < vehicle width ≤ 5 feet (1.5 m)
Top speed		
Ultra low-speed	SP1	Top speed ≤ 8 mph (13 km/h)
Low-speed	SP2	8 mph (13 km/h) < top speed ≤ 20 mph (32 km/h)
Medium-speed	SP3	20 mph (32 km/h) < top speed ≤ 30 mph (48 km/h)
Power source		
Electric	E	Powered by an electric motor
Combustion	C	Powered by an internal combustion engine