

Public Myths & Objections Regarding the Segway® (and its use by people with disabilities)



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Overview

Segway, Inc.

The Segway¹ is a universally designed assistive technology device, designed to (as closely as possible) represent the human footprint and human mobility characteristics.

In 2001, Dean Kamen announced the arrival of the first self-balancing, zero emissions personal transportation vehicle: the Segway® Personal Transporter (PT). Founded on the vision to develop highly-efficient, zero-emission transportation solutions using dynamic stabilization technology, Segway's research and development was focused on creating devices that took up a minimal amount of space, were extremely maneuverable and could operate on pedestrian sidewalks and pathways.

Since the Segway first went on sale to the general public in late 2002, the company's average annual growth rate has exceeded 50 percent². Approximately 60 percent of Segway's sales volume is comprised of individual consumers and commercial customers account for the remaining 40 percent. The Police and Security customer segment is one of Segway's fastest growing commercial sectors. More than 1,000 organizations worldwide now use Segway's as a policing and security tool³.

In 2006, the second generation Segway PTs were introduced. All the products feature breakthrough LeanSteer™ technology and a wireless InfoKey™ controller that enhance the Segway experience by making the ride even more intuitive and adding new and useful functions.

Segway's global distribution network is made up of more than 350 authorized retail points in 80 countries (approx. 115 in North America), 47 global authorized distributors and more than 200 guided tour operators around the world. Over 50,000 Segway's have been manufactured and distributed worldwide since its introduction.

¹ Segway is a registered trademark of Segway, Inc.

² <http://www.segway.com/downloads/pdfs/SegwayFact-Sheet.pdf>

³ <http://www.segway.com/downloads/pdfs/Police%20Patrol%20Overview.pdf>

Myths

1. Segways are too large and/or too heavy.

The width of the Segway (at 25 inches) is consistent with the shoulder width of an average framed human being and smaller of than the shoulder width of a large framed human being which typically exceeds 26 inches. A person on a Segway takes up roughly the same amount of space as a pedestrian.

In order to assure access, most wheelchairs are designed to maneuver within the parameters required under the Americans with Disability Act Accessibility Guidelines⁴ which would include having a footprint which is not larger than 30" x 48" and to be able to turn around in a 60" x 60" space. However scooters are not nearly as maneuverable as manual or power wheelchairs and some are unable to maneuver in the minimum space requirements by ADAAG models even utilizing three-point turns.

The footprint of the Segway⁵ is much smaller than that of a wheelchair and is able to maneuver in passageways as narrow as 25.5 inches and, because it has a zero turning radius, it can turn around in spaces less than 38 inches in diameter.

The Segway is designed to be usable indoors and is battery operated. The weight of a Segway (at 97 pounds or less) is lighter than most ECV's⁶ or scooters and virtually all powered wheelchairs. The empty weight for ECV's, scooters and power wheelchairs start at approx. 100 pounds on the low end and can exceed 400 pounds on the top end with the average exceeding 200 pounds – over twice the weight of the Segway on average and over four times the weight of the Segway at the top end of the spectrum.

2. Segways travel too fast.

The Segway is designed to operate at infinitely variable speeds consistent with human behavior between 0 mph and 12.5 mph. While the top speed of the Segway is consistent with that of the fastest power wheelchairs and ECV's or scooters, its top speed is slower than the typical human being⁷. The Segway's top speed is the equivalent of running a 5-minute mile.

⁴ <http://www.access-board.gov/adaag/html/adaag.htm>

⁵ Length x Width: i2 Series is 25.5" x 25", i Series is 19" x 25", P Series is 16" x 22"

⁶ Electric Convenience Vehicles

⁷ The fastest human being has been recorded at 27 mph, however the typical human can run at an average speed of 15 mph. Even older humans are quicker than the Segway. In 2005, at the National Senior Games, Bobby Whilden, (age 70 to 74 bracket) ran the hundred meters at a speed of 17.5 mph and James Hammond (age 90 to 94 bracket) ran the hundred meters at a speed of 11.3 mph.

The speed of the Segway is infinitely controllable from zero to the top speed setting. The Segway has the ability to balance in-place. Speed settings can be programmed⁸ to reduce the maximum speed allowed to a slow walking speed and the turning speed is adjusted accordingly for the speed setting utilized. But the Segway only travels at the speed the user determines is appropriate for the conditions. Intuitively, the user will match the speed of the Segway to the conditions of their environment. They will move with the flow of pedestrian traffic just as people do when walking.

The maximum top speed of the Segway (12.5 mph) is “hard-coded” in the electronics of the machine base and cannot be increased by the user. The machine has a built-in speed limiter which forces the user to slow when approaching the programmed speed setting (4.0 to 12.5 mph) and prevents the user from exceeding the speed setting. Additionally, Segway’s are designed to prohibit the user from exceeding the speed setting regardless of the terrain – flat ground, uphill or downhill. The machine simply will not let the user go faster than the programmed speed setting under any circumstances.

3. Segways travel much faster than other devices.

Higher-end power wheelchairs have top speeds ranging from 10 mph to 13 mph. Some ECV’s and scooters can travel more than 10 mph with the average being around 7 mph. According to studies, the use of a power wheelchair at speeds of 6 mph in crowded pedestrian conditions poses greater safety challenges than the use of an EPAMD⁹ at greater speeds in the same environment. See the power wheelchair and ECV-scooter speed charts on the following page¹⁰.

Some of these devices have aftermarket components available to increase the speed beyond the factory settings. These kind of unauthorized speed modifications are not possible with the Segway as discussed in section 2.

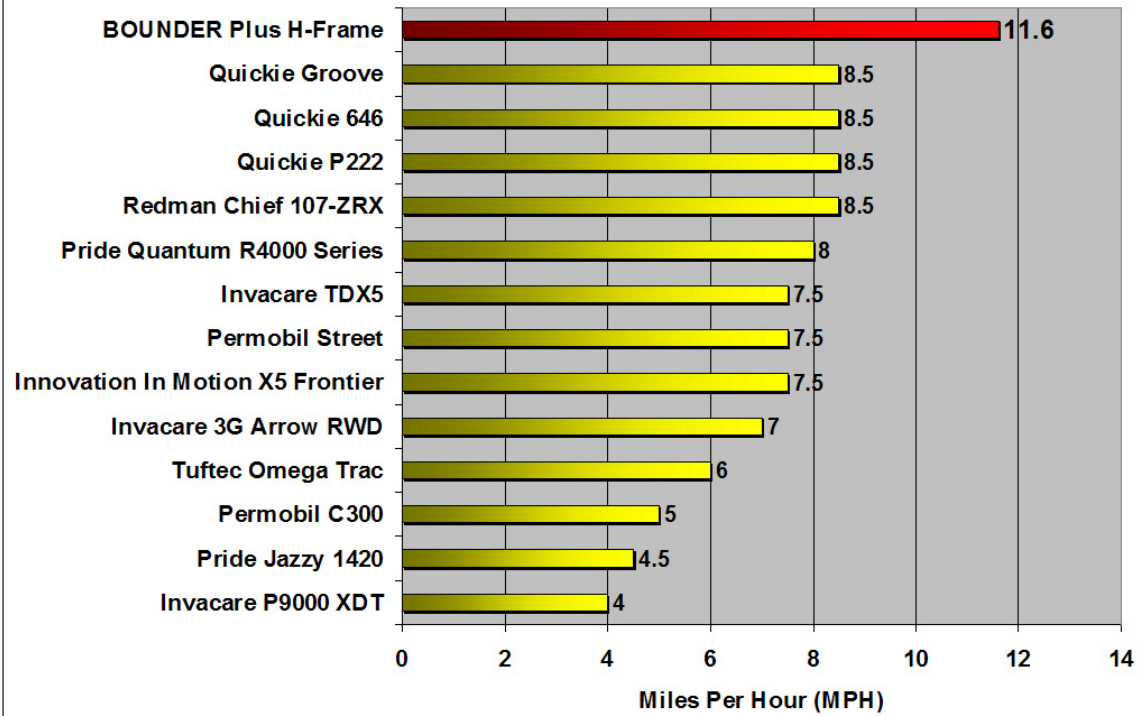
The use of any device at speeds which are unsafe or inappropriate for current conditions, whether using a wheelchair or an EPAMD is a behavioral issue. It is not an issue with the device but rather with the operator of the device and should be handled accordingly with the individual responsible for the behavior.

⁸ The Beginner Setting speed limit options range from 4.0 mph to 8.0 mph in increments of 0.5 mph. The Standard Setting speeds range from 4.0 mph to 12.5 mph in increments of 0.5 mph. (www.segway.com/downloads/pdfs/ReferenceManualSupplement.pdf)

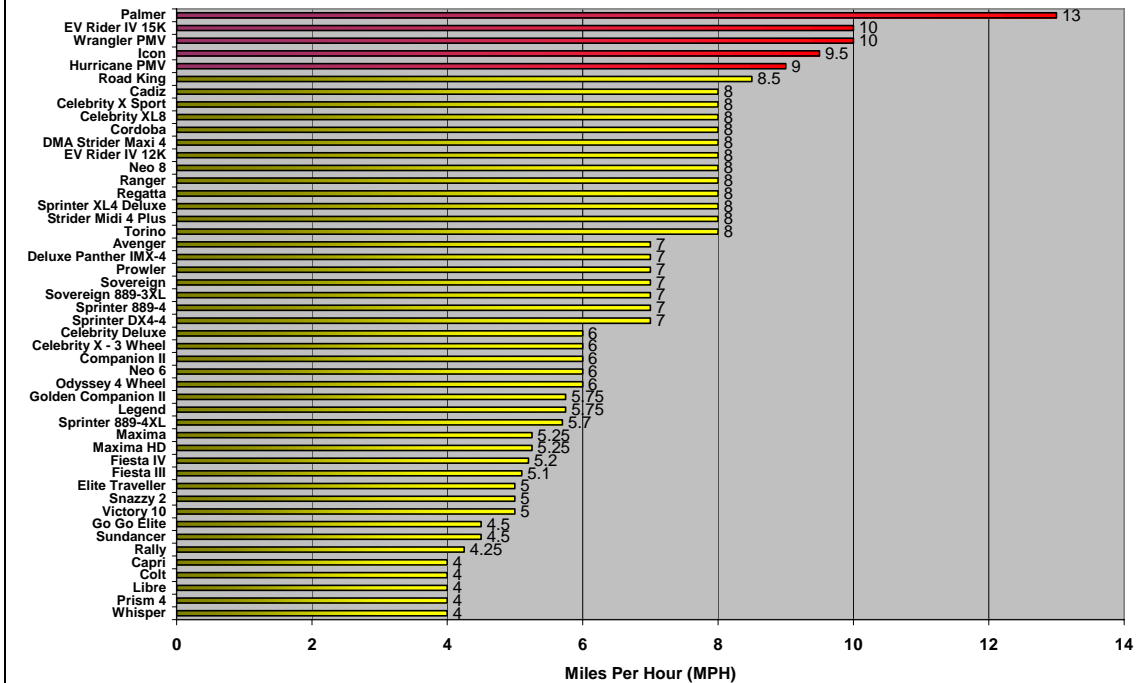
⁹ Electric Personal Assistive Mobility Device

¹⁰ <http://www.wheelchairs.com/fast.htm>, <http://www.betterlifehealthcare.com>, <http://mobility-scooter-reviews.com>, <http://www.scooter.com>, <http://www.discountscoters.com>, <http://palmerind.com>

POWER WHEELCHAIR MAXIMUM TOP SPEED



ECV-SCOOTER MAXIMUM TOP SPEED



4. Segways are not compatible with crowds.

The footprint of a Segway is comparable to that of a standing human and considerably less than an ECV or wheelchair. They are used on a regular basis in highly congested venues such as theme and amusement parks, zoos, museums, airports, train and bus stations, commercial and retail establishments, government buildings and monuments, grocery stores, restaurants and shopping malls.

The tires on the Segway are made of silica and are thus non-marring, they generate virtually no shear force and have less soil compression force than a human footprint, making them less likely to cause damage to flooring or other walking surfaces than human foot traffic. The Segways' tires are low pressure (PSI) and are designed to cause no injury when running over toes or fingers of another person.

The Segway is so appropriate for use in crowded pedestrian environments that it is being used by police and security forces in the densest of crowds at events all over the world including the Super Bowl and the Olympic Games in China. Even studies performed by the Department of Justice - National Institute of Justice¹¹ acclaim the appropriateness and benefits of the use of Segways in community policing efforts allowing officer interaction with pedestrians.

5. A person with a disability cannot safely control a Segway.

The Segway utilizes a new technology called Dynamic Stabilization. A sophisticated array of gyroscopes, tilt sensors, computer CPUs and software cause the machine to check and maintain balance over 100 times per second. The user doesn't balance the machine – the machine balances the user.

People with a wide range of disabilities are fully capable of safely operating the device. These disabilities include MS, COPD, ALS, Parkinson's disease, spina bifida, spinal cord injuries, severe burn victims and single/double amputees to name a few.

There has not been a reported incident of a person with a qualifying disability, using a Segway as a mobility device, causing injury to another person.

There is absolutely no evidence that the Segway poses any additional risk over that of any other mobility device and the continued contemplation of the imagined dangers has no basis in reality and cannot be supported by any scientific or engineering study in existence today.

¹¹ <http://www.ncjrs.gov/App/Publications/abstract.aspx?ID=238448>

6. ECV's are safer than Segways.

The Segway has been consistently rated as safe (or safer) than ECV's or wheelchairs (power or manual). There are a number of governmental¹² and private studies that find the Segway has excellent stability and controllability in a wide range of indoor and outdoor uses. These include the United States Department of Transportation – Federal Highway Administration and the Victoria Transport Policy Institute.

Segways can safely traverse slopes of up to 20° (36%), more than four times greater than most ECV's and power wheelchairs. The Segways' tires are low pressure (PSI) and are designed to cause no injury when running over toes or fingers of another person.

One of the primary performance designs for collision avoidance of the Segway is that the natural reaction of a human being upon recognizing a dangerous situation invokes a body movement which results in slowing the Segway or stopping it completely. The self balancing capabilities of the Segway are accomplished through the use of tilt sensors and gyroscopes. This limits the Segway's ability to continue forward if it were to run into another person or obstacle.

Upon an encounter, unlike a power wheelchair or motorized scooter which would continue to propel itself forward, the handlebars would push back causing the tilt sensors to stop the Segway and reverse its forward motion. The most likely strike point of the Segway would be in the upper body area of another human being versus the most likely strike point of the power wheelchair or motorized scooter being below the knee of another person.

The Segway is also designed to shut down in the event its user would become separated from the device when in operation. It is designed and built with redundant systems which will allow it, in the event of a mechanical failure, to warn the user of an impending shutdown and safely stop operation.

In addition to the white paper published by DRAFT¹³ titled “Universally Designed Technology Solutions – People Who Have Difficulty Walking & The Segway” (December 2007) and a paper published in Archives of Physical Medicine and Rehabilitation¹⁴ titled “The Segway Personal Transporter as an Alternative Mobility Device for People With Disabilities: A Pilot Study” (November 2007), the Segway has

¹² Centre for Electric Vehicle Experimentation in Quebec (CEVEQ), German Federal Board for Road Traffic, Victoria Transport Policy Institute, U.S. Department of Transportation/Federal Highway Administration – see www.segway.com/support/safety-studies.php

¹³ Disability Rights Advocates for Technology – see <http://www.draft.org/EducationAdvocacy/EducationAdvocacyLinks/tabid/75/Default.aspx>

¹⁴ <http://download.journals.elsevierhealth.com/pdfs/journals/0003-9993/PIIS0003999307013433.pdf>

been evaluated by four independent agencies¹⁵ representing interests from around the world.

All of the studies and reports support the assertion that the Segway (if not the safest) is certainly among the safest of all mobility devices and none of the reports cite any unique or substantive safety concerns about the use of the Segway interacting with others. Please review the Segway Safety Studies section contained in the Background section of this paper.

7. Segway, Inc. doesn't want people with disabilities using their device.

Segway's position was publicly stated on June 3, 2009¹⁶ as follows (excerpt):

“Our goal in issuing this statement is to be clear about our position that the Segway PT product is safe when used as directed in a variety of settings. The Segway PT is used by police officers and security personnel in crowded areas such as arena and downtown events.”

“Segway has incorporated the concepts of universal design into its commercially-available products. That said, Segway products are not medical devices and are not FDA approved. Our products are designed for a person (any person, whether disabled or not) who can ascend and descend stairs without assistance and without the use of a handrail, who is capable of exercising good riding judgment, and who is capable of riding in accordance with our instructions. Segway also recommends in the User Materials to be courteous to others in the riding area and to obtain permission before riding on private property.”

8. A mobility device must be FDA approved to qualify under ADA.

This is a common misconception. FDA approval has nothing to do with ADA protections. Canes, crutches, walkers, braces, and many ECV's and scooters are not FDA approved, but are covered under the ADA. Service dogs are covered under the ADA as well but lack FDA approval.

The 1973 Rehabilitation Act as amended in 1998, in the definitions contained in that act, applicable to every section of that act, including section 504, defined an assistive technology device as "any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities." It is an all encompassing definition and includes all items from Segways to wheelchairs. There is absolutely no

¹⁵ Centre for Electric Vehicle Experimentation in Quebec (CEVEQ), German Federal Board for Road Traffic, Victoria Transport Policy Institute, U.S. Department of Transportation/Federal Highway Administration – see www.segway.com/support/safety-studies.php

¹⁶ www.segway.com/about-segway/media-center/press-release/pr_060309.php

definition or mention of any other type of assistive device, including a wheelchair or scooter in the entire 1973 Rehabilitation Act as amended in 1998, nor does there need to be.

9. There is no law that says a disabled person can use a Segway for mobility purposes.

Those whose disabilities meet the standard of "substantial limitation" of a major life activity have protections which are afforded to them under The 1973 Rehabilitation Act and the Americans with Disabilities Act as well as many state laws.

In 1991, in publishing the first regulations implementing the ADA, U. S. Attorney General Richard Thornburgh consistently made reference to the fact that there would be no exhaustive list of devices and services because any attempt to do so would omit the new devices that would become available with new and emerging technology.

The Segway PT is a device that can be used for mobility assistance by a person with a qualifying disability and its use is fully protected by the ADA (Americans with Disabilities Act of 1990). Public Law 101-336. Failure to allow its use by a person with a qualifying disability is a violation of Federal law. The United States Department of Justice has substantial enforcement responsibilities under Title III. 42 U.S.C. 12188(b). Civil penalties and civil actions are possible. Individuals can also file civil actions under ADA Title III.

10. There is no law that says a "private" theme park or other "private" venue has to allow a disabled person access on their Segway.

ADA III-1.2000 Public accommodations¹⁷. The broad range of title III obligations relating to "places of public accommodation" must be met by entities that the Department of Justice regulation labels as "public accommodations." In order to be considered a public accommodation with title III obligations, an entity must be private and it must --

Own;
Lease;
Lease to; or
Operate

a place of public accommodation.

What is a place of public accommodation? A place of public accommodation is a facility whose operations --

¹⁷ www.ada.gov/taman3.html

Affect commerce; and

Fall within at least one of the following 12 categories:

- 1) Places of lodging (e.g., inns, hotels, motels) (except for owner-occupied establishments renting fewer than six rooms);
- 2) Establishments serving food or drink (e.g., restaurants and bars);
- 3) Places of exhibition or entertainment (e.g., motion picture houses, theaters, concert halls, stadiums);
- 4) Places of public gathering (e.g., auditoriums, convention centers, lecture halls);
- 5) Sales or rental establishments (e.g., bakeries, grocery stores, hardware stores, shopping centers);
- 6) Service establishments (e.g., laundromats, dry-cleaners, banks, barber shops, beauty shops, travel services, shoe repair services, funeral parlors, gas stations, offices of accountants or lawyers, pharmacies, insurance offices, professional offices of health care providers, hospitals);
- 7) Public transportation terminals, depots, or stations (not including facilities relating to air transportation);
- 8) Places of public display or collection (e.g., museums, libraries, galleries);
- 9) Places of recreation (e.g., parks, zoos, amusement parks);
- 10) Places of education (e.g., nursery schools, elementary, secondary, undergraduate, or postgraduate private schools);
- 11) Social service center establishments (e.g., day care centers, senior citizen centers, homeless shelters, food banks, adoption agencies); and
- 12) Places of exercise or recreation (e.g., gymnasiums, health spas, bowling alleys, golf courses).

Can a facility be considered a place of public accommodation if it does not fall under one of these 12 categories? No, the 12 categories are an exhaustive list. However, within each category the examples given are just illustrations. For example, the category "sales or rental establishments" would include many facilities other than those specifically listed, such as video stores, carpet showrooms, and athletic equipment stores.

11. Segway's pose a safety risk to others.

Title III of the ADA¹⁸ prohibits discrimination on the basis of disability in "places of public accommodation" (businesses and non-profit agencies that serve the public) and "commercial facilities" (other businesses).

Places of public accommodation include private establishments, such as museums, libraries, parks, zoos, amusement parks, private schools, day care centers, health spas, and bowling alleys. Public accommodations are required to provide goods and services in an integrated setting, unless separate or different measures are necessary to ensure equal opportunity. In so doing, public accommodations must eliminate unnecessary eligibility standards or rules that deny individuals with disabilities an equal opportunity to enjoy the goods and services of a place of public accommodation.

Safety requirements may be imposed only if they are necessary for the safe operation of a place of public accommodation. They must be based on actual risks and not on mere speculation, stereotypes, or generalizations about individuals with disabilities. For example, an amusement park may impose height requirements for certain rides when required for safety.

A "Direct Threat" of safety cannot be perceived or imagined. It has to be objectively evaluated on an individual case-by-case basis.

III-3.8000 Direct threat¹⁹. A public accommodation may exclude an individual with a disability from participation in an activity, if that individual's participation would result in a direct threat to the health or safety of others. The public accommodation must determine that there is a significant risk to others that cannot be eliminated or reduced to an acceptable level by reasonable modifications to the public accommodation's policies, practices, or procedures or by the provision of appropriate auxiliary aids or services. The determination that a person poses a direct threat to the health or safety of others may not be based on generalizations or stereotypes about the effects of a particular disability; it must be based on an individual assessment that considers the particular activity and the actual abilities and disabilities of the individual.

The individual assessment must be based on reasonable judgment that relies on current medical evidence, or on the best available objective evidence, to determine --

- 1) The nature, duration, and severity of the risk;
- 2) The probability that the potential injury will actually occur; and
- 3) Whether reasonable modifications of policies, practices, or procedures will mitigate or eliminate the risk.

¹⁸ www.ada.gov/taman3.html

¹⁹ www.ada.gov/taman3.html

Such an inquiry is essential to protect individuals with disabilities from discrimination based on prejudice, stereotypes, or unfounded fear, while giving appropriate weight to legitimate concerns, such as the need to avoid exposing others to significant health and safety risks. Making this assessment will not usually require the services of a physician. Sources for medical knowledge include public health authorities, such as the U.S. Public Health Service, the Centers for Disease Control, and the National Institutes of Health, including the National Institute of Mental Health.

A public accommodation must make reasonable modifications in its policies, practices, and procedures in order to accommodate individuals with disabilities. A modification is not required if it would "fundamentally alter" the goods, services, or operations of the public accommodation.

As cited by the federal appeals court²⁰, Title III of the Americans with Disabilities Act ("ADA"), in pertinent part, provides as follows:

No individual shall be discriminated against on the basis of disability in the full and equal enjoyment of the goods, services, facilities, privileges, advantages, or accommodations of any place of public accommodation by any person who owns, leases (or leases to), or operates a place of public accommodation. 42 U.S.C. § 12182(a).

The court noted further that "denial of participation" in a program offered by a place of public accommodation is defined as an act of discrimination under Title III of the ADA. 42 U.S.C. § 12182(b)(1)(A)(I).

According to the court, Congress enacted Title III of the ADA to "facilitate disabled individuals' access to places of public accommodation." In so doing, however, the court noted that Congress had also recognized that "the need to protect public health may at times outweigh the rights of disabled individuals." As a result, Congress had "created a narrow exception to this broad prohibition against discrimination based on disability in places of public accommodation." Specifically, the court acknowledged that "a place of public accommodation is entitled to exclude a disabled individual from participating in its program "where such individual poses a direct threat to the health or safety of others." 42 U.S.C. § 12182(b)(3).

The ADA defines "direct threat" as "a significant risk to the health or safety of others that cannot be eliminated by a modification of policies, practices, or procedures or by the provision of auxiliary aids or services." In determining whether an individual poses a "direct threat," the court cited federal regulations requiring places of public accommodation to make "an individualized assessment, based on reasonable judgment that relies on current medical knowledge or on the best available objective evidence." 28 C.F.R. § 36.208(c). In so doing, the court noted that "a place of public accommodation must not base its calculus on stereotypes or generalizations about the effects of a disability":

²⁰ classweb.gmu.edu/jkozlos/2000nov.htm

The relevant factors which the place of public accommodation must weigh and balance are the nature, duration, and severity of the risk and the probability that the potential injury will actually occur.

If the place of public accommodation determines that the individual would pose a significant risk to the health and safety of others, it must then ascertain whether reasonable modifications of policies, practices, or procedures will mitigate the risk, to the point of eliminating it as a “significant” risk. 42 U.S.C. § 12182(b)(3). 28 C.F.R. § 36.208(C)

Under the ADA, a failure to make a reasonable modification is itself an act of discrimination unless the place of public accommodation can demonstrate that implementing the modification would fundamentally alter the nature of the program. See 42 U.S.C. § 12182(b)(2)(A)(ii).

Objections

12. Why don't the disabled just use a wheelchair or ECV?

There are a number of health issues that are exacerbated by prolonged sitting. These include diminished circulatory and respiratory functions, loss of bone density and less flexibility. Conversely, standing helps to minimize these health issues. Standing allows the individual the ability to see (and be seen) better than a low height mobility device (such as an ECV or wheelchair) which requires the user to be seated. The Segway puts them at eye level with the people around them. The mere act of passive standing has dramatic physiologically as well as psychologically benefits.

The act of standing can significantly decrease muscle atrophy particularly in the abdominal, hip flexors, and paraspinal muscles of the body. The act of continued sitting may over time, in many cases, result in the inability of an individual to ever stand again.

Physicians & Therapists recommend standing for many reasons:

- Pressure relief
- Normalizing of kidney and bladder functions
- Improving digestive and bowel function
- Maintenance of bone density
- Improving flexibility and decreasing spasticity
- Greater circulation
- Improving respiration

There are thousands of people today who are using Segways in precisely the same places and conditions as those using wheelchairs, in addition to those places which are inaccessible for wheelchairs. People with multiple sclerosis, Parkinson's disease, COPD, amputations, spinal cord injuries and many other neurological conditions, have been using the Segway as their primary assistive device for more than five years without incident.

13. If a disabled person can stand, then they can walk.

With the introduction of the Segway, people who had difficulty walking now have an option available to them which allow them mobility while also allowing them to remain standing. This includes people who have conditions such as multiple sclerosis, spinal cord injuries, Parkinson's disease, amputations, COPD, spina bifida, traumatic burn injuries, traumatic brain injuries, and many neurological conditions. The Segway has also proven to be highly adaptable to modification allowing even those who are unable to stand for longer periods of time, such as paraplegics, to take advantage of its increased maneuverability, particularly in outdoor environments.

For those having the ability to use the Segway as an assistive device it offers them mobility more consistent with that which they enjoyed prior to becoming disabled. They are able to reach things from high shelves, move in and out of tight spaces, including closets and even move about the kitchen in a manner consistent with their pre-disability movements. They are able to better see and be seen when interacting with others. The mere act of passive standing has dramatic physiological and psychological benefits.

14. Some cities have banned Segways.

New York City, New York, San Francisco, California, Key West (Old Town section), Florida, and Sanibel Island, Florida, are several cities that have enacted a ban on Segways. Although the local bans cover the general public, these cities recognize the Segway as an ADA protected assistive mobility device and have specific language allowing persons with disabilities to continue to use their Segways in these cities.

15. Segways don't have brakes.

Not in the traditional sense like most automobiles or bicycles, but they do have sophisticated electric motors that propel the Segway as well as providing the braking system. Newer hybrid vehicles are now utilizing regenerative braking technology similar to a Segway. An added advantage of the Segway is that when torque and speed oppose one another, the motor operates as a generator, providing braking torque to the wheels and energy to the batteries. Ordinary friction brakes would not work on the Segway PT, of course, because the wheels must be free to balance the machine.

The Segway has been found in safety studies to have exceptional braking characteristics and braking distances that surpass other mobility devices. In fact, reaction times on a Segway are significantly better than other mobility devices due to its unique and intuitive design.

Background

Segway Safety Studies.

The Segway® Personal Transporter (PT) has been evaluated by four independent agencies representing interests from around the world.

Centre for Electric Vehicle Experimentation in Quebec (CEVEQ) Second Phase - Pilot Project for Evaluating the Segway HT in Real Conditions²¹

The Second Phase of the two-phase report detailed use of the Segway PT by 143 participants who rode more than 9,000 total kilometers on sidewalks, paths, and roadway shoulders, in three major cities located in the Province of Quebec. The report noted that no incident or serious injury, nor any Segway PT/pedestrian collision or physical interference, was reported during the evaluation. Upon completion the study “Recommendations” indicate that Segway PTs should be allowed to operate on urban pedestrian areas and that such use will have little impact on user safety and still less on the safety of pedestrians, cyclists, motorists and other walkway users.

Publish date: April 2006

Centre for Electric Vehicle Experimentation in Quebec (CEVEQ) First Phase - Pilot Project for Evaluating Motorized Personal Transportation Devices²²

The first phase of the two-phase report detailed information discovered during the evaluation of motorized personal transportation devices (MPTD) specifically, the ergonomic, operational and technical aspects of the devices. Findings included that the Segway PT was very stable and gave users a feeling of being in control. Also, Segway PTs compared favorably to other types of devices and were far superior in the area of stability as compared to bicycles and mopeds. Lastly the report noted that the Segway PT could meet a large number of mobility requirements for a broad market, could facilitate transfers to other forms of transportation, and serve as an alternative to automobiles.

Publish date: May 2004

²¹ <http://www.tc.gc.ca/tdc/publication/pdf/14500/14567e.pdf>

²² <http://www.tc.gc.ca/tdc/publication/pdf/14200/14285e.pdf>

German Federal Board for Road Traffic - *Segway in Public Spaces*²³

The three-month study was conducted by the German government in conjunction with the Ministry of Internal Affairs, Ministry of Commerce of the Saarland, Saarbrücken Police Department, and Municipal Office of Neunkirchen. Results for braking, steering and general handling of the device were very favorable. The study also reports that Segway PTs are best suited for bicycle lanes and pedestrian traffic areas.

Publish date: March 2006

Victoria Transport Policy Institute - *Managing Personal Mobility Devices (PMDs) On Nonmotorized Facilities*²⁴

This study researched the use of various personal mobility devices such as electric scooters, powered wheelchairs and Segway PTs on non-motorized infrastructure including sidewalks and bike lanes/paths. Overall the study found that Segway PTs would have medium impact or risk to others (namely pedestrians), the same which was found true of joggers and runners. As a comparison, bicycles were found to have medium to large impact or risk to others.

Publish date: October 2005

U.S. Department of Transportation/Federal Highway Administration - *Characteristics of Emerging Road Users & Their Safety*²⁵

The study was undertaken to clarify the operational characteristics of both motorized and non-motorized transportation. Data was collected to obtain physical dimensions, turning capabilities, acceleration, speed and stopping distance of these devices. The Segway PT and its rider were found to have the second shortest braking distance, highest sight lines, one of the smallest footprints, and quickest perception-reaction time. The Segway PT met or exceeded all recommendations made by the American Association of State Highway & Transportation Officials (AASHTO) Guide to the Development of Bicycle Facilities.

Publish date: October 2004

²³ http://www.segway.com/downloads/pdfs/safetystudies/german_study.pdf

²⁴ http://www.vtppi.org/man_nmt_fac.pdf

²⁵ <http://www.tfhrc.gov/safety/pubs/04103/04103.pdf>
<http://www.tfhrc.gov/safety/pubs/04104/roadstechbrief.pdf>

Segway Safety Recalls.

Since the Segway PT became available to the public, they have been recalled twice – voluntarily by Segway, Inc. In fact, only nine people reported issues that prompted the two recalls with over 20,000 machines in service at the time of the second recall in 2006. Both recalls were quickly resolved with a software upgrade performed on the machines by the factory or in the field by an authorized factory representative.

September 2003²⁶ - Based on reports from three users.

In cooperation with the U.S. Consumer Product Safety Commission (CPSC), Segway LLC of Manchester, New Hampshire is voluntarily recalling approximately 6,000 Segway HT Human Transporters. Under certain operating conditions, particularly when the batteries are near the end of charge, some Segway HTs may not deliver enough power, allowing the rider to fall. This can happen if the rider speeds up abruptly, encounters an obstacle, or continues to ride after receiving a low-battery alert.

September 2006²⁷ - Based on reports from six users.

In cooperation with the U.S. Consumer Product Safety Commission (CPSC), Segway Inc., of Bedford, N.H., is voluntarily recalling about 23,500 Segway Personal Transporters (PT) [also known as the Segway Human Transporter (HT)]. The personal transporter can unexpectedly apply reverse torque to the wheels, which can cause a rider to fall. This can occur when the device is tilted back by the Speed Limiter and the rider comes off and then back onto the device within a short period of time.

Federal Segway Policies.

General Services Administration – GSA²⁸

The General Services Administration (GSA) recognizes that some persons with mobility impairments are utilizing the Segway Personal Transporter (Segway) and similar devices as their preferred means of locomotion. GSA is committed to making all reasonable efforts to make its facilities accessible to persons with disabilities.

National Park Service – NPS – US Department of the Interior²⁹

In order to evaluate the long-term effect of this issue and to assess the impacts on the diverse settings represented throughout the National Park System, the NPS has decided to temporarily allow each park superintendent to establish their own interim

²⁶ <http://www.cpsc.gov/cpsc/pub/prerel/prhtml03/03553.html>

²⁷ <http://www.cpsc.gov/cpsc/pub/prerel/prhtml06/06258.html>

²⁸ http://www.gsa.gov/gsa/cm_attachments/GSA_DOCUMENT/Interim_Segway_Policy_121007_R2-z-pU_0Z5RDZ-i34K-pR.pdf

²⁹ http://www.nps.gov/policy/Segway_memo.pdf

policies and practices regarding the use of Segways by people with disabilities in their particular park.

All park superintendents are directed to review this issue by January 19, 2007, for their individual park and make a decision on whether they can accommodate the use of this device. If the decision is made that you can accommodate it, you must do so.

Many NPS parks and recreation areas have established policies favoring Segways when utilized as a mobility device for the disabled. The most recent occurred on May 27, 2009 at the Glen Canyon National Recreation Area and Rainbow Bridge National Monument. Their Segway policy is as follows:³⁰

Use of Segways*: The use of Segways is authorized for mobility impaired persons only.

***Segway defined:** For the purpose of this compendium, the term "Segway" is defined as a motorized wheelchair, which is defined in 36 Code of Federal Regulations §1.4 as: Motorized wheelchair means a self propelled wheeled device, designed solely for and used by a mobility-impaired person for locomotion, that is both capable of and suitable for use in indoor pedestrian areas.

Federal Transit Administration – FTA – US Department of Transportation³¹

The Department’s ADA rule (49 CFR Part 37, §37.3) defines a “wheelchair” as “a mobility aid belonging to any class of three or four-wheeled vehicles, designed for and used by individuals with mobility impairments...” (emphasis added). By this definition, a Segway is not a wheelchair. However, a Segway, when used by a person with a disability as a mobility device, is part of the broad class of mobility aids that Part 37 intends will be accommodated (see for instance §§37.5 and 37.165). In this way, a Segway occupies a legal position analogous to canes, walkers, etc.

Air Carrier Access Act – ACAA – US Department of Transportation³²

Congress enacted the Air Carrier Access Act (ACAA) in 1986. The statute prohibits discrimination in airline service on the basis of disability. The act contains the following definition:

Battery-powered mobility aid means an assistive device that is used by individuals with mobility impairments such a wheelchair, a scooter, or a Segway when it is used as a mobility device by a person with a mobility related disability.

³⁰ <http://www.nps.gov/glca/parkmgmt/upload/CompendiumGLCA2009.pdf>

³¹ http://www.fta.dot.gov/civilrights/ada/civil_rights_3893.html

³² <http://airconsumer.ost.dot.gov/rules/ACAA%20Final%20Rule%20-%20Fed%20Register.pdf>

State EPAMD Laws.

The Segway® Personal Transporter (PT) complies with all Federal product standards and applicable safety standards requirements. Segway PTs may be used in all 50 states on private property with the permission of the property owner.

As of July 2009, 44 states and the District of Columbia³³ have enacted legislation to allow use of Segway PTs on sidewalks, bike paths, and certain roads. The laws differ from state to state, so it is important that potential purchasers and Segway PT users carefully review their state regulations and comply with any special requirements. (Many of these laws use the term "Electric Personal Assistive Mobility Device" or "Personal Motorized Mobility Device", which are generally defined so as to include Segway PT.) In most cases, state legislation gives local authorities the option of enacting additional laws about Segway PT use.

³³ <http://www.segway.com/support/regulatory.php>

Legislation governing use of Segway PTs is primarily at the state level. The following states have enacted **permissive legislation**³⁴:

- Alabama
- Alaska
- Arizona
- California (effective January 1, 2008)
- Colorado (Sections regarding EPAMD)
- Delaware
- District of Columbia
- Florida
- Georgia
- Hawaii
- Iowa
- Idaho
- Illinois
- Indiana
- Kansas
- Louisiana
- Maryland
- Maine
- Michigan
- Minnesota
- Missouri
- Mississippi
- Montana
- Nevada
- North Carolina
- Nebraska (Sections 436 through 465)
- New Hampshire
- New Jersey
- New Mexico
- New York
- Ohio
- Oklahoma
- Oregon
- Pennsylvania
- Rhode Island
- South Carolina
- South Dakota
- Tennessee
- Texas
- Utah
- Virginia
- Vermont
- Washington
- Wisconsin
- West Virginia

³⁴ <http://www.segway.com/support/regulatory.php>

*How does the Segway Work?*³⁵

Dynamic stabilization technology gives these machines the ability to self-balance, freeing them from the constraints of static physics that would ordinarily dictate a design with a low center of gravity and large, stable base to avoid tipping. No simple feat, given that they rely on the way in which humans respond to instability to maintain equilibrium. In fact, the first application of this novel technology was specifically intended to replace the human capabilities of standing, balancing, and walking for individuals who no longer had use of their legs.

In principle, the rider makes the Segway PT move simply by shifting his/her weight. Lean forward and the machine goes forward. Lean back and the machine decelerates to a controlled stop. Continue leaning back, and the machine goes in reverse. The harder you lean, the faster you move. You turn the Segway PT by leaning the handlebar left or right (or twisting the turn grip on older models), which changes the speed of one wheel relative to the other. The Segway PT turns in the direction that you lean the handlebar and the steering system features zero-turn-radius maneuvering.

The Segway PT responds as if it were an extension of the rider's body, driving the wheels as needed to stay upright while moving forward, backward, turning, or standing still. Ironically, it does not do so by detecting the rider's weight, but is controlled by angular position and angular rate of change data (as well as a plethora of other information such as wheel position and steering inputs). Essentially, the machine's goal is to avoid tipping over by applying an appropriate restorative torque. It does so through the interaction of three main subsystems:

Sensors and input subsystem. Combines information from five inertial rate sensors (gyros); optical foot pad sensors; two tilt sensors; motor encoders; and steering sensors. Its function is to provide information on machine status and operating conditions to the controls subsystem, including data on motor and wheel speed, and tilt angle and its rate of change.

Controls subsystem. Consists of two controller boards, each with a DSP that runs closed-loop motor control and balance computations; a user interface controller board; two motors (one for each wheel); power modules for commutating the motors; and batteries. Its function is to process input data and determine how much energy to put into the motors and batteries.

Propulsion subsystem. Consists of couplings; two-stage helical gearboxes; wheels; and pneumatic tires. Its function is to take the torque output from the motor and convert it to propulsion.

³⁵ Sources: Segway, Inc. & Design News - Balancing act - An exclusive look at the engineering behind the Segway HT, with some never-before-published technical details, By John Lewis, Northeast Technical Editor, Karen Auguston Field, Chief Editor -- March 25, 2002

To determine angular position and angular rate of change, the machine employs five inertial rate sensors that provide yaw, pitch, and roll data in three axes. Unlike mechanical gyros, which depend on rotation and the conservation of angular momentum, these tiny, solid-state gyros incorporate a vibrating ring that is excited using the piezoelectric effect. When the Segway PT tilts, this ring is rotated about that axis, causing a change in vibration proportional to the degree of tilt.

When either the angular position or angular rate of change reaches a predetermined value set by the system designers, the controller outputs a current signal to the drive to apply the appropriate torque. The motors are controlled through all four quadrants, meaning that speed and torque can be variously applied in the same or opposite directions. An added advantage is that when torque and speed oppose one another, the motor operates as a generator, providing braking torque to the wheels and energy to the batteries. Ordinary friction brakes would not work on the Segway PT, of course, because the wheels must be free to balance the machine. If not, you would fall flat on your face.

To ensure that the tilt angle never exceeds a critical number beyond which the motor can no longer catch up, engineers employed a scheme called "headroom management". It involves operating inside the performance envelope of the motor. The basic premise is to preserve an extra margin of torque and speed in the motors, so that the machine has the capability to respond to a transient, such as hitting a bump. Response time is critical for recovery and calculations take place over 100 times per second.

Because of the overriding need to maintain balance at all times (even while standing in place the motor torque may be cycling between positive and negative), there is redundancy throughout the design, including two batteries, two control boards, and two motors driving each wheel. Although at first glance it looks like just one motor per wheel, closer inspection reveals two separate connections on the back of each housing. First developed in a preliminary form for the iBOT™ mobility system, the motor features a patented, hemispherically-wound stator with redundant windings so that each motor is wired electrically as two separate motors with separate electrical paths for excitation. When one fails, the other takes over.

While the rider is doing something simple, behind the scenes a sophisticated servo control system is working to maintain metastable equilibrium. Based on steering inputs, inertial data, and motor speed and position data, the controller determines how much energy to supply from the batteries to the motor. The torque output from the motor drives the wheels.

Given the complexity involved with self-balancing and the fact that there is redundancy in the batteries, motors, and electrical system, the Segway PT has relatively few parts and is surprisingly compact.