Highway Systems & Engineering

Stephane Werner

First Edition, 2012

ISBN 978-81-323-3070-7

Published by:
Research World
4735/22 Prakashdeep Bldg,
Ansari Road, Darya Ganj,
Delhi - 110002
Email: info@wtbooks.com

Table of Contents

Chapter 1 - Highway

Chapter 2 - Dual Carriageway

Chapter 3 - Limited-Access Road & Toll Road

Chapter 4 - Road Traffic Safety

Chapter 5 - Traffic Sign

Chapter 6 - Freeway

Chapter 7 - Bypass (Road)

Chapter 8 - Roadway Air Dispersion Modeling

Chapter 9 - Highway Systems by Country

Chapter 1

Highway

Highway 401, the busiest highway in North America.

A German Autobahn in Lehrte.

The Makran Coastal Highway was an ancient road within Pakistan. Now it's a major road leading to the city of Gwadar

The SP-160, known as Rodovia dos Imigrantes, in southeastern Brazil.

A **highway** is a public road, especially a major road connecting two or more destinations. Any interconnected set of highways can be variously referred to as a "highway system", a "highway network", or a "highway transportation system". Each country has its own national highway system.

Overview

Major highways are often named and numbered by the governments that typically develop and maintain them. Australia's Highway 1 is the longest national highway in the world at over 14,500 km (9,000 miles) and runs almost the entire way around the

continent. The United States has the world's largest network of highways, including both the Interstate Highway System and the U.S. Highway System. At least one of these networks is present in every state and they interconnect most major cities. Some highways, like the Pan-American Highway or the European routes, span multiple countries. Some major highway routes include ferry services, such as U.S. Route 10, which crosses Lake Michigan.

Traditionally highways were used by people on foot or on horses. Later they also accommodated carriages, bicycles and eventually motor cars, facilitated by advancements in road construction. In the 1920s and 1930s many nations began investing heavily in progressively more modern highway systems to spur commerce and bolster national defense.

Major modern highways that connect cities in populous developed and developing countries usually incorporate features intended to enhance the road's capacity, efficiency, and safety to various degrees. Such features include a reduction in the number of locations for user access, the use of dual carriageways with two or more lanes on each carriageway, and grade-separated junctions with other roads and modes of transport. These features are typically present on highways built as *motorways* (*freeways*).

Terminology

In English law, parliament and more formal situations the term is used to denote *any* public road used which include streets and lanes as well as main roads, trunk roads and motorways. Acts of parliament have used the term throughout history from the Highways Act 1555 through to the Highways Act 1980. The rules of the road are outlined in the Highway Code.

In England and Wales, a "Public Highway" is a road or footpath over which the public has the right of access, i.e. the opposite of a "private road".

In American law, the word "highway" is sometimes used to denote any public way used for travel, whether major highway, freeway, turnpike, street, lane, alley, pathway, dirt track, footpaths, and trails, and navigable waterways; however, in practical and useful meaning, a "highway" is a major and significant, well-constructed road that is capable of carrying reasonably-heavy to extremely-heavy traffic. Highways generally have a route number designated by the state and federal road comptroller offices.

California Vehicle Code, Sections 360, 590, define a "highway" as only a way open for use of motor vehicles, but the California Supreme Court has held that "the definition of 'highway' in the Vehicle Code is used for special purposes of that act," and that canals in the town of Venice, California, are "highways" that are entitled to be maintained with state highway funds.

Smaller roads may be termed byways.

History

A German autobahn in the 1930s

Modern highway systems developed in the 20th century as the automobile gained popularity. The world's first limited access road was constructed in Italy in 1922. Construction of the Bonn-Cologne autobahn began in 1929 and was opened in 1932 by the mayor of Cologne.

The Special Roads Act 1949 in the United Kingdom provided the legislative basis for roads for restricted classes of vehicles (later termed motorway). The first section of motorway in the UK opened in 1958 (part of the M6 motorway) and then in 1959 the first section of the M1 motorway.

The Federal Aid Highway Act of 1956 provided appropriating $25 billion for the construction of 41,000 miles (66,000 km) of Interstate Highways over a 20-year period in the United States.

Social effects

Reducing travel times relative to city or town streets, modern highways with limited access and grade separation create increased opportunities for people to travel for

business, trade or pleasure and also provide trade routes for goods. Modern highways reduce commute and other travel time but additional road capacity can also create new induced traffic demand. If not accurately predicted at the planning stage, this extra traffic may lead to the new road becoming congested sooner than anticipated. More roads add on to car-dependence, which can mean that a new road brings only short-term mitigation of traffic congestion.

Where highways are created through existing communities, there can be reduced community cohesion and more difficult local access. Consequently property values have decreased in many cutoff neighborhoods, leading to decreased housing quality over time.

Economic effects

In transport, demand can be measured in numbers of journeys made or in total distance travelled across all journeys (e.g. passenger-kilometres for public transport or vehicle-kilometres of travel (VKT) for private transport). Supply is considered to be a measure of capacity. The price of the good (travel) is measured using the generalised cost of travel, which includes both money and time expenditure.

The effect of increases in supply (capacity) are of particular interest in transport economics, as the potential environmental consequences are significant.

In addition to providing benefits to their users, transport networks impose both positive and negative externalities on non-users. The consideration of these externalities - particularly the negative ones - is a part of transport economics. Positive externalities of transport networks may include the ability to provide emergency services, increases in land value and agglomeration benefits. Negative externalities are wide-ranging and may include local air pollution, noise pollution, light pollution, safety hazards, community severance and congestion. The contribution of transport systems to potentially hazardous climate change is a significant negative externality which is difficult to evaluate quantitatively, making it difficult (but not impossible) to include in transport economics-based research and analysis. Congestion is considered a negative externality by economists.

Environment effects

Highways are extended linear sources of pollution:

Roadway noise increases with operating speed so major highways generate more noise than arterial streets. Therefore, considerable noise health effects are expected from highway systems. Noise mitigation strategies exist to reduce sound levels at nearby sensitive receptors. The idea that highway design could be influenced by acoustical engineering considerations first arose about 1973.

Air quality issues: Highways may contribute fewer emissions than arterials carrying the same vehicle volumes. This is because high, constant-speed operation creates an

emissions reduction compared to vehicular flows with stops and starts. However, concentrations of air pollutants near highways may be higher due to increased traffic volumes. Therefore, the risk of exposure to elevated levels of air pollutants from a highway may be considerable, and further magnified when highways have traffic congestion.

New highways can also cause habitat fragmentation, encourage urban sprawl and allow human intrusion into previously untouched areas, as well as (counterintuitively) increasing congestion, by increasing the number of intersections. They can also reduce the use of public transport, indirectly leading to greater pollution.

High-occupancy vehicle lanes are being added to some newer/reconstructed highways in North America and other countries around the world to encourage carpooling and mass-transit. These lanes help reduce the number of cars on the highway and thus reduces pollution and traffic congestion by promoting the use of carpooling in order to be able to use these lanes. However, they tend to require dedicated lanes on a highway, which makes them difficult to construct in dense urban areas where they are the most effective.

Road traffic safety

Road traffic safety aims to reduce the harm (deaths, injuries, and property damage) on the highway system from traffic collisions and includes the design, construction and regulation of the roads, the vehicles that use them and also the training of drivers and other road-users. Improvement of road safety needs to be balanced with the provision of an effective efficient transport system. A report published by the World Health Organization in 2004 estimated that some 1.2m people were killed and 50m injured on the roads around the world each year and was the leading cause of death among children 10 – 19 years of age. The report also noted that the problem was most severe in developing countries and that simple prevention measures could halve the number of deaths. For reasons of clear data collection, only harm involving a road vehicle is included. A person tripping with fatal consequences or dying for some unrelated reason on a public road is not included in the relevant statistics.

Statistics

International sign used widely in Europe denoting the start of special restrictions for a section of highway.

The United States has the world's largest network of highways, including both the Interstate Highway System and the U.S. Highway System. At least one of these networks is present in every state and they interconnect most major cities.

China's highway network is the second most extensive in the world, with a total length of about 3.573 million km. China's expressway network is also the second longest in the world, and it is quickly expanding, stretching some 60,300 km at the end of 2008, In 2008 alone, 6,433 km expressways were added to the network.

- **Longest international highway:** the Pan-American Highway, which connects many countries in the Americas, is nearly 25,000 kilometres (15,534 mi) long as of 2005. The Pan-American Highway is discontinuous because there is a significant gap in it in southeastern Panama, where the rainfall is immense and the terrain is entirely unsuitable for highway construction.

- **Longest national highway (point to point):** The Trans-Canada Highway is 7,821 km (4,857 mi) long as of 2006. The T.C.H. runs east-west across southern Canada, the populated portion of the country, and it connects many of the major

urban centers along its route crossing almost all of the provinces, and reaching almost all of the capital cities. The T.C.H. begins on the east coast in Newfoundland, traverses that island, and crosses to the mainland by ferry. It reaches most of the Maritime Provinces of eastern Canada, and a side route using ferries traverses the province of Prince Edward Island. After crossing the two most populous provinces of Quebec and Ontario, the T.C.H. continues westward across Manitoba, Saskatchewan, Alberta, and British Columbia. After reaching Vancouver, B.C., on the Pacific Coast, there is a ferry route west to Vancouver Island and the provincial capital city of Victoria, B.C.

- **Longest national highway (circuit):** Australia's Highway 1 at over 20,000 km (12,427 mi). It runs almost the entire way around the continent's coastline. With the exception of the Federal Capital of Canberra, which is far inland, Highway 1 links all of Australia's capital cities, although Brisbane and Darwin are not directly connected, but rather are bypassed short distances away. Also, there is a ferry connection to the island state of Tasmania, and then a stretch of Highway 1 that links the major towns and cities of Tasmania, including Launceston and Hobart (this state's capital city).

- **Largest national highway system:** The United States of America has approximately 6,430,366 kilometres (3,995,644 mi) of highway within its borders as of 2008.

- **Busiest highway:** Highway 401 in Ontario, Canada, has volumes surpassing an average of 500,000 vehicles per day in some sections of Toronto as of 2006.

- **Widest highway (maximum number of lanes):** The Katy Freeway (part of Interstate 10) in Houston, Texas, has a total of 26 lanes in some sections as of 2007. However, they are divided up into general use/ frontage roads/ HOV lanes, restricting the traverse traffic flow.

- **Widest highway (maximum number of through lanes):** Interstate 5 along a 2-mile section between Interstate 805 and California State Route 56 in San Diego, California, which was completed in April 2007, is 22 lanes wide.

- **Highest international highway**: The Karakoram Highway, between Pakistan and China, is at an altitude of 4,693 m/15,397 ft.

Bus lane

Highway bus lane on Gyeongbu Expressway in South Korea

Some countries incorporate bus lanes onto highways.

Country	Highway	Bus lanes (km)	Section
Canada	Ontario Highway 417	7	Eagleson Road – Ontario Highway 417 (Ottawa)
Canada	Ontario Highway 403	6	Mavis Road – Winston Churchiil Blvd. (Mississauga)
South Korea	Gyeongbu Expressway	137.4	Hannam IC(Seoul) ~ Sintanjin IC(Daejeon)

Korea

In South Korea, in February 1995 - Bus lane (essentially an HOV-9) established between the northern terminus and Sintanjin for important holidays and in 1 July 2008 - Bus lane enforcement between Seoul and Osan (Sintanjin on weekends) becomes daily between 6

AM and 10 PM. On 1 October this is adjusted to 7 AM to 9 PM weekdays, 9 AM to 9 PM weekends.

Highway 401 in London, Ontario

A Polish expressway in Bielsko-Biała

The Pan-American Highway where it serves as the main street in Máncora, Peru

The Pan-American Highway in the Greater Buenos Aires (city of Florida), Argentina

Highway A1 near Bologna, Italy with 10 lanes

The Dr. Sun Yat-sen Memorial Freeway in Taipei, Taiwan

Chapter 2

Dual Carriageway

A typical British dual carriageway with central barrier on the A63(T) near Hull, England.

Ohio State Route 11 in Ohio

Clara Barton Parkway outside Washington, D.C.

A German dual carriageway in the 1930s

A **dual carriageway** (**divided highway**) is a highway in which the two directions of traffic are separated by a central barrier or strip of land, known as a central reservation (median). It may also have limited access and grade separated junctions. Where more than one lane is provided in each direction this type of road is usually able to carry a great deal more traffic than single carriageways (undivided highways). Each carriageway or roadway usually has at least two lanes for traffic. Dual carriageways generally have lower accident rates than single carriageways (undivided highways) due to the separation of traffic moving in opposing directions.

History

A very early example (perhaps the first) of a dual carriageway was the *Via Portuensis*, built in the 1st century by the Roman emperor Claudius between Rome and its port Ostia at the mouth of the Tiber.

In 1907 the Long Island Parkway opened and roughly 20% of it featured a semi-dual carriageway design. The New York City parkway system, which was built between 1907 and 1934, also pioneered the same design. However the majority of it featured concrete or brick railings as lane dividers as opposed to using grass medians.

In 1924 the first Italian autostrada was opened running 55 km (34 mi) from Milan to Varese. It featured a broad road bed and did not feature lane dividers except near cities and through the mountains.

The London end of the Great West Road became Britain's first dual carriageway when it was opened in 1925 by King George V.

In 1927 the Rome bypass was opened. It ran 92 km (57 mi) bypassing Rome to the east. Almost the entire length featured a dual carriageway design. In the early 1930s it was extended southward all the way to Naples and northward to Florence. Most of the original routing was destroyed by the Allies in the Second World War.

By 1930 several American and European cities had built dual carriageway highways mostly to control traffic jams and/or to provide bypass routes for traffic.

In 1932 the first German Autobahn opened between Cologne and Bonn. It ran 21 km (13 mi) and became a precedent for future highways. Although it, like the first Autostrada, did not feature a dual carriageway design, it inspired the mass construction of future high speed roadways.

During the 1930s, Germany, Italy, and the Soviet Union began construction of a network of dual carriageway expressways. By 1942, Germany had over 3,200 km (2,000 mi) of dual carriageway roads, Italy had nearly 1,300 km (800 mi), and the Soviet Union had 400 km (250 mi).

What may be the world's first long-distance intercity dual carriageway/freeway is the Queen Elizabeth Way in Southern Ontario in Canada, initially linking the large cities of Toronto and Hamilton together by 1939, with construction on this stretch of the present-day Queen Elizabeth Way beginning in 1936 as "Middle Road".

Opened to traffic in 1940, the 160 mile (257 km) long Pennsylvania Turnpike was the first rural dual carriageway built in the United States. By 1955 several states had built dual carriageway freeways and turnpikes and in 1957 the Interstate Highway System began. Completed in 1994, the major highway system links all the major cities of the United States.

European implementations

United Kingdom

In the UK, although the term *dual carriageway* applies to any road with physically separated lanes, it is frequently used as a descriptive term for major routes built in this style. Such major dual carriageways usually have two lanes of traffic in each direction, with the lane nearest the centre being reserved for overtaking. Occasionally dual carriageways have only one lane in each direction, or more than two lanes each way (usually to permit easier overtaking of slower uphill traffic). Different speed limits apply

on dual carriageway sections from those that apply on single carriageway sections of the same class of road, except in cities and built-up areas where the dual carriageway is more of a safety measure, often intended to prevent pedestrians from crossing a busy road.

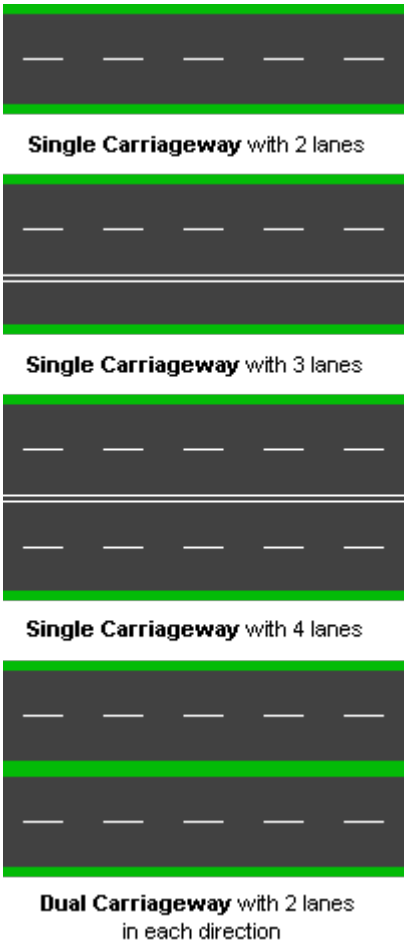


Diagram of types of road in the UK

A sign informing motorists of an oncoming Dual Carriageway in Seacroft, Leeds.

When first constructed, many dual carriageways - including the first motorways - had no crash or other barriers in the central reservation. Hence in the event of delays on the road, or if a driver missed his exit, there was a widespread problem of drivers making a U-turn onto the other carriageway; many accidents were caused as a result of their misjudging the speed of approaching traffic on the other carriageway when doing so. The majority of dual carriageway roads now have barriers. Some are heavy concrete obstructions which can have the effect of bouncing a vehicle back into the path of other traffic; others are made from steel ropes mounted on moderately weak posts, where the rope cuts into the vehicle body to slow the vehicle while keeping it against the barrier until it has stopped. Often on urban dual carriageways where the road has been converted from a four-lane

single carriageway the central reservation will be nominal and often just a small steel divider to save space.

Turning right (that is, across the line of traffic heading in the opposite direction) is usually permitted only at specific locations. Often the driver will be required to turn left (away from the dual carriageway) in order to loop around to an access road that permits crossing the major road. Roundabouts on dual carriageways are relatively common, especially in cities or where the cost of a grade-separated junction would be prohibitive. Where space is even more limited, intersections may be controlled by traffic lights. Smaller residential roads adjoining urban dual carriageways may be blocked off at one end in an attempt to limit the number of junctions on a dual carriageway, often other roads may pass over or under the dual-carriageway without an intersection.

A dual carriageway with grade-separated junctions and which meets other requirements may be upgraded to motorway standard, denoted as an **(M)** added after the road number (e.g. "A1(M)" or "A38(M)"). Unlike in the Republic of Ireland there is no official terminology for 'high-quality dual carriageways', however many roads such as the A1, the A14, the A19 and the A42 are built to a high quality, in many places they are only intersected by grade-separated junctions, have full barriers at both the road side and the central reservations and in some cases three lanes of traffic, however for at least one reason they fall short of motorway standard (often this may be down to the height of overpasses or the quality of intersecting junctions.

Confusion

While most drivers are clear about what a motorway is, some are confused about the definition of a dual carriageway. For a road to be classed as a dual carriageway, the two directions of traffic flow must be physically separated by a central reservation. A road where the two directions of flow are separated only by lines painted on the road surface is a single carriageway, regardless of the number of traffic lanes that may be available to the traffic in each direction. So a road with three or four lanes is not a dual carriageway if there is no central reservation. Increasingly many such roads are being converted into dual carriageways with the erection of a central barrier.

Speed limits

The national speed limit applies on dual carriageways (unless it is in a 'built-up area', or a lower limit is posted), which is as follows:

National speed limits on dual carriageways in the UK

Type of vehicle	Speed limit
Car, motorcycle or a car-based van up to 2 metric tonnes	70 mph (110 km/h)
Car with caravan or trailer	60 mph (97 km/h)
Bus or coach up to 12 m long	60 mph (97 km/h)

Goods vehicle up to 7.5 t	60 mph (97 km/h)
Goods vehicle over 7.5 t	50 mph (80 km/h)

A dual carriageway in a built up area will have a statutory speed limit of 30 mph (48 km/h) unless otherwise sign-posted. It is common for such urban dual carriageways to have an increased speed limit of 40 mph (64 km/h). A built up road is indicated by the presence of street lights, on lit dual carriageways that are not considered to be in a built-up area, the speed limit will be clarified with intermittent signs.

Ireland

A typical modern Irish dual carriageway (opened 2004) along the N11, south of Newtownmountkennedy. On motorways, the yellow hard shoulder markings are unbroken.

An example of a 2+2 dual-carriageway in Ireland. This type is similar to many found in the UK.

Although in the Republic of Ireland the term dual carriageway technically applies to any road with physically separated lanes, it is usually used only to refer to those route sections that do not have a motorway designation. Most often it is *national roads* (roads with a route number prefix of **N**; e.g. N8) that are built as or upgraded to dual carriageway. A number of non-national roads (for example, *regional roads*) are dual carriageway, for example in urban areas near or in cities, or where the road was formerly part of a national route.

Dual carriageways of this class differ from motorways in a number of ways. The hard shoulder is demarcated with a dashed yellow line (as opposed to an unbroken yellow line on motorways). The standard speed limit of 100 km/h (62 mph) for national routes usually applies (by default the limit is 80 km/h (50 mph) for non-national roads, even if dual carriageway). Local authorities have the power to apply a limit of up to 120 km/h (75 mph) as used on most motorways (The High Quality Dual Carriageway section of the N1 between the end of the M1 and the border with Northern Ireland and the N25/N22 Ballincollig Bypass in Cork are the only route sections with such special limits). Traffic lights and junctions are permitted at grade on dual carriageways. For older sections of dual carriageway, this has resulted in fewer flyover junctions. Newer dual carriageway sections are usually near motorway standard, with grade-separated junctions, but may not be designated as motorways due to the need to preserve access to adjoining property or to the absence of a non-motorway alternative route. Also, dual carriageways that are not motorway classified do not need to be equipped with emergency phones.

Motorway restrictions only apply to motorway sections, rather than all dual carriageway sections of national roads (these are signposted with the **N** prefix on the route number, rather than **M**). Some *national secondary roads*, and *regional roads* in particular often have houses, schools and other developments fronting on to them. Less important *national primary roads*, and older sections not yet upgraded may also feature such developments built before the introduction the Irish Planning system in 1964. Today Irish planning policy prohibits such development on National Primary or National Secondary roads where the speed limit exceeds 60 km/h (37 mph). This policy results from concerns expressed by the National Roads Authority. However, a local authority is not obliged to implement this policy and can disregard this policy at it own discretion. This would usually only occur in exceptional circumstances or where planners are over ruled by elected councillors using section 140 of the Local Government Act 2001. Accordingly, hard shoulders are included wherever feasible to provide for the resulting pedestrian and cyclist traffic, and are present on much of the national route network. These hard shoulders may also be used as running lanes by motorised traffic under certain conditions.

Until 2004/2005, many motorways and dual carriageways in Ireland did not have crash barriers in the central reservation, the policy being to use a wider median instead. Crash barriers are now mandatory for such routes, and wire cabling or full crash barriers (depending on whether or not the route is a motorway, and median width) have been fitted to existing routes.

As of 2008 three major types of dual carriageway are being built on national road schemes in the Republic of Ireland:

- High Quality Dual Carriageways (HQDC) - these are being built mainly on the major inter-urban routes, to full motorway standard but without motorway regulations. The Roads Act 2007 allows for these roads to be redesignated as motorways by ministerial order. Many of the sections of HQDC on the major inter-urban routes have been redesignated as motorways and full motorway regulations will apply when the redesignations come into effect.
- Standard dual carriageway of the traditional type is mainly planned for schemes on the N11 road, the N18 road and the N25 road. Plans for this type of dual carriageway on the N20 road have been superseded by newer plans to build a motorway, the M20, to replace most of this route. Traditionally this type of dual-carriageway had a mixture of at grade junctions (including roundabouts), grade separated junctions, and median crossings. Nowadays they are similar to HQDCs, but minor at grade exits - generally left turn only - are allowed and the design speed (by Irish standards) is only 100 km/h. Median crossings and roundabouts are no longer generally found on these schemes. An example of a standard dual carriageway scheme, opened in 2006, is the Ennis bypass although this road has grade separated junctions and no median crossings. This route has now been upgraded to motorway status.
- 2+2 roads - officially these roads are designated as *Type 2* dual carriageways by the National Roads Authority (NRA). They will be created by widening existing

roads or building new roads, and will have two lanes in each direction with a steel cable barrier in the middle but no hard shoulder. Most junctions will be at grade. With the exception of the restricted median width and the lack of lay-bys, this type of dual carriageway is similar to many dual carriageways found in the UK. The first 2+2 scheme (and the only example as of 2008), the N4 Dromod Roosky bypass, opened on 7 December 2007.

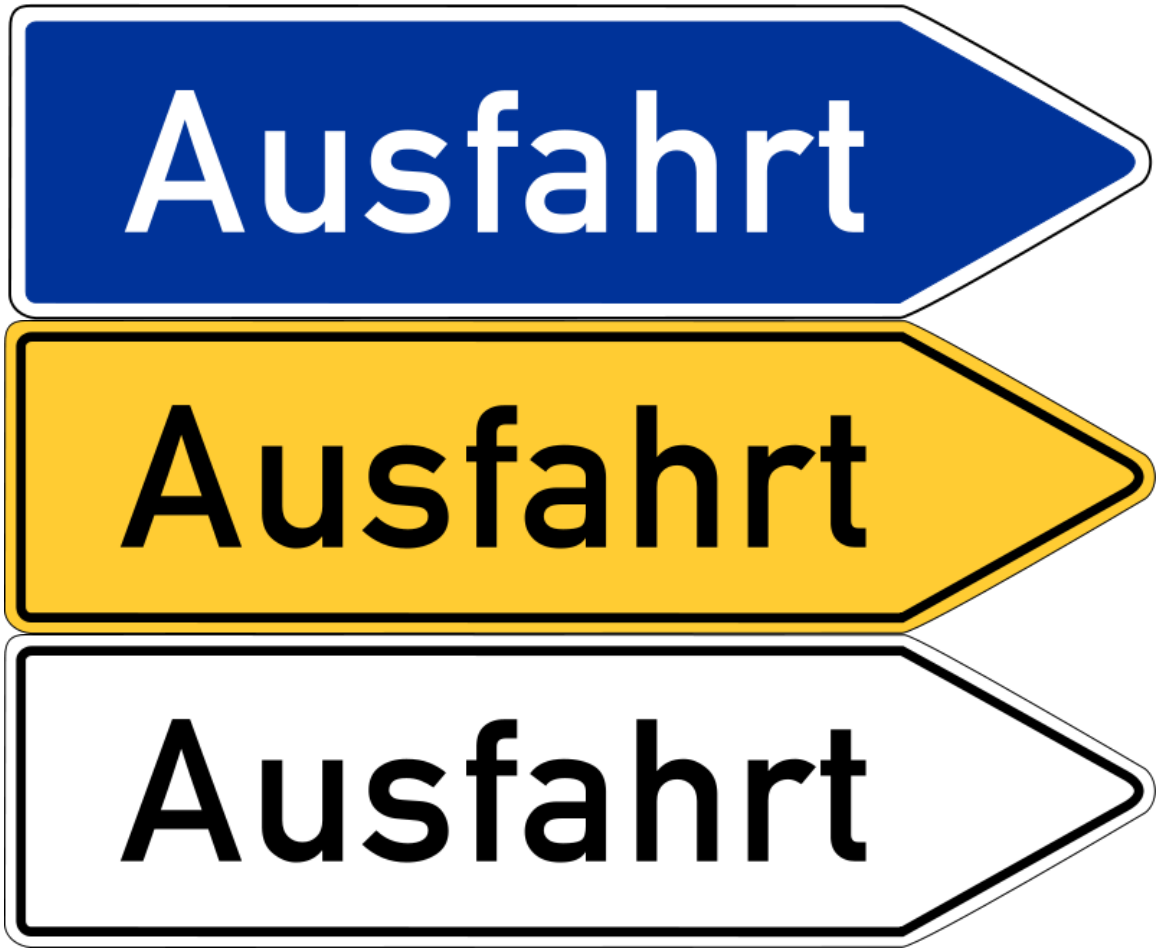
- 2+1 roads - officially these roads are designated as *Type 3* dual carriageways by the NRA. They have two lanes in one direction and one lane in the other, alternating every few kilometres, and usually separated with a steel cable barrier. Sections of 2+1 road have been built on the N20 and the N2. In July 2007, the NRA announced that it would no longer build 2+1 roads and 2+2 roads will be built instead.

Germany

B6(M) near Abbenrode

In Germany the term "Schnellstraße" (expressway) refers to streets that allow for higher speed traffic than is common on other streets which in turn requires them to have a dual carriageway in most cases. A special exception is the 2+1 road system in some rural areas that are also referred to as expressways (three lanes on a single carriageway where bypassing on the lane of the opposite direction is prohibited so that speed restriction is not required to increase safety - they are generally built to a 100 or 120 km/h traffic standard). This is based on the definition of expressways as having an increased amount of grade-separated sections. Technically a dual carriageway with central reservation is the legal foundation that no blank speed limit exists - comparable to the German Autobahn - but expressways are factually always given speed limit signs.

Expressways however can be upgraded to motorway standard which is colloquially referred to as "Gelbe Autobahn" (yellow motorway) because they have the same technical standard of the German autobahn but they use black on yellow signs instead of the white on blue signs on the Autobahn motorway network. These are generally high speed arterial roads of larger cities and important streets inside a federal state that do not connect major cities so that they do not fall under the federal budgeting program for the Autobahn network. The federal road Bundesstraße 27 is an example where about half of its length is upgraded to a high speed motorway standard. Some of these non-Autobahn motorways do not have an actual speed limit (design speed 130 km/h).



Exit signs.

The increasing importance of motorways outside of the Autobahn network is subject to upcoming legislation which does not exist so far in Germany where technically these are just rural roads that refer to the ministerial sign code for high speed dual carriageways. At the moment some (blue) motorways have been taken out of the Autobahn network program while still using the blue signs and on the other hand some former non-Autobahn (yellow) motorways have been added to Autobahn budgeting but the signs were not changed either. Motorways that are neither in the Autobahn network nor in the

Bundesstraße network are given black on white signs following the same sign code for high speed dual carriageways - this is mostly seen with urban trunk roads.

Italy

Italian national road *SS 1 Via Aurelia* near Livorno

In Italy, a dual carriageway is often called *superstrada* (meaning *expressway*), but this name is unofficial.

Italian Highway Code (*Codice della strada*) divides dual carriageways into three different classifications:

- *strada extraurbana principale* (meaning *main highway*) or *type-B road*: a road with separate carriageways, at least two lanes for each direction, paved shoulder on the right and no cross-traffic. This type of road is quite similar to an *autostrada* or *type-A road* (Italian official name for motorways or freeways), but its building standards are lower. Access limitations and drive behaviour on type-B roads are exactly the same of the motorways (no pedestrians, bicycles and other low vehicles), as well as the signage (except for the background color, that is blue instead of green). Speed limit on type-B roads is up to 110 kilometers per hour. Type-B roads are always toll-free.

- *strada extraurbana secondaria* (meaning *less importance road*) or *type-C road*. This category contains all the roads in non-urban context that are neither *autostrada* (type A) nor *strada extraurbana principale* (type B). This means that a dual carriageway that may not be classified as type-B road, since it does not meet such quality standards, belongs to this category. For type-C roads, there aren't neither special signage nor access restrictions, unless a specific sign is placed. Speed limit is 90 kilometers per hour, on both single and dual carriageways.
- *strada urbana di scorrimento* (meaning *urban expressway*) or *type-D road*: a road in urban context, with separate carriageways, and at least two lanes for each direction. At-level junctions with smaller roads, regulated by traffic lights, are allowed as well as roundabouts. Unless a prohibition sign is placed, there are not access restrictions. Speed limit on this type of road is up to 70 kilometers per hour.

Italian type-B and type-C roads do not follow a specific numbering criterion. They may be numbered as state roads (SS), regional roads (SR), provincial roads (SP) or municipal roads (SC).

Croatia

Dual carriageways or expressways in Croatia (Croatian: *brza cesta*) are non-tolled roads with 2 or more lanes in each direction, but without emergency lanes. The main highways/motorways in Croatia are also dual carriageways, but they have emergency lanes and tolls.

Many bypasses and beltways of smaller cities in Croatia have been recently constructed or planned as dual carriageways. All dual carriageways in Croatia house a central median, usually fitted with guardrails.

The most heavily used dual carriageway in Croatia is the B28 expressway, connecting capital Zagreb to a satellite town, Vrbovec. The D28 is currently finished up to the Gradec interchange. It is undergoing extensions which will increase the traffic traversing it.

Other regional implementations

United States

A divided highway (U.S. Route 52) in the state of Indiana.

Savery Avenue in Massachusetts
First Divided Highway in the U.S.

In the U.S., this sign tells motorists they are crossing a divided highway

In the United States, this type of road may be called a divided highway, boulevard, parkway, expressway, freeway, or interstate, and has a grassy median or Jersey barrier separating the traffic directions. With few exceptions, all roads in the federally funded Interstate Highway System are fully-controlled access divided highways known as freeways. A broader definition, expressways, includes both freeways and partial limited-access divided highways, and "expressway" is often used specifically to refer to the latter. United States Numbered Highways, state highways and other locally maintained highways may also be divided. Speed limits on rural divided highways range from 65–75 miles per hour (105–121 km/h), with some portions as high as 80 miles per hour (130 km/h). Urban divided highways which are at grade and typically have much lower speed limits are sometimes called boulevards.

In keeping with the U.S. Department of Transportation's *Manual of Uniform Traffic Controls and Devices* (MUTCD), since the early 1970s all divided highways are striped by color to show the direction of traffic flow. Two-way undivided roads have an amber center line, with a broken line indicating passing zones and a solid line indicating no passing zones and solid white baseline shoulder stripes. On undivided roads with more than one lane in each direction, the center is normally marked with a double solid line. The double solid stripe denotes that it is illegal to pass on the other side of the center line. Multilane one-way carriageways use broken white lines between lanes; the median-side baseline is solid amber, and the right sideline is solid white. Frequently in the U.S. the two carriageways are separated by some distance (wide medians with small forests or even hills in them), but drivers can always tell whether the roadway is two-way or one-way—and, if one-way, the direction in which the traffic flows—by looking at the striping coloration.

Canada

Highway 401 in Ontario, Canada, uses a divided highway, collector / express system to separate local traffic from longer distance travelers.

In Canada, "divided highway" is used for this type of road, and the segment between the roadways is referred to as a "median". More informally, a divided highway may be referred to as "twinned". This stems from the practice of "twinning" an existing two-lane highway (usually controlled-access) and converting it into a divided highway. On some portions of Ontario's 400-series highway network, the median may be either steel guardrail or an Ontario tall-wall barrier rather than an unpaved strip.

Like the US, there are two types of divided highways, fully-controlled access divided routes known as freeways, while expressways may include both freeways and partial limited-access divided highways. Canadians often use "highway" to refer to freeways. Partial limited-access divided highways such as the Hanlon Parkway and Black Creek Drive have at-grade intersections and private entrances but have sufficient right-of-way to convert them to full freeways if traffic warrants. There are also RIRO expressways, such as Highway 11 and a portion of Highway 35, which are not full freeways since they allow access to existing properties, but traffic speeds are faster than regular roads due to a median barrier preventing left turns (motorists have to use a "turnabout" overpass to access exits on the opposing direction).

Junctions may be at-grade or grade-separated, and there may be gaps in the median strip to allow turning and crossing. Divided highways are seldom equipped with traffic circles, roundabouts, or rotaries.

Australia

A typical dual carriageway in Melbourne, Australia.

Examples of dual carriageways on non-urban roads in Australia include the Hume Highway and the Pacific Highway (Australia); the Hume Highway by 2012, will be 100% dual carriageway and the Pacific Highway by 2016 will also be 100% dual carriageway. Today, 90% of the Hume Highway is dual carriageway and only 40% or 280 km (174 mi) of the Pacific Highway is dual carriageway, plus 10% of the Pacific Highway or 78 kilometres (48 miles) is under construction. The Federal Highway between the Hume Highway at Goulburn and Canberra is 100% dual carriageway, completed before the 2000 Summer Olympic Games. Some parts of the Princes Highway, Great Western Highway (A32) and the Barton Highway are also dual carriageway. Most non-urban dual carriageway highways/freeways are speed limited to 110 km/h (100 km/h for heavy vehicles), except for a short section in the Australian Capital Territory on the Federal Highway which is state limited to 100 km/h. The Warrego Highway between Brisbane and Toowoomba in Queensland is also dual carriageway with a maximum speed limit of 100km/h.

In Australia there is much confusion among the local population between a freeway and a dual carriageway, particularly those roads found in rural areas. While to be labelled a freeway, a road in Australia must have graded junctions, a physical barrier to separate the carriageways is not required. Speed limits do not change when road grades change from freeway to dual carriageway and vice versa. Stopping and U-turn prohibitions on Australian freeways are routinely ignored and rarely enforced. The Hume Freeway in Victoria, is actually a dual-carriageway grade road for much of its length with many ungraded junctions. Despite this, it has officially been called the "Hume Freeway" and

given a route marking of M31. An **M** marking is traditionally used for Motorway or Freeway lengths of roads in international jurisdictions that adopt the same MABC route labelling system as Victoria.

China

The best examples of dual carriageways in mainland China can be seen on the China National Highways. On some routes, such as China National Highway 106, there is a central reservation.

Singapore

A high proportion of roads in Singapore are dual carriageways with central reservations; examples include Clementi Road, Commonwealth Avenue and Holland Road. Often there might be railings erected on the central reservation to prevent pedestrians from dashing across the road. These usually have traffic lights along the way but flyovers and road tunnels (or 'underpasses') can be built to minimise the use of traffic lights; for example, at the Holland Road-Farrer Road-Queensway junction there are three levels of roads. Before the 1980s roundabouts were popular but since then many have been changed to traffic-light controlled junctions.

These dual carriageways are to be distinguished from motorways, known in Singapore as expressways such as the Pan-Island Expressway (PIE) and Ayer Rajah Expressway (AYE) where no traffic lights are used.

Malaysia

There are dual expressways, such as East Coast Expressway.

Chapter 3

Limited-Access Road & Toll Road

Limited-Access Road

Limited access to the A1214 main road in the Ipswich (UK). Map source: Ordnance Survey

California State Route 1 is showing parallel service roads for local traffic. Map source OpenStreetMap

A **limited-access road** (also **limited-access highway**, **controlled-access road**) is a highway to which access from adjacent properties is limited in some way; a limited access road (for example a freeway) may also have a divided highway, grade separated junctions and prohibit some modes of transport such as bicycles or horses; however others may be city streets where controls are placed on the number of driveway accesses by the provision of a parallel service road or other means. The precise definition of these terms varies by jurisdiction.

History

The first implementation of limited-access roadways in the United States was of the Bronx River Parkway in New York, in 1907. The New York State Parkway System was constructed as a network of high speed roads in and around New York City.

The first limited access highway built is thought to be the privately built Long Island Motor Parkway in Long Island, New York.

The concept evolved into uninterrupted arterial roads that are commonly known as expressways in some parts of the world and by other names including motorway and autobahn in others.

Regional implementations

In the United States, the national Manual on Uniform Traffic Control Devices (MUTCD) uses "full control of access" only for freeways. Expressways are defined as having "partial control of access" (or *semi-controlled access*), meaning that major roads typically use interchanges and commercial development is accessed via cross roads or frontage roads, while minor roads can cross at grade and farms can have direct access. This definition is also used by some states, some of which also restrict freeways only to motor vehicles capable of maintaining a certain speed. Some other states use "controlled access" to mean a higher standard than "limited access", while others reverse the two terms.

In the United Kingdom, ribbon development became a problem with the advent of the motorcar and was controlled by the Restriction of Ribbon Development Act 1935. Some roads from this period started to be built parallel service roads. The Special Roads Act 1949 provided for the construction of motorways including the M1 motorway which opened in 1958 which incorporated limited access, divided highways and grade separated junctions.

Toll Road

A **toll road** (or **tollway**, **turnpike**, **toll highway** or an **express toll route**) is a privately or publicly built road for which a driver pays a **toll** (a fee) for use. Structures for which tolls are charged include toll bridges and toll tunnels. Non-toll roads are financed using other sources of revenue, most typically fuel tax or general tax funds. The building or facility in which a toll is collected may be called a **toll booth**, **toll house**, **toll plaza**, **toll station**, **toll bar** or **toll gate**. This building is usually found on either side of a bridge and at exits.

Road tolling concepts

Road tolls were levied traditionally for a specific access (e.g. city) or for a specific infrastructure (e.g. roads, bridges). These concepts were widely used until the last century. However, the evolution in technology made it possible to implement road tolling policies based on different concepts. The different charging concepts are designed to suit different requirements regarding purpose of the charge, charging policy, the network to the charge, tariff class differentiation etc.:

Time Based Charges and Access Fees: In a time-based charging regime, a road user has to pay for a given period of time in which he may use the associated infrastructure. For the practically identical access fees, the user pays for the access to a restricted zone for a period or several days.

Motorway and other Infrastructure Tolling: The term tolling is used for charging a well-defined special and comparatively costly infrastructure, like a bridge, a tunnel, a mountain pass, a motorway concession or the whole motorway network of a country.

Classically a toll is due when a vehicle passes a tolling station, be it a manual barrier-controlled toll plaza or a free-flow multi-lane station.

Kilometre or Area Charging: In a kilometre or area charging system concept, vehicles are charged per total distance driven in a defined area.

Variations

Three systems of toll roads exist: open (with mainline barrier toll plazas); closed (with entry/exit tolls) and all-electronic toll collection (no toll booths, only electronic toll collection gantries at entrances and exits, or at strategic locations on the mainline of the road).

On an open toll system, all vehicles stop at various locations along the highway to pay a toll. While this may save money from the lack of need to construct tolls at every exit, it can cause traffic congestion, and drivers may be able to avoid tolls (shunpiking) by exiting and re-entering the highway.

With a closed system, vehicles collect a ticket when entering the highway. In some cases, the ticket displays the toll to be paid on exit. Upon exit, the driver must pay the amount listed for the given exit. Should the ticket be lost, a driver must typically pay the maximum amount possible for travel on that highway. Short toll roads with no intermediate entries or exits may have only one toll plaza at one end, with motorists traveling in either direction paying a flat fee either when they enter or when they exit the toll road. In a variant of the closed toll system, mainline barriers are present at the two endpoints of the toll road, and each interchange has a ramp toll that is paid upon exit or entry. In this case, a motorist pays a flat fee at the ramp toll and another flat fee at the end of the toll road; no ticket is necessary.

In an all-electronic system (such as that used on Highway 407 in the Canadian province of Ontario and the Fort Bend Westpark Tollway in the U.S. state of Texas), no cash toll collection takes place, tolls are usually collected with the use of a transponder mounted on the windshield of each vehicle, which is linked to a customer account which is debited for each use of the toll road. On some roads, such as Highway 407, automobiles and light trucks without transponders are permitted to use the road (though trucks with a gross vehicle weight over 5,000 kilograms must have a transponder) - a bill for the toll due is then sent to the registered owner of the vehicle by mail; by contrast, the Fort Bend Westpark Tollway requires all vehicles to be equipped with a transponder.

Modern toll roads often use a combination of the three, with various entry and exit tolls supplemented by occasional mainline tolls.

Some toll roads charge a toll in only one direction, such as where the M4 in Great Britain crosses the River Severn on either of the two Severn Bridges. On these bridges, it is free to travel from Wales into England, but a toll must be paid on the return journey. Crossings between Pennsylvania and New Jersey operated by Delaware River Port

Authority, and crossings between New Jersey and New York operated by Port Authority of New York and New Jersey, use this method (in coordination with the E-ZPass electronic transponder system) given the distance between the bridges along the river, commuter traffic between the two states, and similar tolls on each bridge. This is practical where the detour to avoid the toll is large or the toll differences are small.

Toll payments may be made in cash, by credit card, by pre-paid card, or by an electronic toll collection system. In some European countries, payment is made using stickers which are affixed to the windscreen. Some toll booths are automated. Tolls may vary according to the distance traveled, the building and maintenance costs of the motorway, and the type of vehicle.

Early toll roads

The history of tolls stretches back to Greek mythology where Charon the ferryman charged a toll to carry the dead across the rivers Acheron and Styx to Hades. If the soul paid a toll, Charon ferried it across the river. If not, it wandered between death and life for eternity.

Tolls have been placed on roads at various times in history, often to generate funds for repayment of toll revenue bonds used to finance constructions and/or operation.

Toll roads are at least 2700 years old, as tolls had to be paid by travellers using the Susa–Babylon highway under the regime of Ashurbanipal, who reigned in the seventh century BC. Aristotle and Pliny refer to tolls in Arabia and other parts of Asia. In India, before the 4th century BC, the Arthasastra notes the use of tolls. Germanic tribes charged tolls to travellers across mountain passes. Tolls were used in the Holy Roman Empire in the 14th century and 15th century.

A 14th century example (though not for a road) is Castle Loevestein in the Netherlands, which was built at a strategic point where 2 rivers meet, and charged tolls on boats sailing along the river.

Many modern European roads were originally constructed as toll roads in order to recoup the costs of construction. In 14th century England, some of the most heavily used roads were repaired with money raised from tolls by pavage grants. Turnpike trusts were established in England from 1706 onwards, and were ultimately responsible for the maintenance and improvement of most main roads in England and Wales, until they were gradually abolished from the 1870s. Most trusts improved existing roads, but some new ones, usually only short stretches of road, were also built. Thomas Telford's Holyhead road (now the A5 road) is exceptional as a particularly long new road, built in the early 19th century with many toll booths along its length.

19th century toll booth in Kings County, New York

Some cities in Canada had toll roads in the 19th Century. Roads radiating from Toronto required users to pay at toll gates along the street (Yonge Street, Bloor Street, Davenport Road, Kingston Road) and disappeared after 1895.

19th century plank roads were usually operated as toll roads. One of the first U.S. motor roads, the Long Island Motor Parkway (which opened on October 10, 1908) was built by William Kissam Vanderbilt II, the great-grandson of Cornelius Vanderbilt. The road was closed in 1938 when it was taken over by the state of New York in lieu of back taxes.

In the 20th century, road tolls have been introduced in Europe for financing the construction of motorway networks and specific road infrastructure such as bridges and tunnels. Italy has been the first European country to apply the use of motorway tolls on a 50 km motorway section near Milan in 1924. It was followed by Greece, which made users to pay for the network of motorways around and between its cities in 1927. Later in the 1950's and 1960's, also France, Spain and Portugal started to build motorways largely with the aid of concessions, allowing rapid development of this infrastructure

without massive State debts. Since then, road tolls have been introduced in the majority of the EU Member States.

National toll-road differences

Toll roads are found in many countries. The way they are funded and operated may differ from country to country. Some of these toll roads are privately owned and operated. Others are owned by the government. Some of the government-owned toll roads are privately operated.

Some toll roads are managed under such systems as the Build-Operate-Transfer (BOT) system. Private companies build the roads and are given a limited franchise. Ownership is transferred to the government when the franchise expires. Throughout the world, this type of arrangement is prevalent in Australia, India, South Korea, Japan, Philippines, and Canada. The (BOT) system is a fairly new concept that is gaining ground in the United States, with Arkansas, California, Delaware, Florida, Illinois, Indiana, Mississippi, Texas, and Virginia already building and operating toll roads under this scheme. Pennsylvania, Massachusetts, New Jersey, and Tennessee are also considering the BOT methodology for future highway projects.

The more traditional means of managing toll roads in the United States is through semi-autonomous public authorities. New York, Massachusetts, New Hampshire, New Jersey, Maryland, Ohio, Pennsylvania, Kansas, Oklahoma, and West Virginia manage their toll roads in this manner. While most of the toll roads in California, Delaware, Florida, Texas, and Virginia are operating under the BOT arrangement, a few of the older toll roads in these states are still operated by public authorities.

In France, all toll roads are operated by private companies, and the government takes a part of their profit.

Critics of toll roads

Toll roads have been criticized as being inefficient in various ways:

1. They require vehicles to stop or slow down, manual toll collection wastes time and raises vehicle operating costs.
2. Collection costs can absorb up to one-third of revenues, and revenue theft is considered to be comparatively easy.
3. Where the tolled roads are less congested than the parallel "free" roads, the traffic diversion resulting from the tolls increases congestion on the road system and reduces its usefulness.
4. By tracking the vehicle locations, their drivers are subject to an effectual restriction of their freedom of movement and freedom from excessive surveillance.

Toll collection technology

An adaptation of military "identification friend or foe" or RFID technology, called electronic toll collection, is lessening the delay incurred in toll collection. The electronic system determines whether a passing car is enrolled in the program, alerts enforcers if it is not. The accounts of registered cars are debited automatically without stopping or even opening a window. Currently, DSRC is used as a wireless protocol. Other systems are based on GPRS/GSM and GPS technology. Such a system (for trucks only) in Germany launched successfully in January 2005 and by the end of its first year of operation will have charged tolls for around 22 billion driven kilometres. One of the advantages of GPS-based systems is their ability to adapt easily and quickly to changes in charge parameters (road classes, vehicle types, emission levels, time slots, etc.). Another advantage is the systems' ability to support other value-added services on the same technology platform. These services might include fleet and vehicle engine management systems, emergency response services, pay-as-you-drive insurance services and navigation capabilities.

The first major deployment of an RFID electronic toll collection system in the United States was on the Dallas North Tollway in 1989 by Amtech. The Amtech RFID technology used on the Dallas North Tollway was originally developed at Sandia Labs for use in tagging and tracking livestock. In the same year, the Telepass active transponder RFID system was introduced across Italy.

Highway 407 in the province of Ontario, Canada has no toll booths, and instead reads a transponder mounted on the windshields of each vehicle using the road (the rear license plates of vehicles lacking a transponder are photographed when they enter and exit the highway). This made the highway the first all-automated highway in the world. A bill is mailed monthly for usage of the 407. Lower charges are levied on frequent 407 users who carry electronic transponders in their vehicles. The approach has not been without controversy: In 2003 the 407 ETR settledPDF a class action with a refund to users. The same method is used on Highway 6 in Israel and the reversible lanes of the Lee Roy Selmon Crosstown Expressway in Hillsborough County, Florida (in the latter case, the system reads SunPass transponders).

Throughout most of the East Coast of the United States, E-ZPass (operated under the brands I-Pass in Illinois, i-Zoom in Indiana, and Fast Lane in Massachusetts) is accepted on almost all toll roads. Similar systems include SunPass in Florida, FasTrak in California, and ExpressToll in Colorado. The systems use a small radio transponder mounted in or on a customer's vehicle to deduct toll fares from a pre-paid account as the vehicle passes through the toll barrier. This reduces manpower at toll booths and increases traffic flow and fuel efficiency by reducing the need for complete stops to pay tolls at these locations.

By designing a tollgate specifically for electronic collection, it is possible to carry out open-road tolling, where the customer does not need to slow at all when passing through the tollgate. The U.S. state of Texas is testing a system on a stretch of Texas 121 that has

no toll booths. Drivers without a TollTag have their license plate photographed automatically and the registered owner will receive a monthly bill, at a higher rate than those vehicles with TollTags.

Another feature of many electronic toll collection systems is interagency interoperability, where the same transponder is accepted at many toll agencies. For instance, the E-ZPass tag is accepted at most toll facilities in the Eastern United States, from Virginia to Maine, west to the Peace Bridge spanning the Niagara River, and in Ohio, Indiana, and Illinois. The TxTAG system allows interoperability throughout the state of Texas, but is not compatible with systems used outside of Texas.

Electronic toll collection systems also have drawbacks. A computer glitch can result in delays several miles long. Some U.S. state turnpike commissions have debated implementing E-ZPass but have found that such a system would be ineffective because most of the people who use the turnpike are not commuters, are from states that have no ETS on turnpikes, or are from states that don't have a turnpike at all. The toll plazas of some turnpikes are antiquated because they were originally built for traffic that stops to pay the toll or get a ticket.

The technology does have its limits. For instance, the Highway 407 automatic number plate recognition technology has a reputation for the occasional misread plate, leading to bills being sent to motorists in remote parts of Ontario who have never been near the tollway. The Ontario government responded to complaints by hiring an ombudsman to address 407 toll complaints.

One of the first all-electric toll roads, the Triangle Parkway, will open at the end of 2011 in North Carolina.

Closed system

For toll roads, a "closed system" refers to a road where a motorist obtains a ticket upon entering the toll road, then pays a toll upon exiting the expressway. The toll is calculated by the distance travelled on the toll road. In the United States, for instance, the Kansas Turnpike, Pennsylvania Turnpike, Ohio Turnpike, and portions of Florida's Turnpike currently implement closed systems. In contrast, a toll road using an 'open system' consists of mainline toll plazas (a.k.a., toll barriers) at set intervals; it is possible for motorists to get on an 'open toll road' after one toll barrier and exit before the next one, thus travelling on the toll road toll-free. Most open toll roads have ramp tolls or partial access junctions to prevent this. The Massachusetts Turnpike or "MassPike," the Pennsylvania Turnpike and the New York State Thruway implement both systems in different sections.

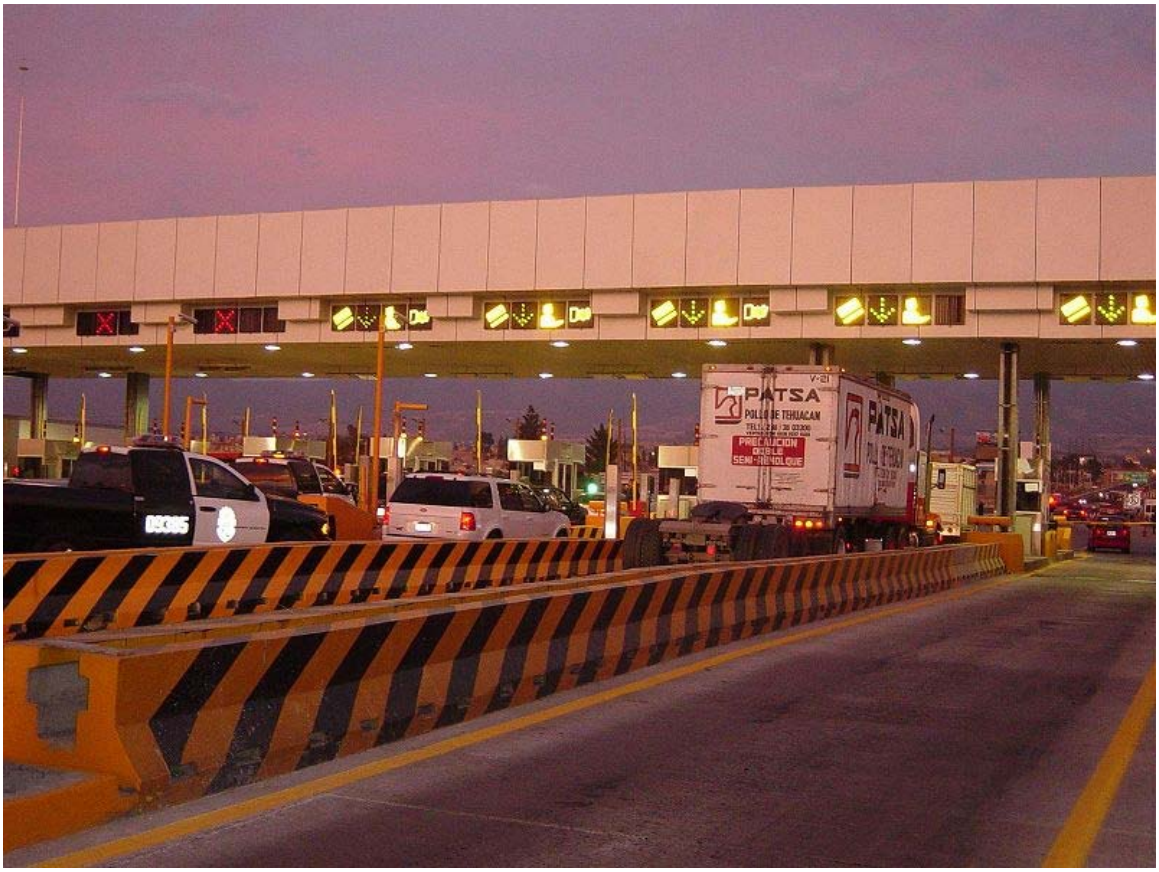
Toll road leading to the Kingsway Tunnel which connects Wallasey and Liverpool under the River Mersey in England, United Kingdom

A high-speed toll booth on SR 417 near Orlando, Florida, United States

On the Sayama bypass (Saitama prefectural road 397) in Japan

A New Jersey Turnpike Toll Gate for Exit 8A in Monroe Township, New Jersey, United States

The open road tolling lanes at the West 163rd Street toll plaza, on the Tri-State Tollway near Hazel Crest, Illinois, United States

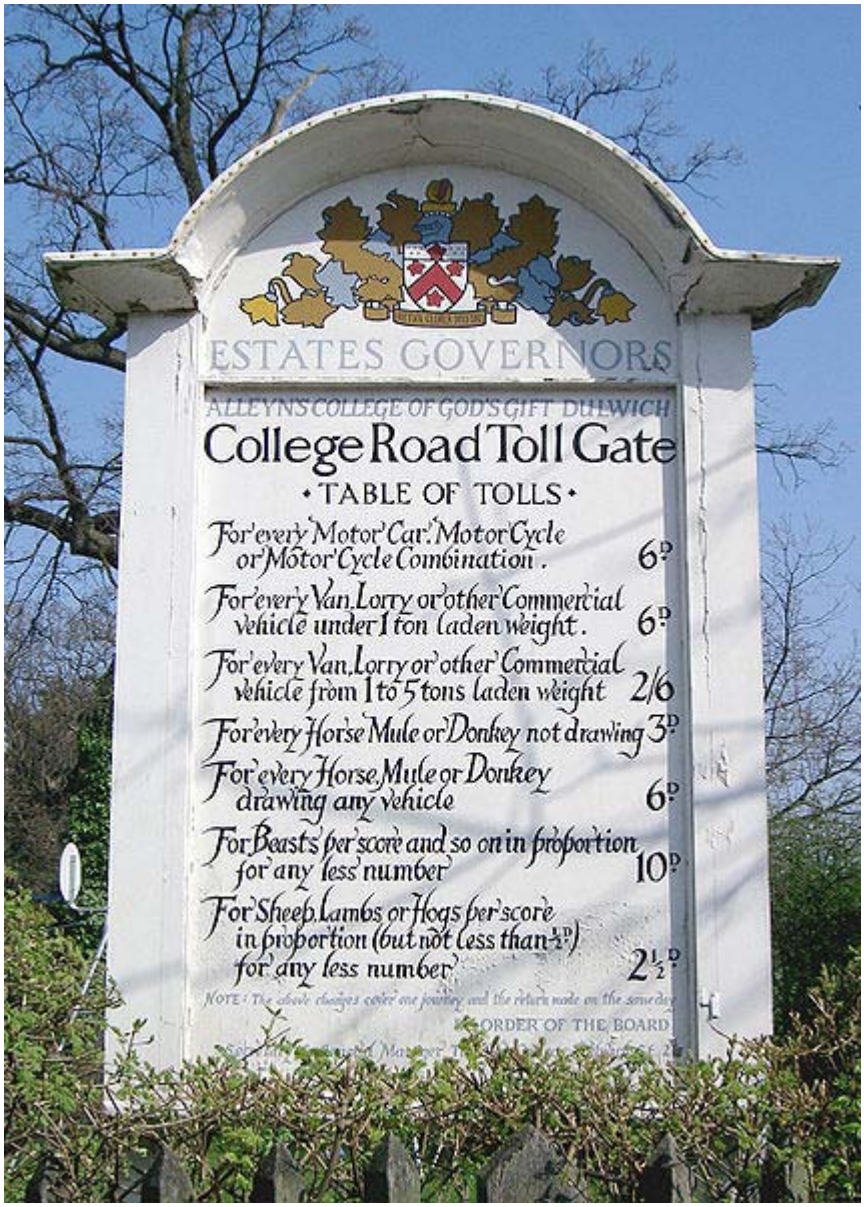


Toll gate *San Marcos*, at the México-Puebla autopista, Mexico

M6 Toll at Great Wyrley near Birmingham in England, United Kingdom

Venice Toll Gate in Autostrada A57 in Italy

ERP gantry at North Bridge Road. Singapore



A table of tolls in pre-decimal currency for the College Road, Dulwich, London SE21 tollgate.

On the Dom Pedro I Highway near the city of Itatiba, Brazil

The Balintawak Toll Barrier of the North Luzon Expressway located in Caloocan City, Philippines.

Service areas provide food, fuel, and travel information on the Ohio Turnpike, in the United States.

407ETR overhead cameras used to capture rear license plates in Ontario, Canada.

Northern Terminus of Cipularang Toll Road, West Java, Indonesia.

Chapter 4

Road Traffic Safety

Sidewalks, curbs and traffic signals in Maryland, United States

Speed limits in different areas, unusually with only a "recommended" limit (130km) for the Autobahn

The term **road traffic safety** is an indication of how safe individual users are on some particular road, or on the roads belonging to some region. The main danger to road users is the likelihood of a traffic collision. Such dangers can be reduced by individual road users operating cautiously and defensively, by building roads in alignment with competent traffic engineering practices, by the application of rational traffic control methods, and by designing road vehicles so they are more able to avoid and survive collisions.

Background

Guardrails save a vehicle from a long fall c. 1920.

Road traffic crashes are one of the world's largest public health and injury prevention problems. The problem is all the more acute because the victims are overwhelmingly healthy prior to their crashes. According to the World Health Organization (WHO), more than a million people are killed on the world's roads each year. A report published by the WHO in 2004 estimated that some 1.2m people were killed and 50m injured in traffic collisions on the roads around the world each year and was the leading cause of death among children 10 – 19 years of age. The report also noted that the problem was most severe in developing countries and that simple prevention measures could halve the number of deaths.

The standard measures used in assessing road safety interventions are fatalities and Killed or Seriously Injured (KSI) rates, usually per billion (10^9) passenger kilometres. In the United States, crashes per million vehicle miles is typically used for road safety.

Speed is a key goal of modern road design, but impact speed affects the severity of injury to both occupants and pedestrians. For occupants, Joksch (1993) found the probability of death for drivers in multi-vehicle accidents increased as the fourth power of impact speed (often referred to by the mathematical term δv ("delta V"), meaning change in velocity). Injuries are caused by sudden, severe acceleration (or deceleration), this is difficult to measure. However, crash reconstruction techniques can be used to estimate vehicle speeds before a crash. Therefore, the change in speed is used as a surrogate for acceleration.

Interventions take many forms. Contributing factors to highway crashes may be related to the driver (such as driver error, illness or fatigue), the vehicle (brake, steering, or throttle failures) or the road itself (lack of sight distance, poor roadside clear zones, etc.). Interventions may seek to reduce or compensate for these factors, or reduce the severity of crashes that do occur. A comprehensive outline of interventions areas can be seen in Management systems for road safety.

Infrastructure design

For road traffic safety purposes it can be helpful to classify roads into ones in built-up area, non built-up areas and then major highways (Motorways/Freeways etc.)

Most casualties generally occur in on roads in built-up areas and major highways are the safest. Reported Road Casualties Great Britain for 2008 show that most fatalities occur on non built-up roads but that the vast majority of serious injuries and injuries occur in built-up areas:

Road Type	Killed	Serious injury	Slight injury	total injury	ref	Note
Non Built-up (excludes motorways)	1,323	8,342	48,810	58,475		52% of the total killed, 32% of total seriously injured, 25% of total with slight injuries
Built-up	1,057	16,823	143,079	160,959		42% of the total killed, 65% of total seriously injured, 70% of total with slight injuries
Motorway	158	869	10,444	11,471		6% of the total killed, 3% of total seriously injured, 5% of total with slight injuries. Fatalities on motorways have decreased by 9 per cent since 1994-98 in a period with traffic levels increased by 28%"
All casualties	**2,538**	**26,034**	**202,333**	**230,905**		

Built-up areas

Pedestrian crossing, line markings and street furniture.

A curb extension at a mid-block crosswalk

Utrecht has specially-painted bicycle-only lanes.

On neighborhood roads where many vulnerable road users, such as pedestrians and bicyclists can be found, traffic calming can be a tool for road safety. Shared space schemes, which rely on human instincts and interactions, such as eye contact, for their effectiveness, and are characterised by the removal of traditional traffic signals and signs, and even by the removal of the distinction between carriageway (roadway) and footway (sidewalk), are also becoming increasingly popular. Both approaches can be shown to be effective.

Modern safety barriers are designed to absorb impact energy and minimize the risk to the occupants of cars, and bystanders. For example, most side rails are now anchored to the ground, so that they cannot skewer a passenger compartment, and most light poles are designed to break at the base rather than violently stop a car that hits them. Some road fixtures such as road signs and fire hydrants are designed to collapse on impact. Highway authorities have also removed trees in the vicinity of roads; while the idea of "dangerous trees" has attracted a certain amount of skepticism, unforgiving objects such as trees can cause severe damage and injury to any errant road users.

Most roads are cambered (crowned), that is, made so that they have rounded surfaces, to reduce standing water and ice, primarily to prevent frost damage but also increasing traction in poor weather. Some sections of road are now surfaced with porous bitumen to

enhance drainage; this is particularly done on bends. These are just a few elements of highway engineering. As well as that, there are often grooves cut into the surface of cement highways to channel water away, and rumble strips at the edges of highways to rouse inattentive drivers with the loud noise they make when driven over. In some cases, there are raised markers between lanes to reinforce the lane boundaries; these are often reflective. In pedestrian areas, speed bumps are often placed to slow cars, preventing them from going too fast near pedestrians.

Poor road surfaces can lead to safety problems. If too much asphalt or bitumenous binder is used in asphalt concrete, the binder can 'bleed' or flush' to the surface, leaving a very smooth surface that provides little traction when wet. Certain kinds of stone aggregate become very smooth or polished under the constant wearing action of vehicle tyres, again leading to poor wet-weather traction. Either of these problems can increase wet-weather crashes by increasing braking distances or contributing to loss of control. If the pavement is insufficiently sloped or poorly drained, standing water on the surface can also lead to wet-weather crashes due to hydroplaning.

Lane markers in some countries and states are marked with Cat's eyes or Botts dots, bright reflectors that do not fade like paint. Botts dots are not used where it is icy in the winter, because frost and snowplows can break the glue that holds them to the road, although they can be embedded in short, shallow trenches carved in the roadway, as is done in the mountainous regions of California.

Road hazards and intersections in some areas are now usually marked several times, roughly five, twenty and sixty seconds in advance so that drivers are less likely to attempt violent manoeuvres.

Most road signs and pavement marking materials are retro-reflective, incorporating small glass spheres or prisms to more efficiently reflect light from vehicle headlights back to the driver's eyes.

Designing for pedestrians and cyclists

Pedestrians and Cyclists are among the most vulnerable road users, and in some countries constitute over half of all road deaths. Interventions aimed at improving safety of non-motorised users:

- Sidewalks of suitable width for the expected pedestrian traffic
- pedestrian crossings close to the desire line which allow pedestrians to cross roads safely
- segregated pedestrian routes and cycle lanes away from the main highway
- Overbridges (tend to be unpopular with pedestrians and cyclists due to additional distance and effort)
- Underpasses (these can pose heightened risk from crime is not designed well, can work for cyclists in some cases)
- traffic calming and speed humps

- low speed limits that are rigorous enforced, possibly by speed cameras
- shared space schemes giving ownership of the road space and equal priority to all road users, regardless of mode of use
- pedestrian barriers to prevent pedestrians crossing dangerous locations

Pedestrians' advocates question the equitability of schemes if they impose extra time and effort on the pedestrian to remain safe from vehicles, for example overbridges with long slopes or steps up and down, underpasses with steps and addition possible risk of crime and at-grade crossings off the desire line. The Make Roads Safe was criticised in 2007 for proposing such features. Successful pedestrian schemes tend to avoid over-bridges and underpasses and instead use at-grade crossings (such as pedestrian crossings) close the intended route. Successful cycling scheme by contrast avoid frequent stops even if some additional distance is involved given that the main effort required for cyclists is starting off.

In Costa Rica 57% of road deaths are pedestrians, however a partnership between AACR, Cosevi, MOPT and iRAP has proposed the construction of 190 km of pedestrian footpaths and 170 pedestrian crossings which could save over 9000 fatal or serious injuries over 20 years.

Shared space

A shared space in Brighton (UK).

By 1947 the Pedestrians' Association was suggesting that many of the safety features being introduced (speed limits, traffic calming, road signs and road markings, traffic lights, Belisha beacons, pedestrian crossings, cycle lanes etc.) were potentially self defeating because "every nonrestrictive safety measure, however admirable in itself, is treated by the drivers as an opportunity for more speeding, so that the net amount of danger is increased and the latter state is worse than the first."

During the 1990s a new approach, known as 'shared space' was developed which removed many of these features in some places has attracted the attention of authorities around the world. The approach was developed by Hans Monderman who believed that "if you treat drivers like idiots, they act as idiots" and proposed that trusting drivers to behave was more successful than forcing them to behave. Professor John Adams, an expert on risk compensation suggested that traditional traffic engineering measures assumed that motorists were "selfish, stupid, obedient automatons who had to be protected from their own stupidity" and non-motorists were treated as "vulnerable, stupid, obedient automatons who had to be protected from cars – and their own stupidity".

Reported results indicate that the *shared space* approach leads to significantly reduced traffic speeds, the virtual elimination of road casualties, and a reduction in congestion. Living Streets share some similarities with Shared Spaces. The woonerven also sought to reduce traffic speeds in community and housing zones by the use of lower speed limits enforced by the use of special signage and road markings, the introduction of traffic calming measures, and by giving pedestrians priority over motorists.

Major highways

Guard rail on road in Kaluga Oblast (Russia)

The Pan-American Highway with central median and no freestanding obstructions

Major highways including motorways, freeways, Autobahnen and Interstates are designed for safer high-speed operation and generally have lower levels of injury per vehicle km than other roads.

Safety features include:

- limited access from properties and local roads.
- Grade separated junctions
- Median dividers between opposite-direction traffic to reduce likelihood of head-on collisions
- Removing roadside obstacles.
- Prohibition of more vulnerable road users and slower vehicles.
- Placements of energy attenuation devices (e.g. guard rails, wide grassy areas, sand barrels).
- Eliminating road toll booths

The ends of some guard rails on high-speed highways in the United States are protected with impact attenuators, designed to gradually absorb the kinetic energy of a vehicle and slow it more gently before it can strike the end of the guard rail head on, which would be devastating at high speed. Several mechanisms are used to dissipate the kinetic energy.

Fitch Barriers, a system of sand-filled barrels, uses momentum transfer from the vehicle to the sand. Many other systems tear or deform steel members to absorb energy and gradually stop the vehicle.

In some countries major roads have "tone bands" impressed or cut into the edges of the legal roadway, so that drowsing drivers are awakened by a loud hum as they release the steering and drift off the edge of the road. Tone bands are also referred to as "rumble strips," owing to the sound they create. An alternative method is the use of "Raised Rib" markings, which consists of a continuous line marking with ribs across the line at regular intervals. They were first specially authorised for use on motorways as an edge line marking to separate the edge of the hard shoulder from the main carriageway. The objective of the marking is to achieve improved visual delineation of the carriageway edge in wet conditions at night. It also provides an audible/vibratory warning to vehicle drivers, should they stray from the carriageway, and run onto the marking.

Better motorways are banked on curves in order to reduce the need for tire-traction and increase stability for vehicles with high centers of gravity.

An example of the importance of roadside clear zones can be found on the Isle of Man TT motorcycle race course. It is much more dangerous than Silverstone because of the lack of runoff. When a rider falls off at Silverstone he slides along slowly losing energy, so minimal injuries. When he falls of in the Manx he impacts with trees and walls. Similarly, a clear zone alongside a freeway or other high speed road can prevent off-road excursions from becoming fixed-object crashes.

The U.S. has developed a prototype automated roadway, to reduce driver fatigue and increase the carrying capacity of the roadway. Roadside units participating in future Wireless vehicle safety communications networks have been studied.

Motorways are far more expensive and space-consumptive to build than ordinary roads, so are only used as principal arterial routes. In developed nations, motorways bear a significant portion of motorized travel; for example, the United Kingdom's 3533 km of motorways represented less than 1.5% of the United Kingdom's roadways in 2003, but carry 23% of road traffic.

The proportion of traffic borne by motorways is a significant safety factor. For example, even though the United Kingdom had a higher fatality rates on both motorways and non-motorways than Finland, both nations shared the same overall fatality rate in 2003. This result was due to the United Kingdom's higher proportion of motorway travel.

Similarly, the reduction of conflicts with other vehicles on motorways results in smoother traffic flow, reduced collision rates, and reduced fuel consumption compared with stop-and-go traffic on other roadways.

The improved safety and fuel economy of motorways are common justifications for building more motorways. However, the planned capacity of motorways is often

exceeded in a shorter timeframe than initially planned, due to the under estimation of the extent of the suppressed demand for road travel. In developing nations, there is significant public debate on the desirability of continued investment in motorways.

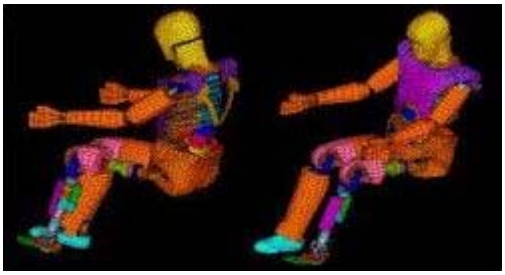
Motorways around the world are subject to a broad range of speed limits. Recent experiments with variable speed limits based on automatic measurements of traffic density have delivered both improvements in traffic flow and reduced collision rates, based on principles of turbulent flow analysis.

With effect from January 2005 and based primarily on safety grounds, the UK's Highways Agency's policy is that all new motorway schemes are to use high containment concrete step barriers in the central reserve. All existing motorways will introduce concrete barriers into the central reserve as part of ongoing upgrades and through replacement as and when these systems have reached the end of their useful life. This change of policy applies only to barriers in the central reserve of high speed roads and not to verge side barriers. Other routes will continue to use steel barriers.

30% of highway crashes that occur in the vicinity of toll collection booths in the countries that have them, these can be eliminated by switching to a system of government taxation for road use

Vehicle safety

Cars



Simulated crashes using crash test dummies can help improve automobile design

Safety can be improved by reducing the chances of a driver making an error, or by designing vehicles to reduce the severity of crashes that do occur. Most industrialized countries have comprehensive requirements and specifications for safety-related vehicle devices, systems, design, and construction. These may include:

- Passenger restraints such as seat belts — often in conjunction with laws requiring their use — and airbags
- Crash avoidance equipment such as lights and reflectors
- Driver assistance systems such as Electronic Stability Control
- Crash survivability design including fire-retardant interior materials, standards for fuel system integrity, and the use of safety glass

- *Sobriety detectors*: These interlocks prevent the ignition key from working if the driver breathes into one and it detects significant quantities of alcohol. They have been used by some commercial transport companies, or suggested for use with persistent drunk-driving offenders on a voluntary basis

Trucks

According to the European Commission Transportation Department "it has been estimated that up to 25% of accidents involving trucks can be attributable to inadequate cargo securing" . Improperly secured cargo can cause severe accidents and lead to loss of cargo, loss of lives, loss of vehicles and can be a hazard for the environment. One way to stabilize, secure and protect cargo during transportation on the road is by using Dunnage Bags which are placed in the void between the cargo and are designed to prevent the load from moving during transport.

Regulation of road users

Various types of road user regulations are in force or have been tried in most jurisdictions around the world, some these are discussed by road user type below.

Motor vehicle users

Dependent on jurisdiction, driver age, road type and vehicle type, motor vehicle drivers may be required to pass a driving test (public transport and goods vehicle drivers may need additional training and licensing), conform to restrictions on driving after consuming alcohol or various drugs, comply with restrictions on use of mobile phones, be covered by compulsory insurance, wear seat belts and comply with certain speed limits. Motorcycle riders may additionally be compelled to wear a motorcycle helmet. Drivers of certain vehicle types may be subject to maximum driving hour regulations.

Some jurisdictions such as Virginia, U.S. and in Maryland, U.S. are targeting specific regulations such as the prohibiting mobile phone use and limiting passenger numbers at young and inexperienced drivers. It has been noticed that more of these types of serious collision occur at night, when the car has multiple occupants and when seat belt use is less.

Insurance companies have proposed that the following restrictions should be imposed on new drivers: a "curfew" imposed on young drivers to prevent them driving at night, an experienced supervisor to chaperone the less experienced driver, forbidding the carrying of passengers, zero alcohol tolerance, raising the standards required for driving instructors and improving the driving test, vehicle restrictions (e.g. restricting access to 'high performance' vehicles), a sign placed on the back of the vehicle (an N- or P-Plate) to notify other drivers of a novice driver and encouraging good behaviour in the post-test period.

Some countries or states have already implemented some of these ideas. Pay-as-you-drive adjusts insurance costs according to when and where the person drives.

Pedal bicycle users

Dependent on jurisdiction, road type and age, pedal cyclists may be required conform to restrictions on driving after consuming alcohol or various drugs, comply with restrictions on use of mobile phones, be covered by compulsory insurance, wear a bicycle helmet and comply with certain speed limits.

Pedestrians

Dependent on jurisdiction, jaywalking may be prohibited.

Statistics

Rating roads for safety

Since 1999 the EuroRAP initiative has been assessing major roads in Europe with a road protection score. This results in a star rating for roads based on how well its design would protect car occupants from being severely injured or killed if a head-on, run-off, or intersection accident occurs, with 4 stars representing a road with the best survivability features. The scheme states it has highlighted thousands of road sections across Europe where road-users are routinely maimed and killed for want of safety features, sometimes for little more than the cost of safety fencing or the paint required to improve road markings.

There are plans to extend the measurements to rate the probability of an accident for the road. These ratings are being used to inform planning and authorities' targets. For example, in Britain two-thirds of all road deaths in Britain happen on rural roads, which score badly when compared to the high quality motorway network; single carriageways claim 80% of rural deaths and serious injuries, while 40% of rural car occupant casualties are in cars that hit roadside objects, such as trees. Improvements in driver training and safety features for rural roads are hoped to reduce this statistic.

The number of designated traffic officers in the UK fell from 15–20% of Police force strength in 1966 to seven per cent of force strength in 1998, and between 1999 and 2004 by 21%. It is an item of debate whether the reduction in traffic accidents per 100 million miles driven over this time has been due to robotic enforcement.

KSI by country

Country	Killed per 1 Billion Veh·km (Motorways in 2003)	Killed per 1 Billion Veh·km (Non-Motorways in 2003)	Motorway AADT	Road Travel by Motorway	km/h (mph) Motorway 2003 Speed Limit
Austria	5.9	13.4	30,077	23%	130 (80)
Czech Republic	9.9	34.3	25,714	11%	130 (80)
Denmark	3.0	11.9	29,454	25%	110 (70)
Finland	1.4	8.3	22,780	10%	120 (75)
France	4.0	12.8	31,979	21%	130 (80)
Germany	3.8	12.4	48,710	31%	none (130 (80) advisory)
Ireland	7.4	11.0	26,730	4%	120 (75)
Italy	13.0	Unknown	Unknown	Unknown	130 (80)
Japan	4.0	11.9	26,152	9%	100 (60)
Netherlands	2.1	11.7	66,734	41%	120 (75)
Slovenia	8.1	18.7	15,643	19%	130 (80)
Spain	62.3	Unknown	Unknown	Unknown	130 (80)
Sweden	2.5	9.9	24,183	21%	110 (70)
Switzerland	2.8	11.8	43,641	33%	120 (75)
United Kingdom	2.0	9.3	85,536	23%	110 (70)
United States	5.2	10.7	39,634	24%	120 (75)

definition: AADT - average annual daily traffic. The bi-direction traffic count representing an average 24-hour day in a year. Sometimes called "traffic density" although it ignores or assumes a constant number of travel lanes.

Advocacy groups

The Automobile Association was established in 1905 in the United Kingdom to help motorists avoid police speed traps. They became involved in other safety issues and also erected thousands of roadside warning signs.

The Pedestrians Association in the United Kingdom was formed in 1929 to press for better road safety. Other groups have been active in other countries.

Motoring advocacy groups including the Association of British Drivers (UK), Speed cameras.org (UK), National Motorists Association (USA/Canada) argue that the strict enforcement of speed limits does not necessarily result in safer driving, and may even have |negative effect on road safety in general. Safe Speed is a UK group set up specifically to campaign against the use of Speed cameras. The Association of British Drivers also argues that speed humps result in increased air pollution, increased noise pollution, and even unnecessary vehicle damage.

In 1965, Ralph Nader put pressure on car manufactures in his book Unsafe at Any Speed detailing resistance by car manufacturers to the introduction of safety features, like seat belts, and their general reluctance to spend money on improving safety. The GM President James Roche was later forced to appear before a United States Senate subcommittee, and to apologize to Nader for the company's campaign of harassment and intimidation. Nader later successfully sued GM for excessive invasion of privacy.

RoadPeace was formed in 1991 in the United Kingdom to advocate for better road safety and founded World Day of Remembrance for Road Traffic Victims in 1993 which received support from the United Nations General Assembly in 2005.

There is some controversy over the way that the motor advocacy groups has been seen to dominate the road safety agenda. Some road safety activists use the term "road safety" (in quotes) to describe measures such as removal of "dangerous" trees and forced segregation of the vulnerable to the advantage of motorized traffic. Orthodox "road safety" opinion fails to address what Adams describes as the top half of the risk thermostat, the perceptions and attitudes of the road user community.

Criticisms

Some road-safety groups argue that the problem of road safety is largely being stated in the wrong terms because most road safety measures are designed to increase the safety of drivers, but many road traffic casualties are *not* drivers (in the UK only 40% of casualties are drivers), and those measures which increase driver safety may, perversely, increase the risk to these others, through risk compensation.

The core elements of the thesis are:

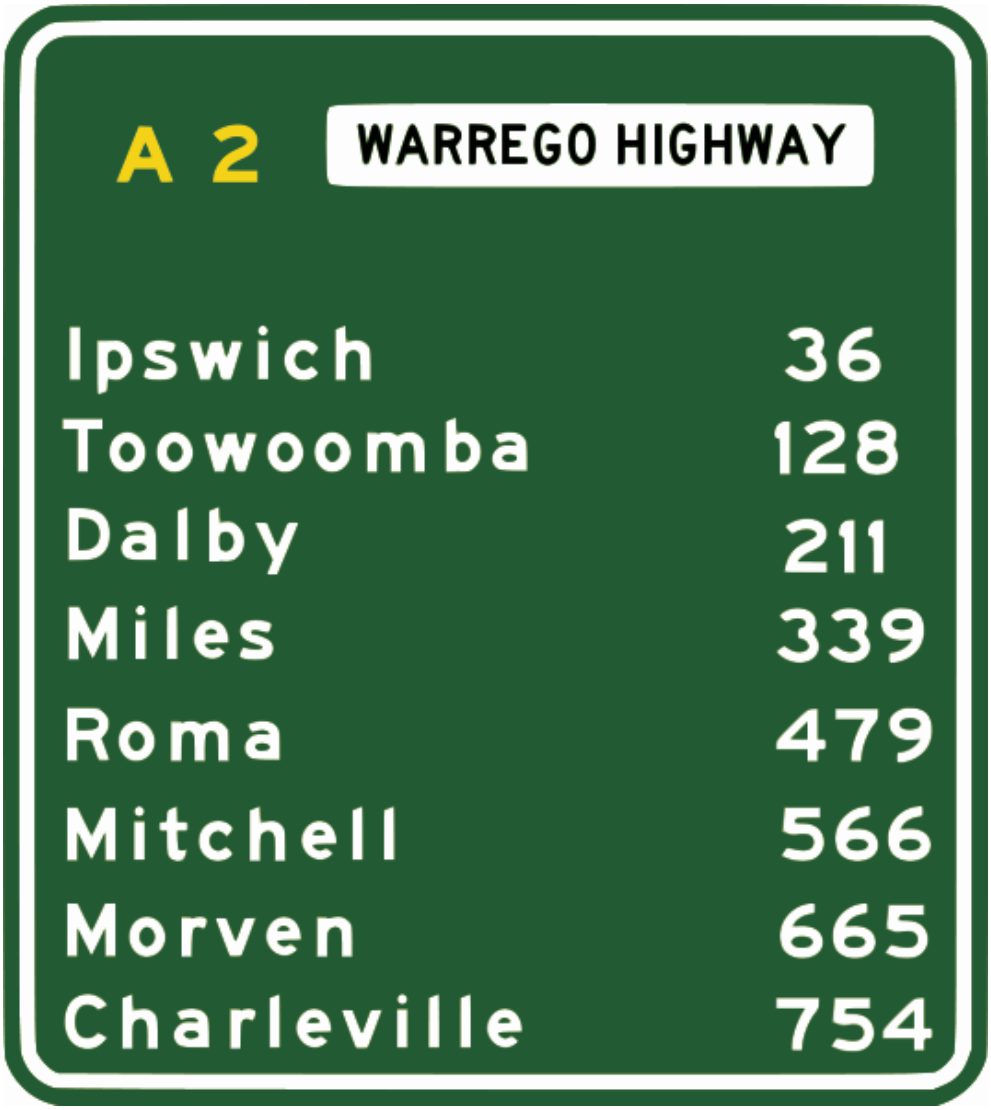
- that vulnerable road users are marginalised by the "road safety" establishment
- that "road safety" interventions are often centred around reducing the severity of results from dangerous behaviours, rather than reducing the dangerous behaviours themselves
- that improved "road safety" has often been achieved by making the roads so hostile that those most likely to be injured cannot use them at all
- that the increasing "safety" of cars and roads is often counteracted wholly or in part by driver responses (risk compensation).

RoadPeace and other groups have been strongly critical of what they see as moves to solve the problem of danger posed to vulnerable road users by motor traffic through increasing restrictions on vulnerable road users, an approach which they believe both blames the victim and fails to address the problem at source. This is discussed in detail by Dr Robert Davis in the book *Death on the Streets: Cars and the mythology of road safety*, and the core problem is also addressed in books by Professor John Adams, Mayer Hillman and others.

For example; the UK publishes Road Casualties Great Britain each year detailing reported road fatalities and injuries and claims to have among the best pedestrian safety in Europe with falling injury rates, as measured in pedestrian KSI per head of population. A study published by the British Medical Journal in 2006 suggested that the reduction in injury levels was due to lower levels of reporting not reducing levels of injury as such. Considerable under-reporting was confirmed by a second report prepared for the UK Department for Transport. and the UK government now acknowledges the issue of under-reporting but is not convinced that the reductions in reported injury levels do not reflect an actual decline. Another independent report investigated if the roads were actually sufficiently dangerous as to deter pedestrians from using them at all.

Chapter 5

Traffic Sign



A "route confirmation" sign on the Warrego Highway in Queensland, Australia, informing motorists of their distance (in kilometres) from the places listed

A sign in the United States of America indicating a local speed limit in miles per hour

The design specifications for a Taiwanese sign warning of double bends ahead

Two or more signs may be displayed on one post. Here a Canadian end-of-road marker appears together with a rural airport sign.

Traffic signs or **road signs** are signs erected at the side of roads to provide information to road users. With traffic volumes increasing over the last eight decades, many countries have adopted pictorial signs or otherwise simplified and standardized their signs to facilitate international travel where language differences would create barriers, and in general to help enhance traffic safety. Such pictorial signs use symbols (often silhouettes) in place of words and are usually based on international protocols. Such signs were first developed in Europe, and have been adopted by most countries to varying degrees.

Categories

A group of green-colored directional signs on the National Highway No. 1 in Kaohsiung, Taiwan.

Traffic signs can be grouped into several types. For example, Annexe 1 of the Vienna Convention on Road Signs and Signals (1968), which at 30 June 2004 had 52 signatory countries, defines eight categories of signs: ***A.** Danger warning signs

- B. Priority signs
- C. Prohibitory or restrictive signs
- D. Mandatory signs
- E. Special regulation signsÁ
- F. Information, facilities, or service signs
- G. Direction, position, or indication signs
- H. Additional panels

In the United States, Canada and Australia signs are categorised as follows:

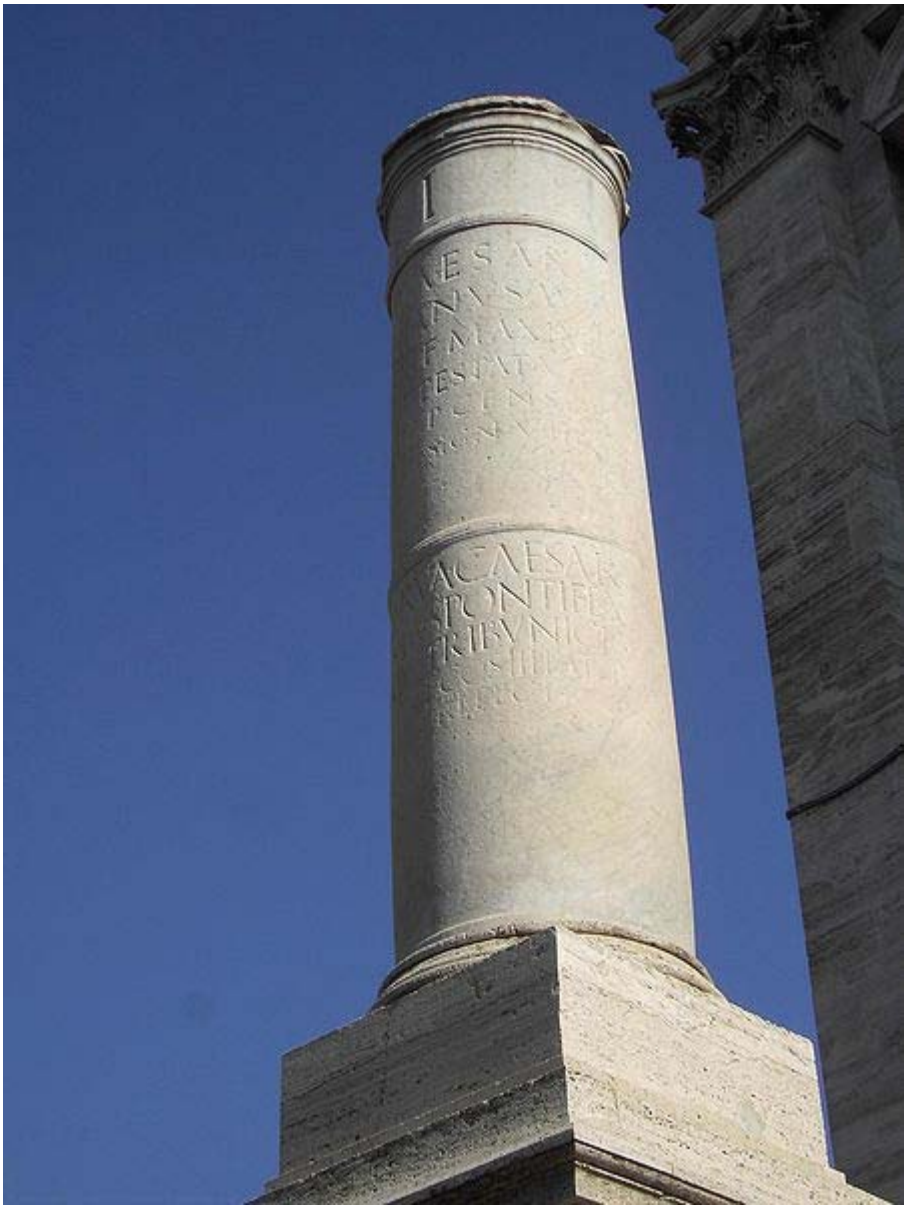
- Regulatory signs
- Warning signs
- Guide signs
  - Street signs
  - Route marker signs
  - Expressway signs

    - Freeway signs
    - Welcome Signs
    - Informational signs
    - Recreation and cultural interest signs
- Emergency management (civil defense) signs
- Temporary traffic control (construction or work zone) signs
- School signs
- Railroad and light rail signs
- Bicycle signs

In the United States, the categories, placement, and graphic standards for traffic signs and pavement markings are legally defined in the Federal Highway Administration's *Manual on Uniform Traffic Control Devices* as the standard.

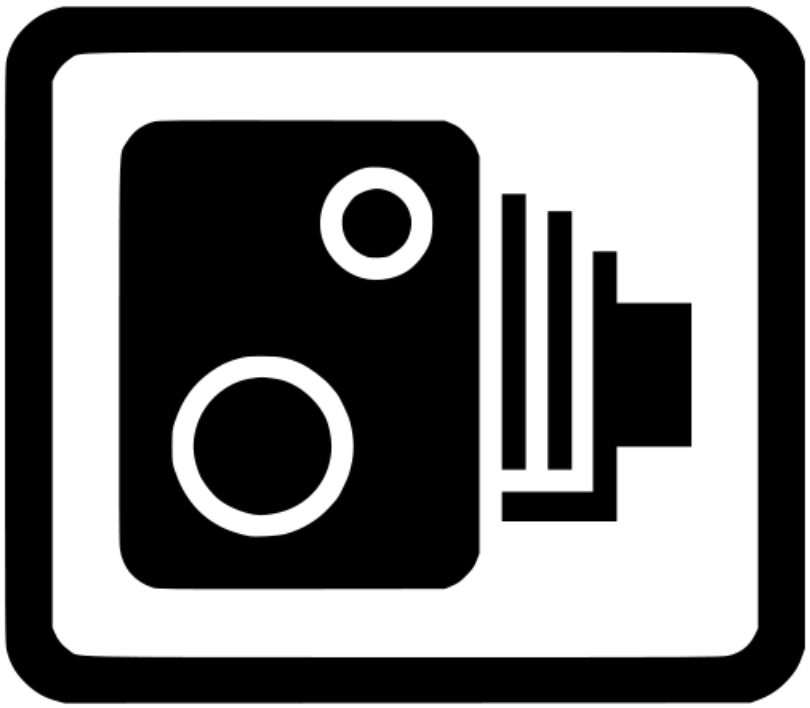
A rather informal distinction among the directional signs is the one between advance directional signs, interchange directional signs, and reassurance signs. Advance directional signs appear at a certain distance from the interchange, giving information for each direction. A number of countries do not give information for the road ahead (so-called "pull-through" signs), and only for the directions left and right. Advance directional signs enable drivers to take precautions for the exit (e.g., switch lanes, double check whether this is the correct exit, slow down). They often do not appear on lesser roads, but are normally posted on expressways and motorways, as drivers would be missing exits without them. While each nation has its own system, the first approach sign for a motorway exit is mostly placed at least 1000 m from the actual interchange. After that sign, one or two additional advance directional signs typically follow before the actual interchange itself.

History



Roman milestone

Rural municipality weight limit sign on a dirt road.



Speed camera sign used in Canada, Cyprus, the Czech Republic, Estonia, Finland, Georgia, Hong Kong, Iceland, Ireland, Latvia, Malta, Ukraine, and the United Kingdom

The earliest road signs were milestones, giving distance or direction; for example, the Romans erected stone columns throughout their empire giving the distance to Rome. In the Middle Ages, multidirectional signs at intersections became common, giving directions to cities and towns.

The first modern roadsigns erected on a wide scale were designed for riders of high or 'ordinary' bicycles in the late 1870s and early 1880s. These machines were fast, silent and their nature made them difficult to control, moreover their riders travelled considerable distances and often preferred to tour on unfamiliar roads. For such riders, cycling organisations began to erect signs that warned of potential hazards ahead (particularly steep hills), rather than merely giving distance or directions to places, thereby contributing the sign type that defines 'modern' traffic signs.

The development of automobiles encouraged more complex signage systems using more than just text based notices. One of the first modern-day road sign systems was devised by the Italian Touring Club in 1895. By 1900, a Congress of the International League of

Touring Organizations in Paris was considering proposals for standardization of road signage. In 1903 the British government introduced four 'national' signs based on shape, but the basic patterns of most traffic signs were set at the 1908 International Road Congress in Rome. In 1909, nine European governments agreed on the use of four pictorial symbols, indicating "bump", "curve", "intersection", and "grade-level railroad crossing". The intensive work on international road signs that took place between 1926 and 1949 eventually led to the development of the European road sign system. Both Britain and the United States developed their own road signage systems, both of which were adopted or modified by many other nations in their respective spheres of influence. The UK adopted a version of the European road signs in 1964 and, over past decades, North American signage began using some symbols and graphics mixed in with English.

Over the years, change was gradual. Pre-industrial signs were stone or wood, but with the development of Darby's method of smelting iron using coke, painted cast iron became favoured in the late eighteenth and nineteenth centuries. Cast iron continued to be used until the mid twentieth century, but it was gradually displaced by aluminium or other materials and processes, such as vitreous enamelled and/or pressed malleable iron, or (later) steel. Since 1945 most signs have been made from sheet aluminium with adhesive plastic coatings, these are normally retroreflective for nighttime and low-light visibility. Before the development of reflective plastics, reflectivity was provided by glass reflectors set into the lettering and symbols.

New generations of traffic signs based on electronic displays can also change their text (or, in some countries, symbols) to provide for "intelligent control" linked to automated traffic sensors or remote manual input. In over 20 countries, real-time Traffic Message Channel incident warnings are conveyed directly to vehicle navigation systems using inaudible signals carried via FM radio, 3G cellular data and satellite broadcasts. Finally, cars can pay tolls and trucks pass safety screening checks using video numberplate scanning, or RFID transponders in windshields linked to antennae over the road, in support on-board signalling, toll collection and travel time monitoring.

Yet another "medium" for transferring information ordinarily associated with visible signs is RIAS (Remote Infrared Audible Signage), e.g., "talking signs" for print-handicapped (including blind/low-vision/illiterate) people. These are infra-red transmitters serving the same purpose as the usual graphic signs when received by an appropriate device such as a hand-held receiver or one built into a cell phone.

North America, Australia and New Zealand

handicap sign

One of Catskill Park's distinctive brown town signs with yellow text, showing the hamlet of Pine Hill

Yellow and black warning signs for kangaroos are common in Australia.

Color schemes

The North American, Australian and New Zealand colours normally have these meanings:

- red with white for stop signs, yield, and forbidden actions (such as No Parking)
- green with white letters for informational signs, such as directions, distances, and places
- brown with white for signs to parks, historic sites, ski areas, forests, and campgrounds
- blue with white for rest areas, food, gasoline, hospitals, lodging, and other services
- white with black (or red) letters for regulatory signs, such as speed limits (or parking)
- yellow with black letters and symbols for warning signs, such as curves and school zones
- orange with black letters for temporary traffic control zones and detours associated with road construction
- purple for "lanes restricted to use only by vehicles with registered electronic toll collection (ETC) accounts", such as EZPass.

The U.S. *Manual on Uniform Traffic Control Devices* prescribes four other colors:

- fluorescent yellow-green for school zone, school bus stop, pedestrian, playground, and bicycle warning signs
- fluorescent pink for incident management signs
- coral and light blue, which are unassigned.

Regulatory signs are also sometimes seen with white letters on red or black signs. In Quebec, blue is often used for tourist attractions and brown public services such as rest areas; many black-on-yellow signs are red-on-white instead.

Many U.S. states and Canadian provinces now use fluorescent orange for construction signs.

Highway symbols and markers

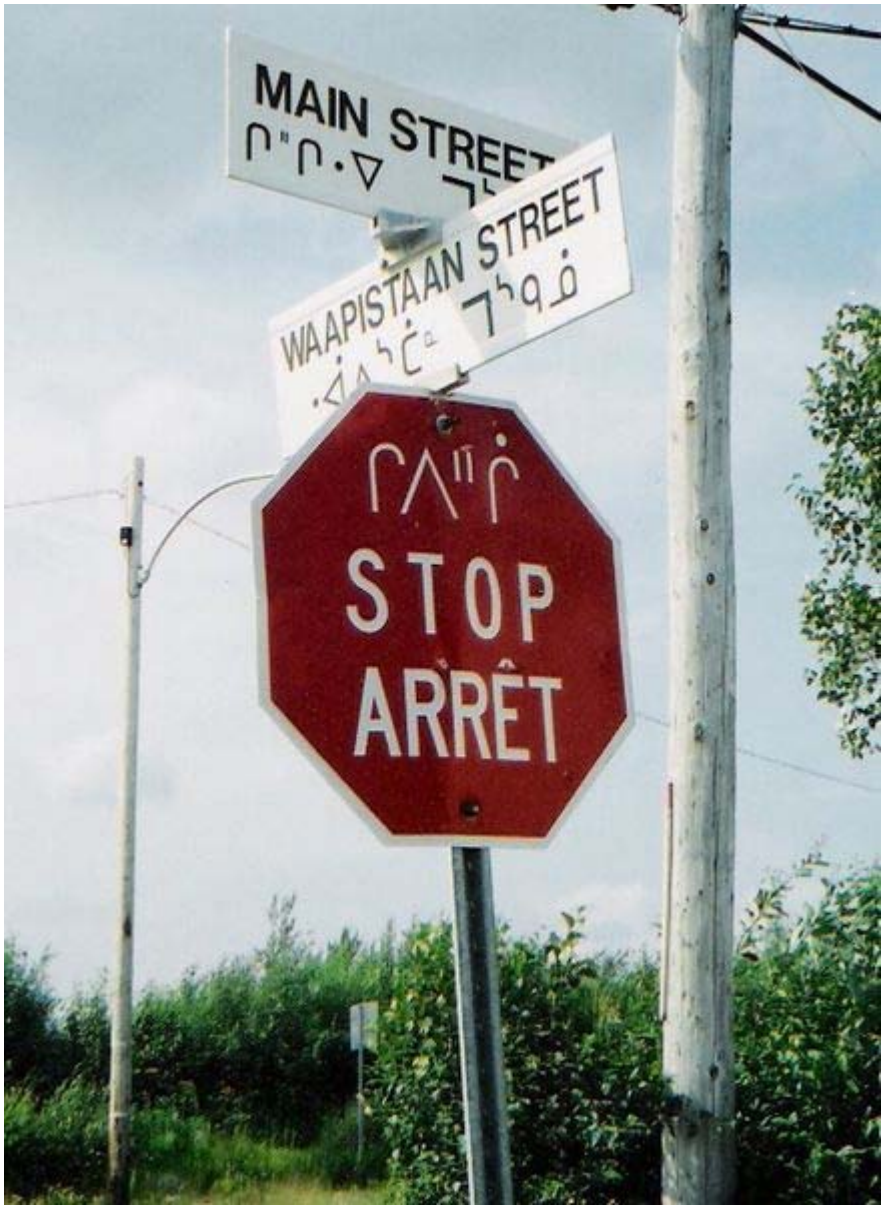
Rural highway sign, Saskatchewan.

Every state and province has different markers for its own highways, but use standard ones for all federal highways. Many special highways– such as the Queen Elizabeth Way, Trans-Canada Highway, and various auto trails in the U.S. – have used unique signs. Counties in the U.S. sometimes use a pentagonal blue sign with yellow letters for numbered county roads, though the use is inconsistent even within states.

Units

Distances on traffic signs generally follow the measurement system in use by the country. Most U.S. road signs use the "U.S. Customary Units" system of miles (or a fraction) or yards (not to be confused with the British "Imperial Measure System", adopted throughout all British possessions following the American Revolution), although the federal Department of Transportation has developed metric standards for all signs. United Kingdom signs also display distances in miles. Elsewhere, metric distances are in very wide use, though not universal.

Languages



Multilingual road signs in Mistissini, Quebec in Cree, English and French.

Where signs use a language, the recognized language/s of the area is normally used. Signs in most of the U.S., Canada, Australia, and New Zealand are in English. Quebec uses French, while New Brunswick and the Jacques-Cartier and Champlain bridges, in Montreal (as well as some parts in the West Island), use both English and French, and a number of other provinces and states, such as Ontario, Manitoba, and Vermont use bilingual French–English signs in certain localities. Mexico and Spain use Spanish. Signs in Belgium are in French, Dutch and German depending on region. In the Brussels Capital Region, road signs are in French and Dutch. Signs in Finland are in Finnish and Swedish. Signs in Germany and Austria are in German. Signs in Luxembourg are in French and German. Signs in Switzerland are in French, German, and Italian. Within a few miles of the U.S.-Mexico border, road signs are often in English and Spanish in places like San Diego, Yuma, and El Paso. Indigenous languages, mainly Nahuatl as well as some Mayan languages, have been used as well.

Typefaces

The typefaces predominantly used on signs in the U.S. and Canada are the FHWA alphabet series (Series B through Series F and Series E Modified). Details of letter shape and spacing for these alphabet series are given in "Standard Alphabets for Traffic Control Devices," first published by the Bureau of Public Roads (BPR) in 1945 and subsequently updated by the Federal Highway Administration (FHWA). It is now part of Standard Highway Signs (SHS), the companion volume to the MUTCD which gives full design details for signfaces.

Initially, all of the alphabet series consisted of uppercase letters and digits only, although lowercase extensions were provided for each alphabet series in a 2002 revision of SHS. Series B through Series F evolved from identically named alphabet series which were introduced in 1927.

Straight-stroke letters in the 1927 series were substantially similar to their modern equivalents, but unrounded glyphs were used for letters such as B, C, D, etc., to permit more uniform fabrication of signs by illiterate painters. Various state highway departments and the federal BPR experimented with rounded versions of these letters in the following two decades.

The modern, rounded alphabet series were finally standardized in 1945 after rounded versions of some letters (with widths loosely appropriate for Series C or D) were specified as an option in the 1935 MUTCD and draft versions of the new typefaces had been used in 1942 for guide signs on the newly constructed Pentagon road network.

The mixed-case alphabet now called Series E Modified, which is the standard for destination legend on freeway guide signs, originally existed in two parts: an all-uppercase Series E Modified, which was essentially similar to Series E, except for a larger stroke width, and a lowercase-only alphabet. Both parts were developed by the California Division of Highways (now Caltrans) for use on freeways in 1948–1950.

Initially, the Division used all-uppercase Series E Modified for button-reflectorized letters on ground-mounted signs and mixed-case legend (lowercase letters with Series D capitals) for externally illuminated overhead guide signs. Several Eastern turnpike authorities blended all-uppercase Series E Modified with the lowercase alphabet for destination legends on their guide signs.

Eventually, this combination was accepted for destination legend in the first manual for signing Interstate highways, which was published in 1958 by the American Association of State Highway Officials and adopted as the national standard by the BPR.

Uses of non-FHWA typefaces

Some traffic signs, such as the left-turn prohibition sign hanging from this gantry, are lit for better visibility, particularly at night or in inclement weather.

The U.S. National Park Service uses NPS Rawlinson Roadway, a serif typeface, for guide signage; it typically appears on a brown background. Rawlinson has replaced Clarendon as the official NPS typeface, but some states still use Clarendon for recreational signage.

Georgia, in the past, used uppercase Series D with a custom lowercase alphabet on its freeway guide signs; the most distinctive feature of this typeface is the lack of a dot on lowercase *i* and *j*. More recent installations appear to include the dots.

The Clearview typeface, developed by U.S. researchers to provide improved legibility, is permitted for light legend on dark backgrounds under FHWA interim approval. Clearview has seen widespread use by state departments of transportation in Arkansas, Illinois, Maryland, Michigan, Ohio, Pennsylvania, Texas, and Virginia. In Canada, the Ministry of Transportation for the Province of British Columbia specifies Clearview for use on its highway guide signs, and its usage has shown up in Ontario on the Don Valley Parkway and Gardiner Expressway in Toronto and on new 400-series highway installations in Hamilton, Halton and Niagara, as well as street signs in various parts of the province. The font is also being used on newer signs in Alberta, Manitoba, and Quebec.

A new Clearview typeface sign beside an old FHWA typeface, Quebec

It is common for local governments, airport authorities, and contractors to fabricate traffic signs using typefaces other than the FHWA series; Helvetica and Arial are common choices.

Moose crossing warning with kill-counter, Alaska

New Zealand

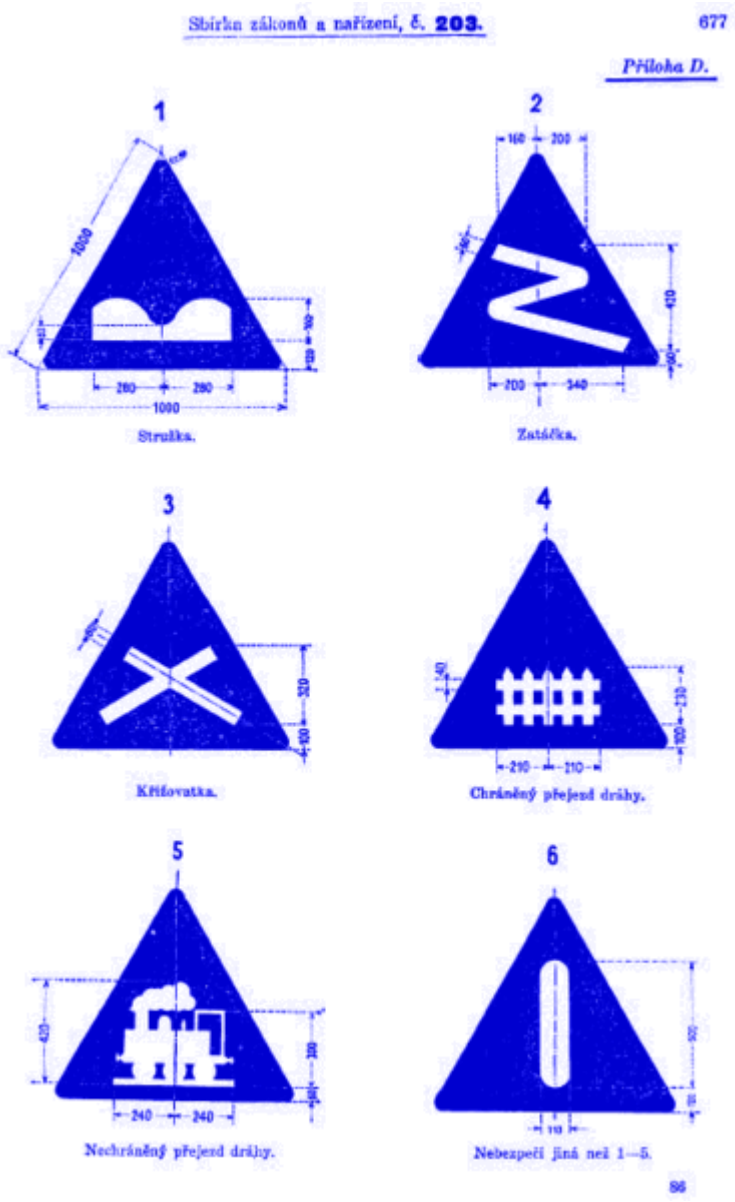
New Zealand road signs are influenced both by American and European practices.

Warning signs are diamond shaped with a yellow background for permanent warnings, and an orange background for temporary warnings. They are somewhat more pictorial than their American counterparts. This is also true for Canadian signage.

Regulatory signs follow European practice, with a white circle with a red border indicating prohibitive actions, and a blue circle indicating mandatory actions. White rectangular signs with a red border indicate lane usage directions. Information and direction signs are rectangular, with a green background indicating a state highway, a blue background for all other roads and all services (except in some, where directional signage is white), and a brown background for tourist attractions.

Before 1987, most road signs had black backgrounds - diamonds indicated warnings, and rectangles indicated regulatory actions (with the exception of the Give Way sign (an inverted trapezium), and Stop sign and speed limit signs (which were the same as today)). Information signs were yellow, and direction signage was green on motorways and black everywhere else.

Europe



The first road signs established in Czechoslovakia on November 1, 1935: six blue-white danger warning signs. They were later supplanted with red-white-black signs.

Road sign in Beussent, France.

Keep right, Portugal.

Romantic road sign in southern Germany.

In 1968, the European countries signed the Vienna Convention on Road Traffic treaty, with the aim of standardizing traffic regulations in participating countries in order to facilitate international road traffic and to increase road safety. Part of the treaty was the Vienna Convention on Road Signs and Signals, which defined the traffic signs and signals. As a result, in Western Europe the traffic signs are well standardised, although there are still some country-specific exceptions, mostly dating from the pre-1968 era.

The principle of the European traffic sign standard is that shapes and colours are to be used for indicating same purposes. Triangular shapes (white or yellow background) are used in warning signs. Additionally, the Vienna convention allows an alternative shape for warning signs, a diamond shape, which is rarely used in Europe. The prohibition signs in Europe are round with a red border. Informative and various other secondary signs are of rectangular shape. Animals shown on warning signs include moose, frogs, deer, ducks, cows, sheep, horses, polar bears (on Svalbard), and monkeys (in Gibraltar). The Convention allows any animal image to be used.

Directional signs have not been harmonised under the Convention, at least not on ordinary roads. As a result, there are substantial differences in directional signage throughout Europe. Differences apply in typeface, type of arrows and, most notably, colour scheme. The convention however specifies a difference between motorways and

ordinary roads, and that motorways use white-on-green (e.g., Italy, Switzerland, Denmark, Sweden, Finland, Slovenia, Croatia, Czech Republic, Greece, Cyprus, Bulgaria, Romania, Slovakia, Serbia, Republic of Macedonia, Albania) or white-on-blue (e.g., Norway, Germany, the Republic of Ireland, France, United Kingdom, Spain, Netherlands, Belgium, Austria, Luxembourg, Poland, Portugal, Latvia). Hungary switched from white-on-green to white-on-blue in the early 2000s during the reconstruction of existing and construction of new motorways.

Differences are greater for non-motorways: white-on-blue in Italy, Switzerland, Sweden, Czech Republic, Greece, Cyprus, Slovakia, Bulgaria, Romania, Latvia, Estonia, Finland and Netherlands (in this case the same as motorways), white-on-green in France, United Kingdom, Republic of Ireland, Poland and Portugal, black-on-yellow in Germany, Luxembourg, Norway, Slovenia, Serbia and Croatia, red-on-white in Denmark (though white-on-blue on motorway exits and all overhead gantries), and black-on-white in Spain.

Secondary roads are different from primary roads in France, United Kingdom, Finland, Republic of Ireland, Switzerland and Portugal, always signposted in black-on-white. In Germany, Italy, Romania and Sweden, black-on-white indicates only urban roads or urban destinations.

Signposting road numbers differs greatly as well. Only the European route number, if signposted, will always be placed in white letters on a green rectangle. European route numbers are not signed at all in the United Kingdom.

Some signs like "STOP", "ZONE" etc. are recommended to be in English, but the local language is also permitted. If the language uses non-Latin characters, the names of cities and places should also be in Latin transcription. Road signs in the Republic of Ireland are bilingual, using Irish and English. Wales is also the same, with bilingual Welsh-English signs; some parts of Scotland also have bilingual Scottish Gaelic-English signs. Finland also uses bilingual signs, in Finnish and Swedish.

European countries use the metric system on road signs (distances in kilometres or metres, heights/widths in metres) with the notable exception of the UK, where distances are indicated in miles, and on remaining finger post signs in the Republic of Ireland erected before 1977, where distances are also indicated in miles (which were formally used for all directional signage in the Republic of Ireland prior to 1977 and on speed limits prior to 2005). For countries driving on the left, the convention stipulates that the traffic signs should be mirror images of those used in countries driving on the right. This practice, however, is not systematically followed in the four European countries driving on the left, Cyprus, the Republic of Ireland, Malta and the United Kingdom. The convention permits the use of two background colours for danger and prohibit signs, white or yellow. Most countries use white with a few exceptions like Sweden, Finland, Iceland and Poland, as yellow tends to be more visible in areas in which snow is prevalent.

The European traffic signs have been designed with the principles of heraldry on mind; i.e., the sign must be clear and able to be resolved with one single glance. Most traffic signs conform to heraldic tincture rules, and rather use symbols than written texts for better semiotic clarity.

United Kingdom

One of the more unusual UK road signs, at the Magic roundabout in Swindon

Traffic signing in the UK conforms broadly to European norms, though a number of signs are unique to Britain and direction signs omit European route numbers. The current sign system, introduced on 1 January 1965, was developed in the late 1950s and early 1960s by the Anderson Committee, which established the motorway signing system, and by the Worboys Committee, which reformed signing for existing all-purpose roads.

Britain remains the only European Union member nation and the only major Commonwealth country to use non-metric (Imperial) measurements for distance and speed, although metric "authorised-weight" signs were prescribed in 1981 and there is now a dual-unit (imperial first) option for restriction signage, used on safety grounds where foreign drivers may use the routes so that they may better understand the restriction and/or advice about a hazard ahead.

Three colour schemes exist for direction signs. A road may be a motorway (white on blue), a primary route (white on dark green with yellow route numbers), or a non-primary route (black on white). A fourth colour scheme, black on yellow, is seen on temporary signs, for example marking a diversionary route avoiding a road closure.

Two typefaces are specified for British road signs. Transport *Medium* or Transport *Heavy* are used for all text on fixed permanent signs and most temporary signage, depending on the colour of the sign and associated text color; dark text on a white background is normally set in *Heavy* so that it stands out better. This is except for route numbers on motorway signs, for which a taller limited character set typeface called Motorway is used.

Signs are generally in English although bilingual signs are used in Wales (English/Welsh) and are beginning to be seen in parts of the Scottish Highlands (English/Scottish Gaelic).

The Netherlands

Road signs in The Netherlands follow the Vienna Convention. Directional signs (which have not been harmonised under the Convention) always use blue as the background colour. The destinations on the sign are printed in white. If the destination is not a town (but an area within town or some other kind of attraction), that destination will be printed in black on a separate white background within the otherwise blue sign.

The Netherlands always signpost European road numbers where applicable (i.e., on the advance directional signs, the interchange direction signs and on the reassurance signs). Dutch national road numbers are placed on a rectangle, with motorways being signposted in white on a red rectangle (as an Axx) and primary roads in black on a yellow rectangle (as Nxx). When a motorway changes to a primary road, its number remains the same, but the A is replaced by the N. So at a certain point the A2 becomes N2, and when it changes to a motorway again, it becomes A2 again.

Signs intended for bike-riders always go on white signs with red or green letters.

The Dutch typeface, known as ANWB-Ee, is based on the US typeface. A new font, named ANWB-Uu (also known as Redesign), has been developed in 1997 and appears on many recent Dutch signs. On the motorways however the typeface remains the ANWB-Ee or a similar typeface. The language of the signs is typically Dutch, even though bilingual signs may be used, when the information is relevant for tourists.

Sweden

Swedish elk warning sign

The road signs in Sweden mostly follow the Vienna Convention with a few adaptations, however, allowed within the convention:

- the background of warning signs is yellow
- warning signs for elk and reindeer
- the background of direction signs is blue with white text
- the background of motorway direction signs is green with white text
- when applicable, the language is Swedish in Sweden.

The signage typeface Tratex is used exclusively in Sweden and is available as freeware.

Croatia

Traffic signs in Croatia are the same as traffic signs in the rest of the former Yugoslavia. Croatian road signs follow the Vienna convention (SFR Yugoslavia was the original signatory for Croatia, which is now a contracting party itself). The most common signs are yellow and black signs *for direction*, blue and white signs *for information* and white-on-green signs are used on the highways.

Ireland

Advance directional sign in for a roundabout in Ireland. The green background indicates that this sign is on a national road, with the blue patches left and right indicating a motorway (with symbol) and the white patches indicating a regional road or local road.

Irish warning signs

Until the partition of Ireland in 1922 and the independence of Southern Ireland (now the Republic of Ireland) British standards applied across the island. In 1926 road sign standards similar to those used in the UK at the time were adopted. Law requires that the signs be written in both Irish and English .

In 1956, road signs in the Republic were changed to markedly differ from the UK standard, with the adoption of U.S.-style "diamond" signs for many road hazard warnings (junctions, bends, railway crossings, traffic lights). Some domestic signs were also invented, such as the keep-left sign (a black curved arrow pointing to the upper-left, although some are similar to the European "white arrow on blue disk" signs), while some other signs are not widely adopted outside Ireland, such as the no-entry sign (a black arrow pointing ahead in a white circle with a red slashed circumference).

Directional signage is still firmly based on the United Kingdom standard, however, with the basic design of directional signs remaining the same as the UK in most cases. The same colours are used for directional signs in Ireland as in the UK, and the UK Transport and Motorway fonts are used. However, signage in the Republic of Ireland is bilingual, with the Irish text in mixed case italics, while the English text is in all upper-case.

The 'wild animals' warning sign, used in Italy, Spain, Germany, Latvia, and other countries and in the other former republics of the Soviet Union

In January 2005 Ireland adopted metric speed limits. Around 35,000 existing signs were replaced and a further 23,000 new signs erected bearing the speed limit in kilometres per hour. To avoid confusion with the old signs, each speed limit sign now has "km/h" beneath the numerals. Also, since the adoption of signs based on the *Warboys Committee* standard in 1977, Irish directional signs have used the metric system, however, unlike

with the later speed limit change over, there was no effort made to change the existing signage, and as of 2007 many finger posts still remain on rural roads with distances in miles, although the numbers continue to decline as roads are improved.

In late 2007 Ireland started to radically replace signs and posts. Good examples are the M1 (Dublin - Dundalk) and the M50 (Dublin). While being mostly the same as the old signs, it is welcome as a lot of the signs were damaged / stained. About 1/2 of the new posts are now two medium posts with crosshatched metal posts in-between instead of one large pole to minimize the damage in case of a crash.

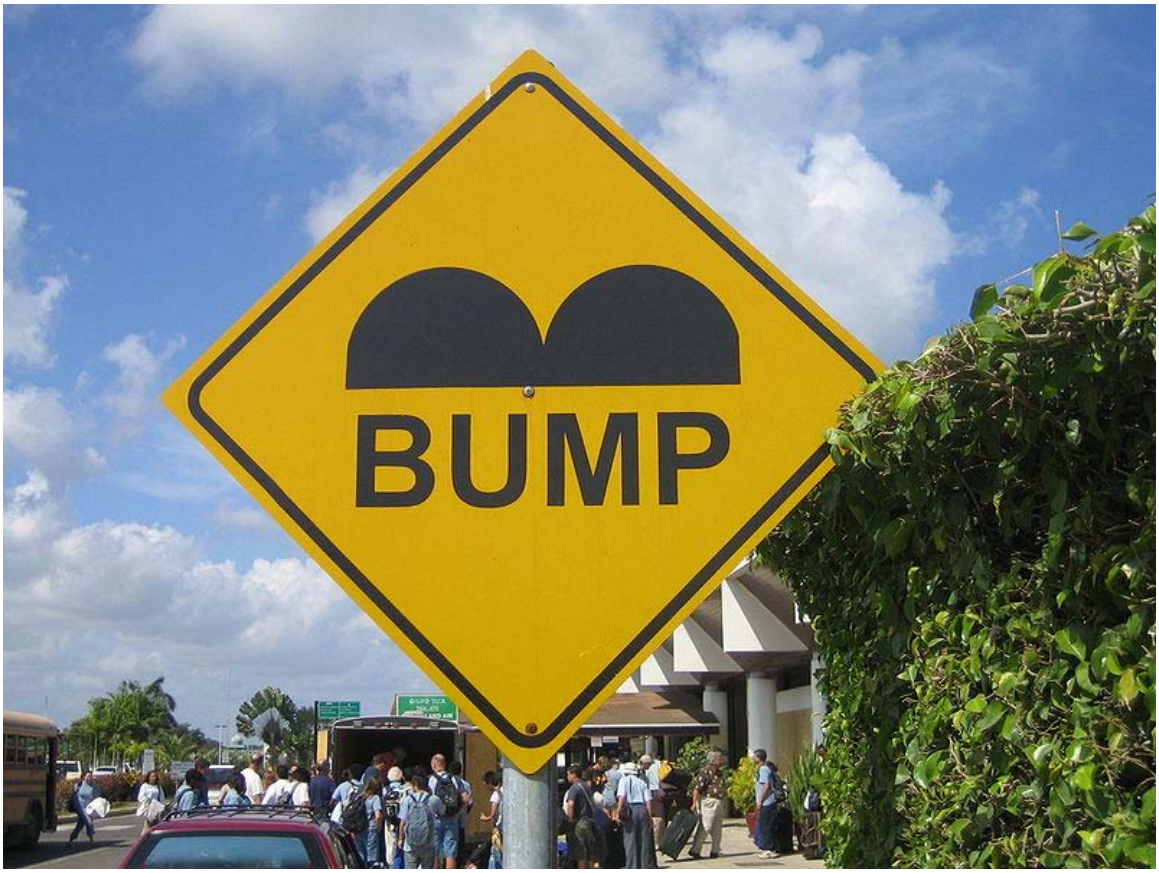
Iceland

Road signs in Iceland mainly follow the Vienna Convention, but use a variant of the colour scheme and minor design changes similar to the signs in Sweden.

Latvia

Road signs in Latvia mainly of Vienna Convention regulations, only the design is different from many other European countries. The signs have many design issues common with Russian road signs since the times of USSR.

Mexico, South and Central America



Speed bump sign in Belize.

Road signs in Mexico, Central America, and South America vary from country to country. For the most part, conventions in signage tend to resemble United States signage conventions more so than European and Asian conventions. For example, warning signs are typically diamond shaped and yellow rather than triangular and white. Some variations include the "No Parking" sign, which uses a letter *E* instead of *P* (the Spanish word for "parking" is *estacionamiento* and *estacionamento* in Brazilian Portuguese), as well as the Stop sign, which usually reads "Pare" or "Alto". Notable exceptions include speed limit signs, which follow the European conventions, and the "No Entry" sign, often replaced with a crossed upwards arrow.

Colombia

Traffic signs in Colombia are classified into three categories. These are Warning signs, Mandatory signs and Information signs.

Warning signs are very similar to warning signs in United States. They are yellow diamond shaped with a black symbol (the yellow color is changed to an orange color in areas under construction). In certain cases, the yellow color is shifted to fluorescent yellow (in the School area sign and Chevron sign).

Mandatory signs are similar to European signs. They are circular with a red border, a white background and a black symbol. Stop sign and Yield sign are as European, except the word “Stop” is changed for “Pare” and the Yield sign has no letters, it is a red triangle with white center.

Information signs have many shapes and colors. Principally they are blue with white symbols and in many cases these signs have an information letter below the symbol.

Asia

Philippines

By law road signs in the Philippines follow the Vienna Convention, however, in reality most road signs are of various character and can occur in different styles and shapes. For example MMDA's (Metro Manila Development Authority) uses pink colored traffic signs within Metro Manila.

China

Warning signs in China are triangular with a black border, yellow background and black symbol. Mandatory signs generally follow European conventions (circular with red border/blue circle)with some local variations. Direction signs are green for expressways,

brown for tourist attractions and blue for other roads. Occasionally black on white is used for directions to local facilities.

Japanese stop sign with the word Tomare (止まれ), meaning Stop

Japan

Road signs in Japan are either controlled by local police authorities under Road Traffic Law (道路交通法) or by other road-controlling entities including Ministry of Land, Infrastructure and Transport, local municipalities, NEXCO (companies controlling expressways), under Road Law (道路法). Most of the design of the road signs in Japan are similar to the signs on the Vienna Convention, except for some significant variances, such as stop sign with a red downward triangle. The main signs are categorized into four meaning types: guidance (white characters on blue in general - on green in expressways), warning (black characters and symbols on yellow diamond), regulation (red or blue circle, depending on prohibition or regulation), and instruction (mostly white characters or symbols on blue square).

Automatic traffic sign recognition

Cars are beginning to feature cameras with automatic traffic sign recognition, beginning with the Opel Insignia. It mainly recognises speed limits and no-overtaking areas.

Street sign theft

Street sign theft occurs when street signs are stolen, often to be used as decorations, but also sometimes to avoid obeying the law by claiming later the sign was not there. Although the theft often seems arbitrary, signs that are unusual or amusing tend to be stolen more frequently. Sometimes considered to be a prank by the perpetrators, the theft is often costly and inconveniencing for the municipality or agency that owns the sign. In the United States, each street sign generally costs between $100 and $500 to replace.

Popular culture can act as a catalyst to street sign theft. Popular bands The Beatles and Lynyrd Skynyrd have inadvertently perpetuated street sign theft as their songs and albums include real place names including Penny Lane, Blue Jay Way, Abbey Road, and Brickyard Road.

Another commonly stolen sign marks the entrances to the village of Fucking, Austria. The sign simply says the name of the village. Because of the vulgar connotation of the word, "fucking," this sign has been repeatedly stolen by pranksters.

Chapter 6

Freeway

Interstate 75 and Interstate 85 (Downtown Connector) in Downtown Atlanta, Georgia, United States: a typical American freeway (MUTCD definition)

The High Five Interchange in Dallas, Texas, United States, an extreme example of stack interchange design.

A **freeway** is a limited access divided highway with grade separated junctions and without traffic lights or stop signs. This term is used in the United States, Canada, Australia, and South Africa.

Etymology

The word *freeway* was coined by the "Father of American Zoning," Edward M. Bassett, in an influential article published in February 1930. Bassett argued that roads should be classified into three basic types: highways, parkways, and freeways. In Bassett's zoning and property law-based system (he was a Columbia-trained lawyer), abutting property

owners have the rights of light, air, and access to highways, but not parkways and freeways; the latter two are distinguished in that the purpose of a parkway is recreation, while the purpose of a freeway is movement. Thus, as originally conceived, a freeway is simply a strip of public land devoted to movement to which abutting property owners do not have rights of light, air, or access.

In the United States, the term *freeway* is used nationwide. In some regions of the U.S., other terms are also used, including *expressway*, *Interstate Highway*, *thruway*, *highway*, and *turnpike*. While some people use these terms interchangeably, turnpikes and thruways usually have associations with toll roads, such as the New Jersey Turnpike, Ohio Turnpike, Pennsylvania Turnpike, West Virginia Turnpike, Florida's Turnpike, and the New York State Thruway.

Consequently, the term *freeway* is often used to refer to a toll-free highway as opposed to its original meaning – in which the component "free" implies freedom from traffic interference rather than "at no cost" – still used in other countries and in parts of the U.S.

General characteristics

High-capacity freeway interchange in Los Angeles, California, United States

Freeways, by definition, have no at-grade intersections with other roads, railroads or multi-use trails. Movable bridges, such as the Interstate Bridge on Interstate 5 between Oregon and Washington, do require drivers to stop for ship traffic.

State Route 11 in Ohio.

Confounding the term, not all highways bearing the name of freeway are in fact "freeways" by definition; for example, the William L. Wilson Freeway (U.S. Route 340) by Harpers Ferry, West Virginia, is a two-lane undivided roadway featuring at-grade intersections.

The crossing of freeways by other routes is typically achieved with grade separation either in the form of underpasses or overpasses. In addition to sidewalks (footpaths) attached to roads that cross a freeway, specialized pedestrian footbridges or tunnels may also be provided. These structures enable pedestrians and cyclists to cross the freeway at that point without a detour to the nearest road crossing.

Access to freeways is typically provided only at grade-separated interchanges, though lower-standard right-in/right-out access can be used for direct connections to side roads. In many cases, sophisticated interchanges allow for smooth, uninterrupted transitions between intersecting freeways and busy arterial roads. However, sometimes it is necessary to exit onto a surface road to transfer from one freeway to another. An example of this would be Interstate 70 in the town of Breezewood, Pennsylvania.

The M25 motorway near Reigate in the United Kingdom. In most Commonwealth nations, freeway-like roads are referred to as motorways.

Speed limits are generally higher on freeways and are occasionally nonexistent (as on much of Germany's Autobahn network). Because higher speeds reduce decision time, freeways are usually equipped with a larger number of guide signs than other roads, and the signs themselves are physically larger. Guide signs are often mounted on overpasses or overhead gantries so that drivers can see where each lane goes. Exit numbers are commonly derived from the exit's distance in miles or kilometers from the start of the freeway. In some areas, there are public rest areas or service areas on freeways, as well as emergency phones on the shoulder at regular intervals.

In the United States, mileposts start at the southern or westernmost point on the freeway (either its terminus or the state line). California, Ohio, and Nevada use milepost systems in which the markers indicate mileage through the state's individual counties. However, in Nevada and Ohio, and freeways that pass through Kern County, California, also use the standard milepost system concurrently with their respective postmile systems.

Cross sections

An 18 lane, quad roadway highway in southern Ontario, an extreme example of multilane freeway design.

Two-lane freeways, often undivided, are sometimes built when traffic volumes are low or right-of-way is limited; they may be designed for easy conversion to one side of a four-lane freeway. Otherwise, freeways typically have at least two lanes in each direction; some busy ones can have as many as 16 or more lanes in total.

In Mississauga, Ontario, Highway 401 uses collector-express lanes for a total of 18 lanes through its intersection with 403/410 and 427. In San Diego, California, Interstate 5 has a similar system of express and local lanes for a maximum width of 21 lanes on a two-mile segment between Interstate 805 and California State Route 56.

These wide freeways may use separate collector and express lanes to separate through traffic from local traffic, or special high-occupancy vehicle lanes, either as a special restriction on the innermost lane or a separate roadway, to encourage carpooling. These HOV lanes, or roadways open to all traffic, can be reversible lanes, providing more capacity in the direction of heavy traffic, and reversing direction before traffic switches. Sometimes a collector/distributor road, a shorter version of a local lane, shifts weaving between closely-spaced interchanges to a separate roadway or altogether eliminates it.

In some parts of the world, notably parts of the U.S., frontage roads form an integral part of the freeway system. These parallel surface roads provide a transition between high-

speed "through" traffic and local traffic. Frequent slip-ramps provide access between the freeway and the frontage road, which in turn provides direct access to local roads and businesses.

Except on some two-lane freeways (and very rarely on wider freeways), a median separates the opposite directions of traffic. This strip may be as simple as a grassy area, or may include a crash barrier such as a "Jersey barrier" or an "Ontario Tall Wall" to prevent head-on collisions. On some freeways, the two carriageways are built on different alignments; this may be done to make use of available corridors in a mountainous area or to provide narrower corridors through dense urban areas.

Some roads in Ohio that conform to freeway criteria use at-grade intersections in lieu of over/under-passes, with occasional interchanges to avoid signalized traffic interruption (i.e., traffic lights are omitted). Examples include US 23 between OH-15's eastern terminus and Delaware, Ohio, along with Highway 15 between its eastern terminus and I-75, US-30, OH-29/US-33, and US-35 in western and central Ohio. These highways are fundamentally expressways, but expressways tend to have lower design speeds, and signalized at-grade intersections.

Access restrictions

A bicyclist using a freeway legally

To reduce the probability that high-speed freeway traffic will have to slow down for slower same-direction traffic, access to freeways is usually limited to drivers of motor vehicles that are powerful enough to maintain a certain minimum speed. Some East Asian countries partially restrict the use of motorcycles or ban them completely from freeways (or expressways in countries where that term is used).

Travelers in a low-powered transportation class (such as pedestrians, bicyclists, equestrians, and moped drivers) are banned at all times from the freeways in many areas by default. In some jurisdictions, these classes are allowed on the shoulders of certain freeways (usually where the freeway has completely replaced an existing road) or on sidepaths.

Legal definitions

United States

Santa Clara County Route G4 (Montague Expressway), an American expressway under the MUTCD definition

In the United States, a *freeway* is defined by the federal government's Manual on Uniform Traffic Control Devices as a divided highway with full control of access. This means two things. First, adjoining property owners do not have a legal right of access, meaning that they cannot connect their lands to the highway by constructing driveways, although frontage roads provide access to properties adjacent to a freeway in many places. When an existing road is converted into a freeway, all existing driveways must be removed and access to adjacent private lands must be blocked with fences or walls.

Second, traffic on a freeway is "free-flowing". All cross-traffic (and left-turning traffic) is relegated to overpasses or underpasses, so that there are no traffic conflicts on the main line of the highway which must be regulated by traffic lights, stop signs, or other traffic control devices. Achieving such free flow requires the construction of many overpasses, underpasses, and ramp systems. The advantage of grade-separated interchanges is that freeway drivers can almost always maintain their speed at junctions since they do not need to yield to vehicles crossing perpendicular to mainline traffic.

In contrast, an expressway is defined as a divided highway with partial control of access. Expressways may have driveways and at-grade intersections, though these are usually less numerous than on ordinary arterial roads.

This distinction was apparently first developed in 1949 by the Special Committee on Nomenclature of what is now the American Association of State Highway and Transportation Officials. In turn, the definitions were incorporated into AASHTO's official standards book, the Manual on Uniform Traffic Control Devices, which would become the national standards book of the U.S. Department of Transportation under a 1966 federal statute. The same distinction has also been codified into the statutory law of eight states: California, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, Ohio, and Wisconsin.

However, each state codified the federal distinction slightly differently. California expressways do not necessarily have to be divided, though they must have at least partial access control. For both terms to apply, in Wisconsin, a divided highway must be at least four lanes wide; and in Missouri, both terms apply only to divided highways at least 10 miles (16 km) long that are not part of the Interstate Highway System. In North Dakota and Mississippi, expressways may have "full or partial" access control and "generally" have grade separations at intersections; a freeway is then defined as an expressway with full access control. Ohio's statute is similar, but instead of the vague word *generally*, it imposes a requirement that 50% of an expressway's intersections must be grade-separated for the term to apply. Only Minnesota enacted the exact MUTCD definitions, in May 2008.

The term *expressway* is also used for what the federal government calls "freeways". Where the terms are distinguished, freeways can be characterized as expressways upgraded to full access control, while not all expressways are freeways.

In contrast, there are at least four highways in the United States which are technically expressways (under the federal definition) but contain the word "freeway" in their names: State Fair Freeway in Kansas, Chino Valley Freeway, Rockaway Freeway in New York, and Shenango Valley Freeway (a portion of U.S. Route 62) in Pennsylvania.

South Africa

In South Africa, the term *freeway* differs from most parts of the world. A freeway is a road where certain restrictions apply. These are not allowed on a freeway:

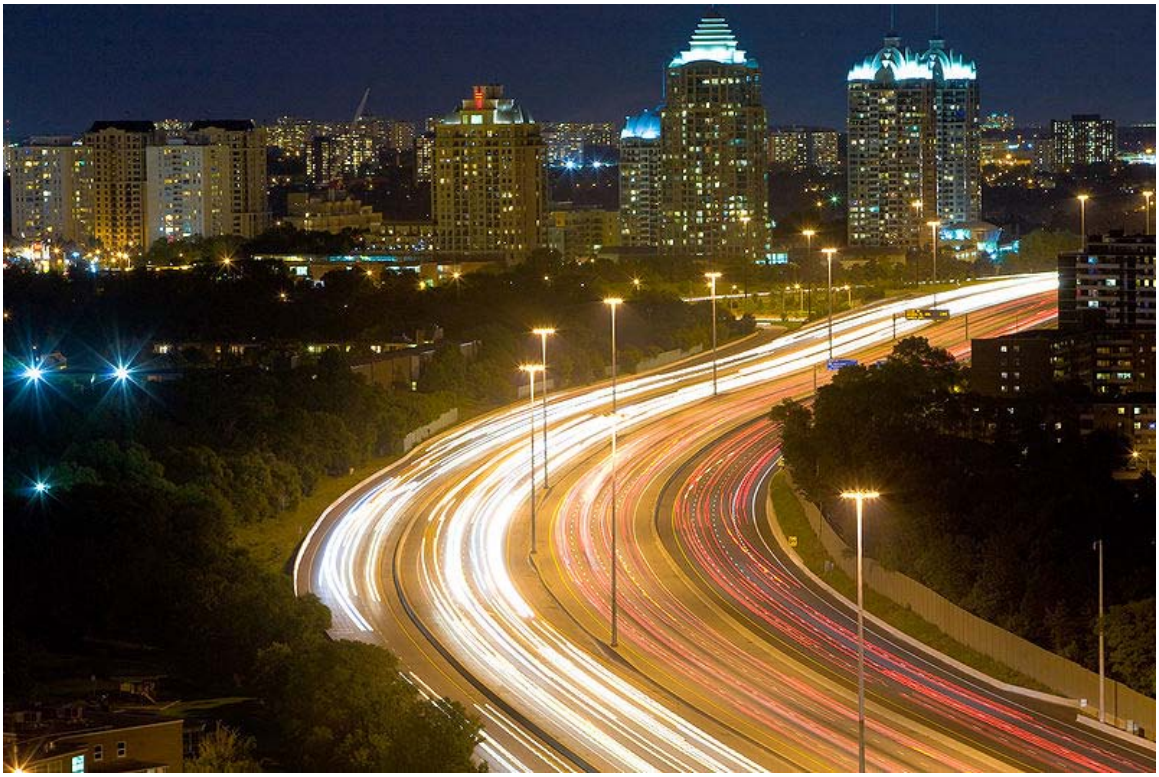
- a vehicle drawn by an animal;
- a pedal cycle (such as a bicycle);
- a motor cycle having an engine with a cylinder capacity not exceeding 50 cm^3 or that is propelled by electrical power;
- a motor tricycle or motor quadrucycle;
- pedestrians

Drivers may not use hand signals on a freeway (except in emergencies) and the minimum speed on a freeway is 60 km/h (37 mph). Drivers in the rightmost lane of multi-carriageway freeways must move to the left if a faster vehicle approaches from behind to overtake.

Despite popular opinion that "freeway" means a road with at least two lanes, single carriageway freeways exist, as is evidenced by the statement that "the roads include 1,400 km of dual carriageway freeway, 440 km of single carriageway freeway and 5 300 km of single carriage main road with unlimited access." The Afrikaans translation of *freeway* is *snelweg* (literally *fast road* or *expressway*).

Effects and controversy

Rush hour on I-45, downtown Houston, Texas.



Highway lighting can have a negative influence on those living close to the freeway. High mast lighting is an alternative as it concentrates the light on the road, but the tall structures can also have a NIMBY effect.

Freeways have been constructed both between urban centers and within them, leading to the sprawling suburban development found near most modern cities. Freeways reduced travel times and accident rates, though the higher speeds have increased the severity and death rates of the collisions that do occur.

Freeways have been heavily criticized by environmentalists, urbanists, and preservationists for the noise, pollution, and economic shifts they bring. Additionally, they have also been criticized by the driving public for the inefficiency with which they handle peak hour traffic.

Often, rural freeways open up vast areas to economic development, generally raising property values. In contrast to this, above ground freeways in urban areas are often a source of lowered property values, contributing to urban decay. Even with overpasses and underpasses, above ground freeways divide neighborhoods — especially impoverished ones where residents are less likely to own a car, or to have the political and economic influence to resist construction efforts. Beginning in the early 1970s, the U.S. Congress identified freeways and other urban highways as responsible for most of the noise exposure of the U.S. population. Subsequently, computer models were developed to analyze freeway noise and aid in their design to help minimize noise exposure.

Some cities have implemented freeway removal policies in which freeways have even been demolished and reclaimed as boulevards or parks, notably in Portland (Harbor Drive), New York City (West Side Highway), Boston (Central Artery), San Francisco (Embarcadero Freeway) and Milwaukee (Park East Freeway).

An alternative to surface or above ground freeway construction has been the construction of underground urban freeways using tunnelling technologies. This has been extremely successful in the Australian cities of Sydney (which has five such freeways) and Melbourne (which has two such freeways). This has had the benefit of removing traffic from surface roads and in the case of Melbourne's Eastlink Motorway, has helped preserve an ecologically sensitive area from destruction.

Other Australian cities face similar problems (lack of available land, cost of home acquisition, aesthetic problems, and community opposition). Brisbane, which also has to contend with physical boundaries (the river) and heavy population increases, has embraced underground tunnel freeways. There are currently three under active development, one of which (the North-South Bypass Tunnel) is currently under construction. All of the planned tunnels include provisions for public transport, whether underground or in reclaimed space on the surface.

Similarly, a below-grade freeway, Sweden's National Highway 75, the Stockholm Southern Link was constructed under an area of dense development south of downtown Stockholm and opened to traffic in 2004.

Freeway opponents have found that freeway expansion is often self-defeating: expansion simply generates more traffic. That is, even if traffic congestion is initially shifted from local streets to a new or widened freeway, people will begin to run errands and commute to more remote locations. Over time, the freeway and its environs become congested again as both the average number and distance of trips increases. This idea is known as induced demand.

Interstate H-1 eastbound into Honolulu, Hawaii.

Urban planning experts such as Drusilla Van Hengel, Joseph DiMento, and Sherry Ryan argue that although properly designed and maintained freeways may be convenient and safe, at least in comparison to uncontrolled roads, they may not expand recreation,

employment and education opportunities equally for different ethnic groups, or for people located in certain neighborhoods of a given city. Still, they may open new markets to some small businesses.

Construction of urban freeways for the U.S. Interstate Highway System, which began in the late 1950s, led to the demolition of thousands of city blocks, and the dislocation of many more thousands of people. The citizens of many inner city areas responded with the freeway and expressway revolts. Through the study of Washington's response, it can be shown that the most effective changes came not from executive or legislative action, but instead from policy implementation. One of the foremost rationales for the creation of the U.S. Department of Transportation (DOT) was that an agency was needed to mediate between the conflicting interests of interstates and cities. Initially, these policies came as regulation of the state highway departments. Over time, DOT officials re-focused highway building from a national level to the local scale. With this shift of perspective came an encouragement for alternative transportation, and locally based planning agencies.

At present, freeway expansion has largely stalled in the United States, due to a multitude of factors that converged in the 1970s: higher due process requirements prior to taking of private property, increasing land values, increasing costs for construction materials, local opposition to new freeways in urban cores, the passage of the National Environmental Policy Act (which imposed the requirement that each new federally funded project must have an environmental impact statement or report), and falling gas tax revenues as a result of the nature of the flat-cent tax (it is not automatically adjusted for inflation), the tax revolt movement, and growing popular support for high-speed mass transit in lieu of new freeways.

History

The concept of limited-access automobile highways dates back to the New York City area Parkway system, whose construction began in 1907–1908; but parkways are traditionally distinguished from freeways by lower design speeds and a ban on commercial traffic. Some parkways, notably the Taconic Parkway and Saw Mill Parkway have at-grade intersections, although direct access to property adjacent to the parkways is prohibited. Designers elsewhere also researched similar ideas, especially in Germany, where the Autobahn would become the first national freeway system.

However, in 1925, Italy was technically the first country to build a freeway-like road, which linked Milan to Lake Como. It is known in Italy as the Autostrada dei Laghi.

Meanwhile, in Great Britain, the related concept of the motorway was first proposed by Sidney Webb in a 1910 book, *The King's Highway*, but was not formally embraced by the government until the passage of the Special Roads Act 1949. In 1926, the English intellectual Hilaire Belloc recognized the necessity of grade-separated roads for "rapid and heavy traffic", but thought they would be the exception rather than the rule:

> The creation of a great network of local highways suitable for rapid and heavy traffic is impossible. Even if the wealth of the community increases, the thing would be impossible, because it would mean the destruction of such a proportion of buildings as would dislocate all social life.

Connecticut's Merritt Parkway was one of the first long-distance freeways in America when it opened on June 29, 1938, but its design standards are well below modern best practices. Two years later, the Pennsylvania Turnpike opened on October 1, 1940, connecting the outskirts of Harrisburg and Pittsburgh. It was designed so that straightaways could handle maximum speeds of 102 miles per hour, and curves could be taken as fast as 90.

In stages from 1938 to 1940, California opened its first significant freeway, the Arroyo Seco Parkway (now called the Pasadena Freeway) which connected Pasadena with Los Angeles. And in 1942, Detroit, Michigan opened the world's first urban depressed freeway, the Davison Freeway. Portions of the first freeway in Texas and the Southern United States, the Gulf Freeway in Houston, opened in 1948. Meanwhile, traffic in Los Angeles continued to deteriorate and local officials began planning the huge freeway network for which the city is now famous.

Today, many freeways in the United States belong to the extensive Interstate Highway system (most of which was completed between 1960 and 1990). Starting in the 1970s freeways began to consider environmental factors, particularly noise and air quality in their location and design. Nearly all Interstate Highways are freeways. The earlier United States highway system and the highway systems of U.S. states also have many sections that are built to controlled-access standards (though these systems are mostly composed of uncontrolled roads). Only a handful of sections of the Interstate system are not freeways, such as I-81 as it crosses the American span of the 2-lane Thousand Islands Bridge and a segment of Interstate 93 through Franconia Notch, New Hampshire that is a 2-lane road with partial access control.

Recent developments

An intersection with the Southern Expressway in Adelaide, South Australia, is the world's longest reversible freeway.

Australia has been innovative in using the newest tunneling technologies to bring freeways into its high-density central business districts (Sydney, Perth and Melbourne). Brisbane currently has three major freeway tunnels under development. The city of Adelaide pioneered the concept of a dedicated reversible freeway. The M2 Southern Expressway operates toward the city centre in the morning and away from the city centre in the afternoon and evening. Its ramps are designed so that they can double as on- or off-ramps, depending upon the time of day. Gates and electronic signage prevent motorists from driving in the wrong direction.

Around the world, major progress has been made in making existing freeways and expressways more efficient. Innovations include the addition of high-occupancy vehicle lanes (HOV lanes) to discourage driving solo, and building new roads, or retro-fitting existing roads with train tracks down the median (or overhead). In the U.S., California's Caltrans has been very innovative in squeezing HOVs into limited right-of-way (by elevating them), and in building special HOV-only ramps so that HOVs can switch freeways or exit the freeway without having to merge across regular traffic. Many states have added truck-only ramps or lanes on heavily congested routes, so that cars need not weave around slow-moving big rigs.

Intelligent transportation systems are also increasingly used, with cameras to monitor and direct traffic, so that police, fire, ambulance, tow, or other assistance vehicles can be dispatched as soon as there is a problem, and to warn drivers via variable message signs, radio, television, and the Web to avoid problem areas. Research has been underway for many years on how to partly automate cars by making smart roads with such things as buried magnets to guide sensor-equipped vehicles, with on-board GPS to determine location, direction, and destination. While these systems may eventually be used on surface streets as well, they are most practical in a freeway setting.

Public-private partnerships in the United States

Until the late 1990s, funding of construction and maintenance of the Interstate Highway System was by the national gasoline tax. Originally, revenues generated by the national gasoline tax were intended solely for the maintenance and expansion of the country's highway system. During the Clinton Administration, federal legislation was passed allowing the use of gasoline tax revenues to fund other government programs and projects not related to highways or transportation. Since this reduced the amount of money available for the intended purpose of maintaining America's road network, many projects were either delayed, canceled, or scaled back.

Additionally, the original Highway Act of 1956 prohibited states from collecting tolls on Interstate-funded freeways. As more miles of freeways were completed, the cost of maintaining the infrastructure increased dramatically. A major issue that has slowed new freeway construction in America has been the application of highway funds to maintaining and repairing existing infrastructure. Most of the freeways in America are near or have exceeded their designed life span, which necessitates replacing of bridges and overpasses and reconstruction of the driving surfaces on many freeways nationwide.

To address the issue of lack of funding for new freeways and maintenance of existing roads, legislation enacted in 1998 gives states greater flexibility in funding major highway projects. Specifically the legislation, known as TEA-21 in official documents, authorizes states to add tolls to Interstate-funded freeways. Additionally, it gave states the latitude to enter into public-private partnership P3 arrangements to facilitate expansion and maintenance of the freeway network.

Texas, Florida, Virginia, and California quickly took advantage of the TEA-21 legislation and began on massive projects to expand their respective states' freeway networks, complementing existing Interstate freeways with privately funded and operated tollways. In 2004, Illinois sealed a $1.8 billion deal with Macquarie Infrastructure Group and Cintras to operate the Chicago Skyway for 99 years. In a similar P3 arrangement in Indiana, the Cintras-Macquarie joint venture assumed responsibility for the Indiana East-West Toll Road for 75 years on June 30, 2006 in a very controversial $3.8 billion deal, which for political purposes was dubbed Major Moves. As of late 2006, Pennsylvania is actively pursuing the P3 toll road concept, but still has to clear challenges in the state legislature before such an arrangement can be implemented on the Pennsylvania Turnpike.

Also in late 2006 Delaware has plans to enter into an agreement with a private firm to design, build, and operate a planned 17 mile (27 km) bypass of U.S. Route 301 between Delaware Route 1 and the Maryland state line. Meanwhile in New York and Massachusetts, the respective state public authorities that operate the New York State Thruway and Massachusetts Turnpike have generated enough revenue to assume maintenance of other freeways beyond the roads on which tolls are collected. The Massachusetts Turnpike Authority provided more than 50 percent of the funding to complete the Big Dig project in Boston, and later assumed responsibility for operating the Central Artery, the Sumner Tunnel, and the Callahan Tunnel following the project's completion in 2005.

As federal funding dries up for expanding and maintaining America's freeway network, states are looking to innovative solutions using a combination of state and federal funding, toll collection through public authorities, and private sector investment.

Construction techniques

Express to collector transfer on Highway 401, a freeway with a collector-express system.

The most frequent way freeways are laid out is usually by building them from the ground up after things such as forestry or buildings are cleared away. Sometimes they deplete farmland, but other methods have been developed for economic, social, and even environmental reasons.

Full freeways are sometimes made by converting at-grade expressways or by replacing at-grade intersections with overpasses; however, any at-grade intersection that ends a freeway remains. Often, when there is a two-lane undivided freeway or expressway, it is converted by constructing a twin corridor on the side by leaving a median between the two travel directions. The opposing side for the old two-way corridor becomes a passing lane.

Other techniques involve building a new carriageway on the side of a divided highway that has a lot of private access on one side and sometimes has long driveways on the other side since an easement for widening comes into place, especially in rural areas.

When a "third" carriageway is added, sometimes it can shift a directional carriageway by 50–200 ft (or maybe more depending on land availability) as a way to retain privrate access on one side that favors over the other. Other instances involve constructing a service drive that shortens the long driveways typically by less than 100 m.

Chapter 7

Bypass (Road)

Chittagong bypass in Bangladesh connects Chittagong port with N 1 highway through Patenga.

A **bypass** is a road or highway that avoids or "bypasses" a built-up area, town, or village, to let through traffic flow without interference from local traffic, to reduce congestion in the built-up area, and to improve road safety.

If there are no strong land use controls, buildings are built in town along a bypass, converting it into an ordinary town road, and the bypass may eventually become as congested as the local streets it was intended to avoid. Shopping centres and some other companies often are built there for ease of access, while homes are often avoided for noise reasons.

United Kingdom

The A21 in the United Kingdom bypassing Sevenoaks and Hildenborough.

The idea of bypasses predates the use of motor vehicles. The first (northern) London bypass, the present Marylebone Road between Paddington and Islington, was started in 1756.

Bypasses can take many years to gain planning approval and funding. Many towns and villages have been campaigning for bypasses for over 30 years e.g. Banwell in North Somerset. Bypass routes are often controversial — by definition they require the building of a road carrying heavy traffic where no road previously existed. This creates a conflict between those who support a bypass to reduce congestion in a built up area, and those who oppose the development of (often rural) undeveloped land.

United States

Old by-pass sign on Maui for State Route 30 thru surface streets.

In the United States, **bypass routes** are a type of special route used on an alternative routing of a highway around a town when the main route of the highway goes through the town. The original designation of these routes were "truck routes" to divert through truck traffic away from the town, but the designation was changed to "bypass" in 1959-1960 by AASHTO. However, many "Truck" routes remain where the mainline of the highway is prohibited for trucks.

In a few cases, both a bypass and a business route exist, both with auxiliary signs (i.e. U.S. Highway 60 in Lexington, Kentucky). Bypass routes are less common than business

routes. Many of those that existed before the era of Interstate highways have lost their old designations. For example in Missouri, the old bypass route of U.S. Highway 71 to the east of Kansas City, Missouri was decertified as Interstate 435 supplanted, the remainder that existed as suburban surface route becoming Missouri State Highway 291; around St. Louis, Missouri, what had been Bypass U.S. Highway 50 was absorbed into a diversion of U.S. Highway 50 from Interstate 44 and Interstate 64.

In the Interstate highway system in the United States, bypasses and loops are designated with a three digit number beginning with an even digit. Note, however, that this pattern is inconsistent enough that, as in greater Des Moines, Iowa the genuine bypass is the main route (in that case, Interstate 35 and Interstate 80, and the loop into downtown Des Moines is Interstate 235; or as in Omaha, Nebraska, where Interstate 480 traverses their downtown area, which is bypassed by Interstate 80 and Interstate 680 and also Interstate 95 which goes through Philadelphia, Pennsylvania and Interstate 295 is the bypass around Philly which goes into New Jersey.

Another meaning of the term **bypass route** (usually simply called a *bypass*) is a highway that was constructed to bypass an area that is often congested with traffic. This includes Interstate highway beltways and U.S. Highways constructed to circumvent downtown areas. Examples of these are U.S. Route 60 bypassing Williamsburg, Virginia, U.S. Routes 31 and 20 bypassing metro South Bend, Indiana (the St. Joseph Valley Parkway), and Interstate 75 bypassing Tampa and St. Petersburg, Florida. These bypasses usually carry mainline routes rather than auxiliary "bypass" routes.

The first bypass route in the United States was completed in 1958, as Alabama State Route 210 (Ross Clark Circle) in Dothan, Alabama.

Shoofly

The term **shoofly**, while common in rail terminology, can also be applied to a short temporary roadway which bypasses a construction site or other obstruction. The U.S. *Manual on Uniform Traffic Control Devices* uses the term "diversion".

Sweden

In the more densely populated southern part of Sweden, many bypasses have been built, both as motorways and ordinary roads. Many cities and villages however still have main roads right through them. Municipality administrations are often lobbying to have a bypass for safety, noise and air quality reasons. In the northern parts of Sweden fewer bypasses have been built, especially in the sparsely populated interior. Here, municipality administrations are often lobbying against bypasses, since they are afraid of losing income from road travellers.

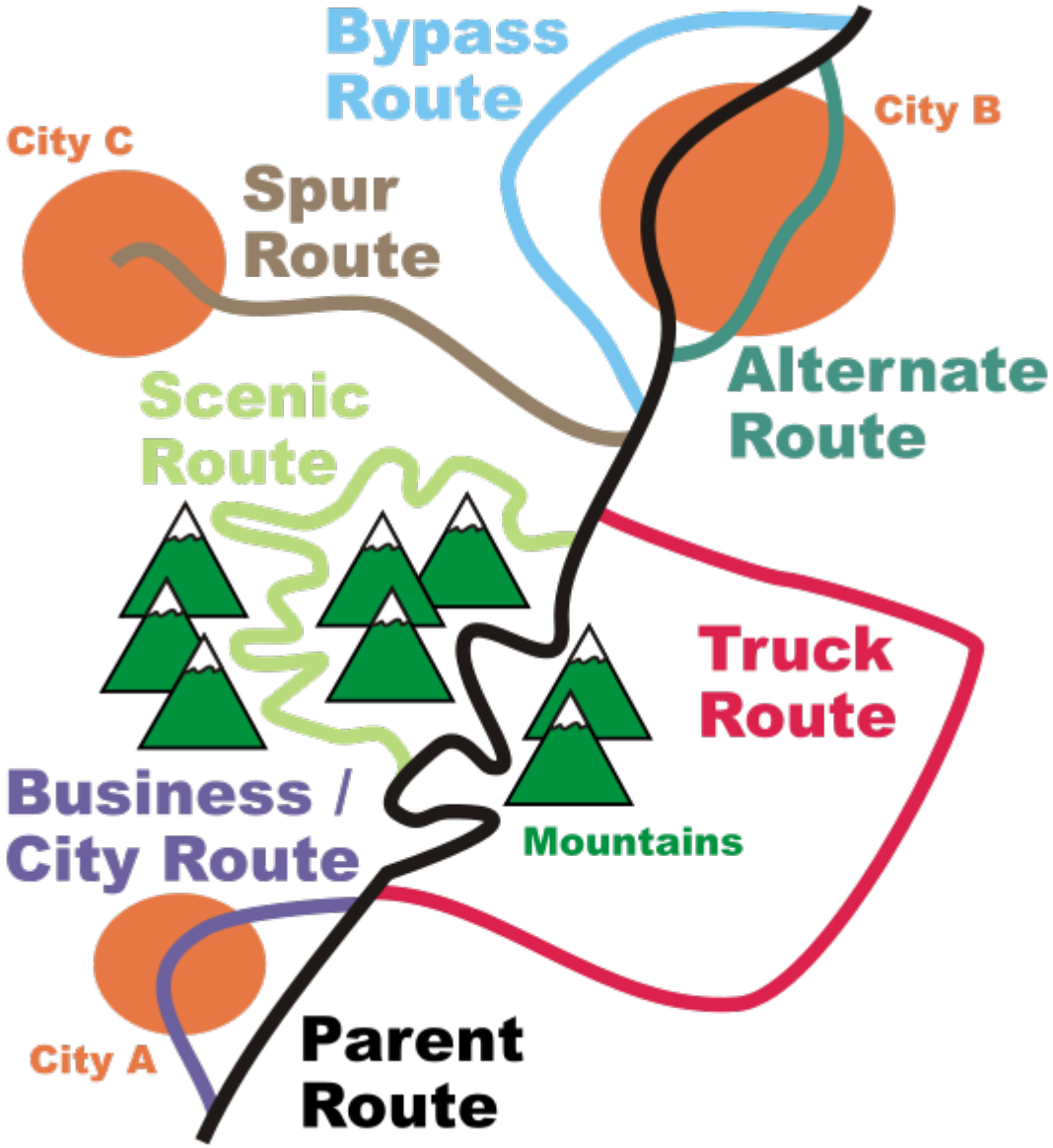
Italy

In Italy the most important bypass, built as motorway, is the *Passante di Mestre* (part of the Autostrada A4). Many other bypass were built but outside the motorway system.

Popular references

In The Hitchhiker's Guide to the Galaxy by Douglas Adams, Arthur Dent's home is destroyed to make way for a bypass. A few minutes later, the entire Earth is destroyed by the Vogons to make way for a hyperspace bypass. In chapter 1, Adams explained what a bypass was:

Bypasses are devices that allow some people to dash from point A to point B very fast while other people dash from point B to point A very fast. People living at point C, being a point directly in between, are often given to wonder what's so great about point A that so many people from point B are so keen to get there, and what's so great about point B that so many people from point A are so keen to get there. They often wish that people would just once and for all work out where the hell they wanted to be.



Types of special routes in the United States

Chapter 8

Roadway Air Dispersion Modeling

Roadway air dispersion is applied to highway segments

Roadway air dispersion modeling is the study of air pollutant transport from a roadway or other linear emitter. Computer models are required to conduct this analysis, because of the complex variables involved, including vehicle emissions, vehicle speed, meteorology, and terrain geometry. Line source dispersion has been studied since at least the 1960s, when the regulatory framework in the United States began requiring quantitative analysis of the air pollution consequences of major roadway and airport projects. By the early 1970s this subset of atmospheric dispersion models were being applied to real world cases of highway planning, even including some controversial court cases.

How the model works

The basic concept of the roadway air dispersion model is to calculate air pollutant levels in the vicinity of a highway or arterial roadway by considering them as line sources. The model takes into account source characteristics such as traffic volume, vehicle speeds, truck mix, and fleet emission controls; in addition, the roadway geometry, surrounding terrain and local meteorology are addressed. For example, many air quality standards require that certain near worst case meteorological conditions be applied.

The calculations are sufficiently complex that a computer model is essential to arrive at authoritative results, although workbook type manuals have been developed as screening techniques. In some cases where results must be refereed (such as legal cases), model validation may be needed with field test data in the local setting; this step is not usually warranted, because the best models have been extensively validated over a wide spectrum of input data variables.

The product of the calculations is usually a set of isopleths or mapped contour lines either in plan view or cross sectional view. Typically these might be stated as concentrations of carbon monoxide, total reactive hydrocarbons, oxides of nitrogen, particulate or benzene. The air quality scientist can run the model successively to study techniques of reducing adverse air pollutant concentrations (for example, by redesigning roadway geometry, altering speed controls or limiting certain types of trucks). The model is frequently utilized in an Environmental Impact Statement involving a major new roadway or land use change which will induce new vehicular traffic.

History

The logical building block for this theory was the use of the Gaussian air pollutant dispersion equation for point sources . One of the early point source air pollutant plume dispersion equations was derived by Bosanquet and Pearson in 1936. Their equation did not include the effect of ground reflection of the pollutant plume. Sir Graham Sutton derived a point source air pollutant plume dispersion equation in 1947 which included the assumption of Gaussian distribution for the vertical and crosswind dispersion of the plume and also addressed the effect of ground reflection of the plume. Further advances were made by G. A. Briggs in model refinement and validation and by D.B. Turner for his user-friendly workbook that included screening calculations which do not require a computer.

In seeing the need to develop a line source model to approach the study of roadway air pollution, Michael Hogan and Richard Venti developed a closed form solution to integrating the point source equation in a series of publications.

The source of virtually all roadway air pollution emissions is the exhaust

While the ESL mathematical model was completed for a line source by 1970, model refinement resulted in a "strip source", emulating the horizontal extent of the roadway surface. This theory would be the precursor of area source dispersion models. But their focus was roadway simulation, so they proceeded with the development of a computer model by adding to the team Leda Patmore, a computer programmer in the field of atmospheric physics and satellite trajectory calculations. A working computer model was produced by late 1970; then the model was calibrated with carbon monoxide field measurements targeting from traffic on U.S. Route 101 in Sunnyvale, California.

The ESL model received endorsement from the U.S. Environmental Protection Agency (EPA) in the form of a major grant to validate the model using actual roadway tests of tracer gas sulfur hexafluoride dispersion. That gas was chosen since it does not occur naturally or in vehicular emissions and provides a unique tracer for such dispersion studies. Part of the Environmental Protection Agency's motives may have been to bring the model into public domain. After a successful validation through the EPA research, the model was soon put to use in a variety of settings to forecast air pollution levels in the vicinity of roadways. The ESL group applied the model to the U.S. Route 101 bypass project in Cloverdale, California, the extension of Interstate 66 through Arlington, Virginia, the widening of the New Jersey Turnpike through Raritan and East Brunswick,

New Jersey, and several transportation projects in Boston for the Boston Transportation Planning Review.

By the early 1970s at least two other research groups were known to be actively developing some type to roadway air dispersion model: the Environmental Research and Technology group of Lexington, Massachusetts and Caltrans headquarters in Sacramento, California. The Caline model of Caltrans borrowed some of the technology from the ESL Inc. group, since Caltrans funded some of the early model application work in Cloverdale and other locations and was given rights to use parts of their model.

The theory

The resulting solution for an infinite line source is:

$$\chi = \int_0^\infty \frac{q}{\pi\,(ucdx^2)\,(cos\alpha\,)} \left(\exp \frac{y^2}{2c^2x^2}\right) dx$$

where:

x is the distance from the observer to the roadway

y is the height of the observer

u is the mean wind speed

α is the angle of tilt of the line source relative to the reference frame

c and *d* are the standard deviation of horizontal and vertical wind directions (measured in radians) respectively.

This equation was integrated into a closed form solution using the error function (erf), and variations in geometry can be performed to include the full infinite line, line segment, elevated line, or arc made from segments. In any case one can calculate three dimensional contours of resulting air pollutant concentrations and use the mathematical model to study alternative roadway designs, various assumptions of worst case meteorology or varying traffic conditions (for example, variations in truck mix, fleet emission controls, or vehicle speed.

The ESL research group also extended their model by introducing the area source concept of a vertical strip to simulate the mixing zone on the highway produced by vehicle turbulence. This model too was validated in 1971 and showed good correlation with field test data.

Example applications of the model

Roadway air dispersion modeling is also done for curved roadways-North-South Express Highway, Malaysia

There were several early applications of the model in somewhat dramatic cases. In 1971 the Arlington Coalition on Transportation (ACT) was the plaintiff in an action against the Virginia Highway Commission over the extension of Interstate 66 through Arlington, Virginia , having filed a suit in the federal district court. The ESL model was used to produce calculations of air quality in the vicinity of the proposed highway. ACT won this case after a decision by the U.S. Fourth Circuit Court of Appeals. The court paid special attention to the plaintiff's expert calculations and testimony projecting that air quality levels would violate Federal ambient air quality standards as set forth in the Clean Air Act.

A second contentious case took place in East Brunswick, New Jersey where the New Jersey Turnpike Authority planned a major widening of the Turnpike. Again the roadway air dispersion model was employed to predict levels of air pollution for residences, schools and parks near the Turnpike. After an initial hearing in Superior Court where the ESL model results were set forth, the judge ordered the Turnpike Authority to negotiate with the plaintiff, Concerned Citizens of East Brunswick and develop air quality mitigation for the adverse effects. The Turnpike Authority hired ERT as its expert, and

the two research teams negotiated a settlement to this case using the newly created roadway air dispersion models.

More recent model refinements

The CALINE3 model is a steady-state Gaussian dispersion model designed to determine air pollution concentrations at receptor locations downwind of highways located in relatively uncomplicated terrain. CALINE3 is incorporated into the more elaborate CAL3QHC and CAL3QHCR models. CALINE3 is in widespread use due to its user friendly nature and promotion in governmental circles, but it falls short of analyzing the complexity of cases addressed by the original Hogan-Venti model. CAL3QHC and CAL3QHCR models are available in the Fortran programming language. They have options to model either particulate matter or carbon monoxide, and include algorithms to simulate queued traffic at signalized intersections .

In addition, several more recent models have been developed that employ non-steady state Lagrangian puff algorithms. The HYROAD dispersion model has been developed through the National Cooperative Highway Research Program's Project 25-06, incorporating ROADWAY-2 model puff and steady-state plume algorithms (Rao et al., 2002).

The TRAQSIM model, developed as part of a Ph.D dissertation with support by the U.S. Department of Transportation's Volpe National Transportation Systems Center's Air Quality Facility is currently under the care of Wyle. The model incorporates dynamic vehicle behavior with a non-steady state Gaussian puff algorithm. Unlike HYROAD, TRAQSIM combines traffic simulation, second-by-second modal emissions, and Gaussian puff dispersion into a fully integrated system (a true simulation) that models individual vehicles as discrete moving sources. TRAQSIM was developed as a next generation model to be the successor to the current CALINE3 and CAL3QHC regulatory models. The next step in the development of TRAQSIM is to incorporate methods to model the dispersion of particulate matter (PM) and hazardous air pollutants (HAPs).

Several models have been developed that handle complex urban meteorology resulting from urban canyons and highway configurations. Examples include the Turner-Fairbank Highway Research Center's Canyon Plume Box model, now in version 3 (CPB-3), the National Environmental Research Institute of Denmark's Operational Street Pollution Model (OSPM), and the MICRO-CALGRID model, which includes photochemistry, allowing for both primary and secondary species to be modeled, Cornell University's CFD-VIT-RIT, which resolves vehicle-induced turbulence (VIT), road-induced turbulence (RIT) and chemical transformation of air pollutants using turbulence reacting flow models.

Recent applications in legal cases

Recent health literature indicating that residents near major roads face elevated rates of several adverse health outcomes has prompted legal dispute over the responsibility of

transportation agencies to use roadway air dispersion models to characterize the impacts of new and expanded roadways, bus terminals, truck stops, and other sources.

Recently, the Sierra Club of Nevada sued the Nevada Department of Transportation and the Federal Highway Administration over its failure to assess the impact of the expansion of U.S. Route 95 in Las Vegas on neighborhood air quality. The Sierra Club asserted that a supplemental Environmental Impact Statement should be issued to address emissions of hazardous air pollutants and particulate matter from new motor vehicle traffic. The plaintiffs asserted that modeling tools were available, including the Environmental Protection Agency's MOBILE6.2 model, the CALINE3 dispersion model, and other relevant models. The defendants won in the U.S. District Court under Judge Philip Pro, who ruled that the transportation agencies had acted in a manner that was not "arbitrary and capricious," despite the agencies' technical arguments regarding the lack of available modeling tools being contradicted by a number of peer-reviewed studies published in scientific journals (e.g. Korenstein and Piazza, Journal of Environmental Health, 2002). On appeal to the U.S. Ninth Circuit, the Appeals Court stayed new construction on the highway pending the court's final decision. The Sierra Club and the defendants settled out of court, setting up a research program on the air quality impacts of U.S. Route 95 on nearby schools.

A number of other high-profile cases have prompted environmental groups to call for dispersion modeling to be used to assess the air quality impacts of new transportation projects on nearby communities, but to date state transportation agencies and the Federal Highways Administration has claimed that no tools are available, despite models and guidance available through EPA's Support Center for Regulatory Air Models (SCRAM).

Among the more contentious of cases the Detroit Intermodal Freight Terminal and Detroit River International Crossing (Michigan, USA), and the expansion of Interstate 70 East in Denver (Colorado , USA).

In all of these cases, community-based organizations have asserted that modeling tools are available, but transportation planning agencies have asserted that too much uncertainty exists in all of the steps. A major concern for community-based organizations has been transportation agencies' unwillingness to define the level of uncertainty that they are willing to tolerate in air quality analyses, how that compares to the Environmental Protection Agency's guideline on air quality models, which addresses uncertainty and accuracy in model use.

Chapter 9

Highway Systems by Country

Highway systems by country describes the highway systems available in selected countries.

Australia

The Tullamarine Freeway showing toll gantries in Melbourne, Australia.

In Australia, a *highway* is a distinct type of road from freeways, expressways and motorways. The word *highway* is generally used to mean major roads connecting large cities, towns and different parts of metropolitan areas. Metropolitan highways often have traffic lights at intersections, and rural highways usually have only one lane in each direction. The words *freeway*, *expressway* or *motorway* are generally reserved for the most arterial routes, usually with grade-separated intersections and usually significantly straightened and widened to a minimum of four lanes. The term *motorway* is used in some Australian cities to refer to freeways that have been allocated a metropolitan route number, and in Sydney, a *motorway* has a toll, whereas a *freeway* is free of charge. On the Hume Highway when traveling from Melbourne to Sydney there is only one set of traffic signals, found in Holbrook. Roads may be part-highway and part-freeway until they are fully upgraded. The Cahill expressway is the only "named" expressway in New South Wales, which opened in 1954 the first in New South Wales .

Belgium

Belgium has the highest density highway network of Europe following The Netherlands at 54.7 km per 1000 km². Most of its highways have three lanes with a few exceptions like the ring-roads around Brussels and Antwerp which have five or six lanes in various stretches. Belgium is situated at a crossroads of several different countries, and its highways are used by people of many nationalities. In Belgium the highways are indicated by the letter "A" and an E(uropean) number. The E numbers are used most often. Roads that are (part of) a ring-road around a city or a town are usually indicated by an R number. Many of the highways in Belgium are illuminated at night, since there is a surplus of nuclear electric power during the off-peak hours.

Bosnia and Herzegovina

As for Bosnia and Herzegovina, the Pan-European Corridor Vc Motorway, Budapest - Osijek - Sarajevo - Ploče, is one of the most significant and project of the highest priority; in Bosnia and Herzegovina it coincides with A1 Motorway. The construction works on the road have already begun, but intensified beginning of the construction will be a key starter of economic and social activities, and will enable Bosnia and Herzegovina to be connected to main European traffic network, as well as to global European economic and social structure.

Construction of the motorway, whose total length is *340 km*, will provide: rational connecting to neighboring countries and regions; stabilizing and developing effects will be reached; transport conditions and quality of life improvement; economy competitiveness enhancement; new projects launched and national and international private investments enhancement.

Brazil

The SP-160, known as Rodovia dos Imigrantes, in southeastern Brazil.

In Brazil, highways (or expressway/freeway) are named "rodovia", and Brazilian highways are divided in two types: regional highways (generally of less importance and entirely inside of one state) and national highways (of major importance to the country). In Brazil, *rodovia* is the name given exclusively to roads connecting two or more cities with a sizable distance separating the extremes of the highway. Urban highways for commuting are uncommon in Brazil, and when they are present, they receive different names, depending of the region (Avenida, Marginal, Linha, Via, Eixo, etc.). Very rarely names other than "rodovia" are used.

Regional highways are named YY-XXX, where YY is the abbreviation of the state where the highway is running in and XXX is a number (e.g. SP-280; where SP means that the highway is running entirely in the state of São Paulo).

National highways are named BR-XXX. National highways connects multiples states altogether, are of major importance to the national economy and/or connects Brazil to another country. The meaning of the numbers are:

- 001-100 - it means that the highway runs radially from Brasília. It is an exception to the cases below.
- 101-200 - it means that the highway runs in a south-north way.
- 201-300 - it means that the highway runs in a west-east way
- 301-400 - it means that the highway runs in a diagonal way (northwest-southeast, for example)
- 400-499 - another exception, they are less important highways and its function is to connect a city to an arterial highway nearby

Often, Brazilian highways receive names (famous people, etc.) their YY/BR-XXX designation (example: SP-280 is also known as Rodovia Castelo Branco).

Canada

Heavy traffic on Highway 401, North America's busiest highway, in Canada.

- In Canada, there is no national standard for nomenclature, although in non-technical contexts *highway* appears to be most popular in most areas. The general speed limits on most Canadian highways range between 80 and 110 km/h (50 and 68 mph) on two-lane highways, and between 90 and 110 km/h (56 and 68 mph) on multi-lane, divided highways.
- Canada is the second largest country in the world in terms of land area, though it only has 1,350,581 kilometers (839,212 miles) of paved roads. This is far less highway and road distance than the United States, which is smaller, but has more than 6,000,000 kilometers of paved roads and highways. However, Canada still has many more roads and highways than Russia, the largest country in the world in land area, with an estimated just 336,000 kilometers (208,000 miles) of paved roads.
- The most extensive freeway network in Canada is in the well-populated southeastern Canada, linking southern Ontario, southern Quebec, Nova Scotia, New Brunswick, and the United States. This makes the freeway network there very well-traveled, requiring these routes to be well-maintained to overcome the frequently harsh winter weather, and also wide enough to accommodate the high traffic volumes that they carry in large metropolitan areas, such as around Toronto, Montreal, Ottawa, and Detroit, to prevent the economical problems and frustrations that result from heavy traffic congestion, and also be safe enough to reduce the number of vehicle accidents.
- In Ontario, all public roads are legally defined as *highways*, though provincially managed roads are known legally as *Provincial Highways*. In day-to-day usage, the term *highway* is used for provincial routes or freeways. It is also common for surface routes to be referred to by number (e.g. "Take *Number 10* from Mississauga to Owen Sound"), especially by older generations. The words *freeway* or *expressway* are sometimes used to refer to controlled-access, high-speed, grade-separated highways such as the 400-series highways, the Gardiner Expressway, the Don Valley Parkway, the Conestoga Parkway, or the E.C. Row Expressway. The only highway officially labeled as a freeway is the Macdonald-Cartier Freeway, usually known as Highway 401, or simply "the 401", which is North America's busiest freeway, as well as one of the widest in the world at 18 through lanes. Nearly all highways in Ontario use parclo interchanges, which were developed by the province. Parclos are used to avoid weaving and to maximize efficiency and safety.
- In Quebec, major highways are called *autoroutes* in French, and *expressways* or *autoroutes* in English.
- Nova Scotia numbers its highways by the trunk routes they parallel. For example, Highway 107 parallels Trunk 7. This, to a lesser extent, also applies in Ontario (e.g. Highway 410 and Highway 420 parallel Highway 10 and Highway 20.) Nova Scotia also numbers its highways according to usage: main arterial highways are in the 100s, secondary or old arterial highways are numbered in the double digits from 1 to 28, and collector roads are numbered in the triple digits starting at 200.
- The Trans-Canada Highway (or Trans-Canada) is a highway that crosses all of Canada from east to west and enters all ten provinces. The actual Trans-Canada

ranges from a two-lane highway across the Great Plains and the Rocky Mountains to a multi-lane urban expressway. There are three or more ferry routes along the Trans-Canada, which allows the it to connect to Newfoundland, Prince Edward Island, and Vancouver Island. However the comparatively-new Confederation Bridge allows driving from New Brunswick to Prince Edward Island without using a ferry. (Ferries do connect this Island to Quebec, where the main Trans-Canada route is.)

Since the Trans-Canada Highway is not a divided, multi-lane highway for the majority of its route, it is considered to be more of an equivalent to the U.S. Route highway network in the neighboring United States of America. On the other hand, Ontario's 400-series expressways, Quebec's autoroutes, New Brunswick's portion of the Trans-Canada, and Nova Scotia's 100-series highways are provincial equivalents to the Interstate Highway System. The Canadian expressways interconnect with each other across provincial lines, and also with the American Interstate system. For example, expressways in Québec connect Montreal with the American border, and thence Interstate 87 continues from there to New York City, and likewise, Toronto is connected to the border by Ontario expressways, and thence by Interstate 190 to Buffalo, New York.

Chile

Chile has a large Highway coverage which connects the whole country but with the exception of the Magallanes Region.

China, People's Republic

"Highways" in China, more often than not, refer to China National Highways. The fully controlled-access, multi-lane, divided routes are instead called expressways. As of 2010, there were 3.98 million km of highways and 74,000 km of expressways in China; both total lengths are second only to the United States.

In Mainland China, private companies reimbursed through tolls are the primary means of creating and financing the National Trunk Highway System (NTHS).

Expressways are lumped with first-grade G-prefixed *guódào* (国道, or "national highway") or A-prefixed first-grade expressways in major municipal cities. All roads in the NTHS and most A-prefixed roads are expressways.

- M-prefix: National (Trunk) Expressways (planned)
- G-prefix: National highways (typically expressways)
- A-prefix: Municipal highways (typically expressways)
- S-prefix: Provincial highways
- X-prefix: County highways
- Y-prefix: Rural roads
- Z-prefix: Special use roads (e.g., airport expressways)

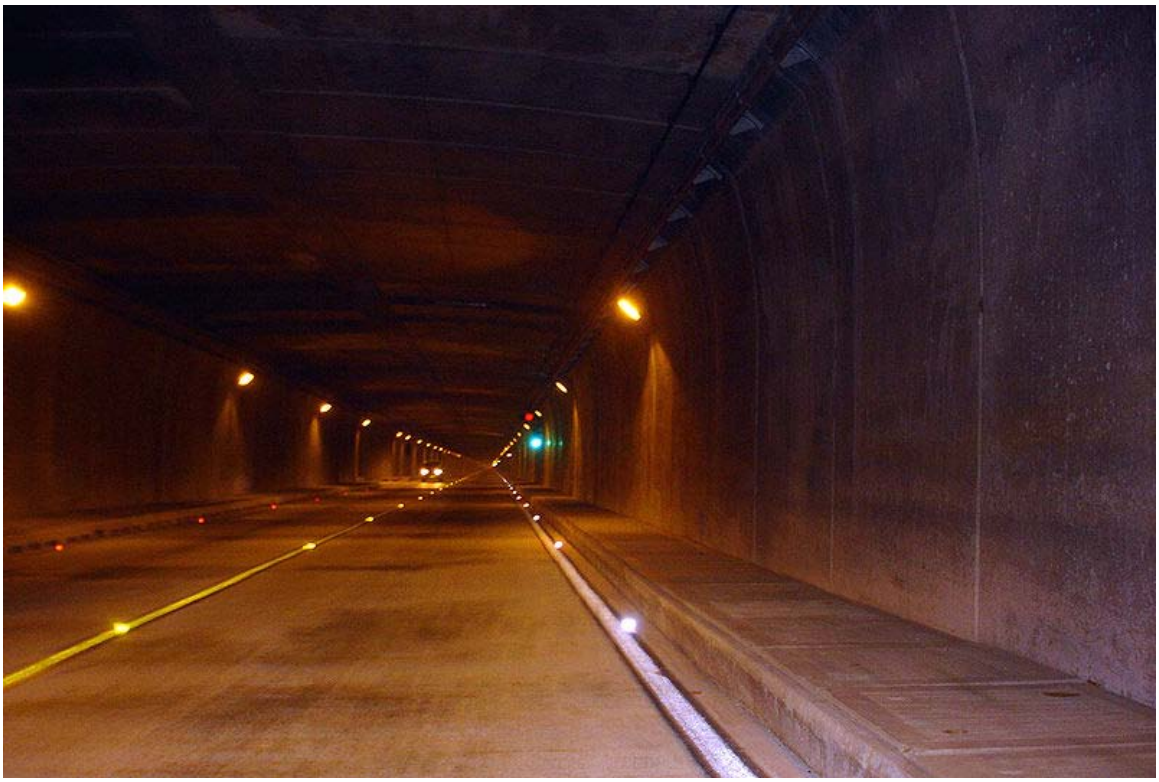
Some highways are numbered with a leading zero (e.g. G030).

The term *Freeway* during the 1990s was used on a few expressways (such as the Jingshi Freeway). The term *freeway* has since been replaced with *expressway* on all signs in China. The Chinese name for expressways is uniform; in pinyin, it is *gāosù gōnglù*, which literally means "high speed public road".

Signs on the National Highways (G-prefix) are green, while on the lower-grade highways and urban expressways (A-prefix) are blue.

Hong Kong

In Hong Kong, the type of high speed roads is referred to as *expressway*, but some are named as *highways* or *roads* ('Yuen Long Highway', 'Tolo Highway', 'Tsuen Wan Road', 'Tuen Mun Road', etc.). Some others are named *corridors* and *bypasses*.



Occidente tunnel, Antioquia.

Colombia

In Colombia are managed by the Colombian Ministry of Transport through the National Institute of Roads. Colombia's road infrastructure is still very underdeveloped with most of the highways presenting a two lane road for outbound and inbound traffic. Some exceptions are the Highways of the Valle del Cauca, an infrastructure improvement

project started about a decade ago which has not yet been entirely finished. Nowadays, the direct public funding on highways is very limited, focused mostly in the recovering of old roads and the construction of 3,125 km of roads (The 2500 Plan).

The most important projects under negotiation or construction are La Ruta del Sol (the Sun Road), a 4-lane highway between Bogota and the Caribbean coast; the Highway between Bogota and Buenaventura (Colombia's largest and busiest port) which includes a 9 km tunnel.

Croatia

Croatia has 13 highways and 10 expressways. The earliest highway in Croatia was built in 1971. The word highway is a common Croatian translation of the term autocesta, which describes a toll highway similar to a freeway or an Autobahn.

Czech Republic

The Czech Republic has 6 motorways and numerous expressways. The earliest Czech highway was built in 1939. The word highway is a common Czech translation of the term dálnice, which describes a toll highway similar to a freeway or an Autobahn.

Denmark

With the completion in the past decade or so of some extremely-long highway bridge-tunnels it is now possible to drive back and forth between the mainland of Denmark ("Jutland") and the major island of the east where the capital city of Copenhagen is located. Also, there is now a bridge-tunnel that connects that major island with Sweden and its highway system (and also its railroad system). Thus, it is now possible to drive from Denmark not only to Germany, but to Sweden, too. Those bridge-tunnels are all interconnected within Denmark by major highways. These bridges, tunnels, and highways now make it possible to drive from northern Sweden to Gibraltar at the southern edge of Spain or to Messina, Italy, at the southern tip of the Italian "boot".

Finland

The national highways in Finland are numbered 1-29 and are in total 9.000 km long. This number system originates from 1938.

France

France has a national highway system dating back to Louis XV. The *chaussées* constructed at this time, radiating out from Paris, form the basis for the "routes nationales" (RN), whose red numbers differ from the yellow numbering used for secondary "routes departementales". The RNs numbered from 1 to 20 radiate from Paris to major ports or border crossings. More recently (after the Second World War), France

has constructed Autoroutes, ex. A6-A7 which is call Autoroute du soliel, superhighways (usually toll) with a speed limit of 130 km/h (110 in rainy conditions or urban areas).

Germany

Aside from highways bearing the Autobahn designation, Germany has many two- and four-lane roads. Federal highways not known as autobahnen are called *Bundesstraßen* (*Bundesstrassen*) and, while usually two-lane roads, they may also be four-lane, limited-access expressways of local or regional importance. Unlike the Autobahnen, though, *Bundesstraßen* (marked by black numbers on a yellow background) mostly have speed limits (usually 100 km/h, but occasionally higher on limited-access segments, and lower in urban areas or near intersections).

Hungary

Hungary has 7 major motorways ("autópálya"):

- M0 is a quasi-circular highway for the traffic bypasing Budapest. It is divided in 4 sectors: Southern (links motorways M1, M7, M6 and M5), South-eastern (links Motorway M5 and Main Road nr. 4), Eastern (links Main Road nr. 4 and Motorway M3), Northern (links Main Road nr. 2 with the Megyeri Bridge) and Western (to be finished in 2015; will link main roads 11, 11 and Motorway M1). The total length will be around 100 km.
- M1: links Budapest and the north-western border with Austria (Hegyeshalom), then continues its way toward Vienna. The total length is around 170 km.
- M3: links Budapest and the north-eastern city of Miskolc (M30 branch), eastern cities of Nyíregyháza (M3) and Debrecen (M35 branch). Provides links toward Slovakia, Ukraine and Romania. It has a total length of around 250 km.
- M5: links Budapest and the southern city of Szeged, then the Serbian border (Röszke). It provides a connection to Southern Europe by route E75 and also links to route 68 in Romania. M5 motorway has a length of around 140 km.
- M7: links Budapest and the southern shore of Lake Balaton, then continues its way toward Croatia and Slovenia. Its length is about 230 km.
- M6: links Budapest and Dunaújváros, then will continue its way toward the southern city of Pécs. The current length is around 60 km.

Also, there are other smaller motorway sections that will be linked to the national motorway network in the future. Motorways usually have 2 traffic lanes and an emergency lane on each direction, divided by a green zone and metallic rail. The speed limit is 130 km/h.

Expressways usually have no dividing lane in the middle, but sometimes have a metallic rail. The number of lanes is one per direction, with sections of 1+2 lanes (for easier overtaking). The speed limit is 110 km/h. Motorways and expressways cannot be used by vehicles that are not able to reach 60 km/h. There is a toll on all motorways, except M0. Trucks and buses have a separate toll system.

Main roads usually have one lane per direction, no dividing rail. The speed limit is 90 km/h.

County roads have less traffic then main roads, the speed limit is 90 km/h.

India

The Bangalore-Chennai Expressway, India.

In India, 'Highway' refers to one of the many *National Highways* or *State Highways* that run up to a total length of about 67,000 km consisting mostly of two-lane paved roads, changing into higher lanes mostly around cities. National Highways are designated as NH followed by the number. As of 2009, the four major cities in India – Mumbai, Chennai, Kolkata, and Delhi – are connected by the Golden Quadrilateral, a set of highways forming a rough quadrilateral that consists of 4 to 6 laned roads. Other major cities are connected to it by the North-South and East-West Corridor.

An expressway refers to any access controlled road with grade-separated intersections and make up a very small portion of India's highway network, at about 200 km in length. Expressways are separate from the highway network, except for the Delhi-Gurgaon Expressway, which is part of NH 8.

Ireland

The Republic of Ireland has a similar system to the United Kingdom except that its major roads are classed as 'N' road or 'R' road rather than 'A' road/'B' road as in the UK.

Israel

Highway 1 passing under Route 412 at Shapirim Interchange, southeast of Tel Aviv, Israel.

Italy

The A3 in Italy.

In Italy the term *highway* can be applied to *superstrada* (can be translated as expressway and it is toll free) and autostrada (Italian term for motorway: the most part of the system

it is mandatory toll). Italy was the first country in the world to build such roads, the first one being the "Autostrada dei Laghi" (*Autostrada of the Lakes*), from Milan to Varese, built in 1921 and finished in 1924. This system of early motorways was extended in the early 1930s till the early 1970s. Now days the Autostrade is a comprehensive system of about 6.500 km of modern motorways where the maximum speed limit is 130 km/h.

Japan

The expressways, or *kōsokudōro* (high speed roads), of Japan are made of a huge network of freeway-standard toll roads. Once government-owned, they have been a turned over to private companies. Most expressways are four lanes with a central reservation, or median. The speed limits, with certain regulations and great flexibility, usually include a maximum speed of 100 km/h, and a minimum speed of 50 km/h.

Malaysia

South section of North-South Expressway in Malaysia, facing towards Kuala Lumpur.

The highest level of major roads in Malaysia, *expressway (lebuhraya)*, has full access control, grade separated junctions, and mostly tolled. The expressways link the major state capitals in Peninsular Malaysia and major cities in Klang Valley.

Highway is lower level with limited access control, some at-grade junctions or roundabouts, and generally with 2 lanes in each separated direction. These are generally untolled and funded by the federal government, hence the first one is called Federal Highway linking Klang and Kuala Lumpur.

The trunk roads linking major cities and towns in the country are called *federal trunk roads*, and are generally 2 lanes single carriageway roads, in places with a third climbing lane for slow lorries.

Mexico

This is a **list of numbered federal highways (*carreteras federales*) in Mexico**. Federal Highways from north to south are assigned odd numbers; highways from west to east are assigned even numbers. The numbering schema starts in the northwest of the country (Tijuana, BC). This list identifies the road terminus always starting from the north or the west end of the highway.

New Zealand

State Highway 1 in South Auckland, New Zealand

In New Zealand, both *motorway* and an *expressway* have at least two lanes of traffic in either direction separated by a median, with no access to adjacent properties. The distinction depends on the type of traffic allowed to use the route. Non-vehicular traffic and farm equipment are prohibited from motorways, while pedestrians, cyclists, tractors, and farm animals are legally entitled to use expressways such as the Waikato Expressway south of the Bombay Hills and the Tauranga expressway system, although this is rare. New Zealand's main routes are designated *state highways* as they are funded by the National Government. State Highway 1 is the only route to run through both the North and South Islands, and runs (in order north-south) from Cape Reinga to Wellington in the North Island, and from Picton to Bluff in the South Island. State Highways 2–5 are main routes in the North Island, State Highways 6–9 in the South Island, and state highways numbered from 10 onwards are generally found in numerical order from north to south. State highways usually incorporate different standards of roads, for example, State Highway 1 from Auckland to Hamilton incorporates the Northern and Southern Motorways in the Auckland area, the Waikato Expressway, and a rural road before passing through the streets of Hamilton. The term *freeway* is rarely used relating to New Zealand roads.

The Netherlands

The Autosnelweg system is in constant development. Most of its parts are owned and funded by the government, but in recent times Public-private partnership come more and more into practice, such as in a part of the A59 between Oss and 's-Hertogenbosch. The Netherlands has the highest density highway network of Europe at 56.5 km per 1000 km², followed by Belgium. The 'Autosnelwegen', the main corridors, are designated with an A while the minor connecting roads have an N number. Sections of the A network are also part of the International E-road network in connecting with neighboring Belgium, Germany and England, the latter by ferry. The speed limit is 120 km/h, unless noted otherwise, and 100 km/h or 80 km/h on various locations. This is done to "protect the environment" and to limit noise to surrounding residential areas, albeit not too effective a measure.

Norway

Motorvei in Bergen, Norway.

Norway has a national highway system, numbered 2-899. Some main highways are also European highways and have an E before the number. The highways are often relatively narrow and curvy. Near the larger cities, especially around Oslo and Trondheim, there are motorways. Norway has also been engaged in recent decades in boring some extremely-long highway tunnels through the mountain ranges, and some of these, now the world's longest, are so long that they have hollowed-out caverns in the midst of them for motorists to stop and take rests.

Pakistan

Faizabad interchange: Gateway to the capital city Islamabad, Pakistan.

Pakistan has its own network of highways and motorways. Motorways extending from M1 to M10 will eventually connect whole length of the country from Peshawar to Karachi. The M2, the first motorway, was built in 1997 with the contract being awarded to the Korean firm Daewoo. It linked the federal capital Islamabad with Punjab's provincial capital Lahore. The network was then extended to Sargodha and then to Faisalabad with the M3. M1 highway to the North-West Frontier Province's capital Peshawar had been completed in October 2007. M4, M5, M6, and M7 have been planned and also being built by local and foreign firms. This will connect Faisalababd, Multan, Dera Ghazi Khan, Rotadero (Larkana) to Karachi. N5 links Karachi to other cities. Entry on all Pakistan highways is restricted to fast moving wheelers only. Slow-moving traffic and two wheelers (such as motorcycles and bicycles) are not allowed and construction and agricultural machinery is also restricted. Highway Police personnel use heavy motor bikes and fast moving Range Rovers for patrolling and are quite good at maintaining the traffic system. M9 and M10 are also functional now that connect Karachi to Hayderabad. The LSM (Lahore Sialkot Motorway) which is 103 km is under construction and will be completed by 2010.

Philippines

Many Philippine expressways are privately owned and maintained. All are located in the largest island, Luzon. They follow the US Interstate Highway Standards and speed limits are strictly enforced. The most modern and the longest expressway, the North Luzon Expressway links the capital, Manila to other provinces in Northern Luzon while the South Luzon Expressway links Manila with provinces on the Southern Luzon.

Presently, all Philippine expressways are under rehabilitation to decrease the occurrence of traffic jams and to improve their quality. They are widened and improved of standards.

There are only seven tollways in Luzon Island, the North Luzon Expressway (connecting Manila to North Luzon), the South Luzon Expressway (connecting Manila to Southern Luzon), the Roman Expressway (in Bataan peninsula), Subic Freeport Expressway (connecting Subic Freeport to Dinalupihan), the Southern Tagalog Access Road (STAR Tollway) (connecting Sto. Tomas to Batangas Port, to decongest the Port of Manila and it will be connected directly to South Luzon Expressway), and the Manila-Cavite Expressway, connecting Metro Manila with the Province of Cavite, Subic-Clark-Tarlac Expressway (connecting the existing Subic Freeport Expressway to Clark Zone and Hacienda Luisita and also extending North Luzon Expressway to Tarlac City but it has 3 km gap between NLEx and SCTEx).

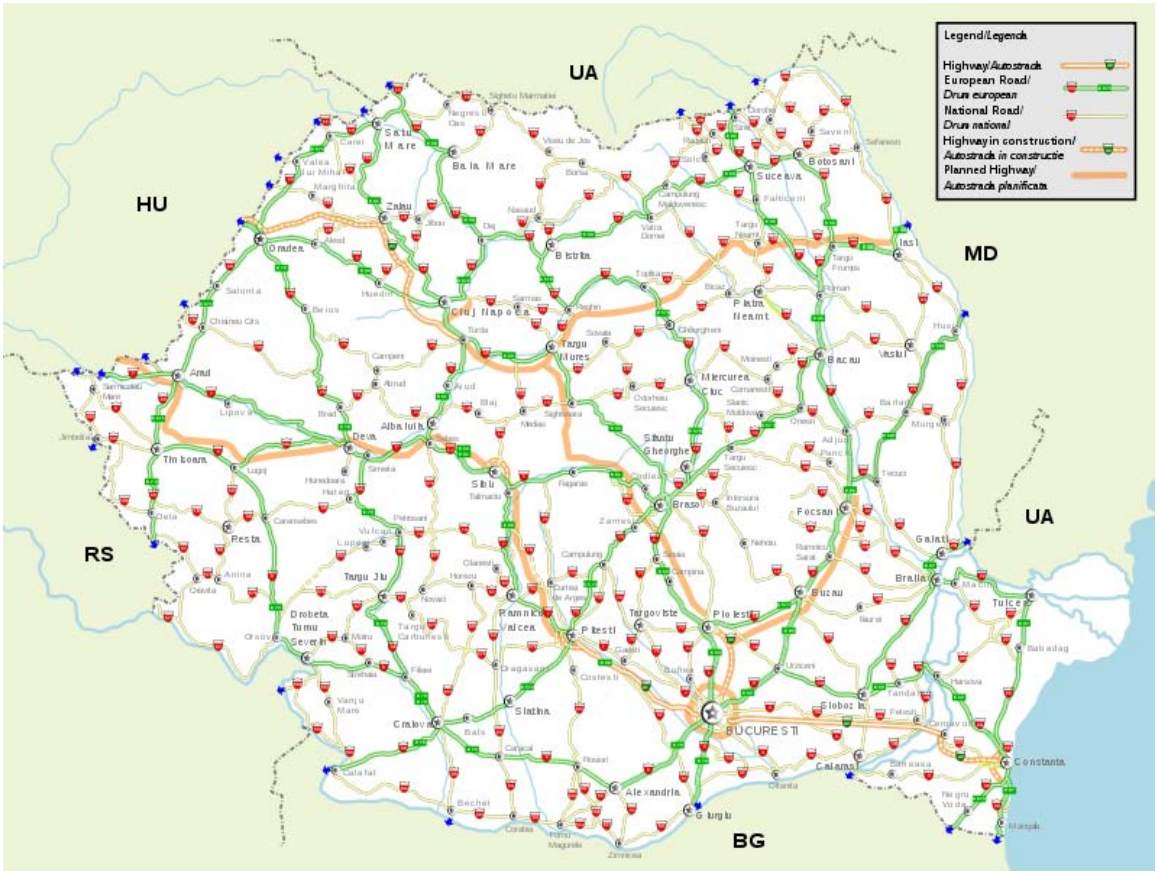
Despite that many highways in Metro Manila, there are still two lane and one way roads like national and provincial roads around the country.

There are plans to extend the existing expressways and to build a new one throughout the Philippines, the Tarlac-La Union Expressway aims to extend North Luzon Expressway to the area near Poro Point but it will be extended initially to Rosario in La Union, Tarlac-Dingalan Expressway aims to convert Dingalan into an International Pacific Port and to decongest the Port of Manila, The Cebu Trans-Axial Expressway aims to benefit Cebu's economy and to decongest the island's coastal road and to protect Cebu's coastal areas from severe exploitation, North East Luzon Expressway aims to connect Metro Manila to Cagayan Valley but it will be built initially to Nueva Ecija. South Luzon Expressway will be extended towards Lucena City.

Romania

Romania currently has three operational highways, summing up to 321 km; that is the least developed motorway network among all the European Union members. They are now being extended and additionally, another three motorways are planned to be built by 2016.

A1 near Pitesti city, Romania.



The orange highways will run next to the green European roads.

- A1: Bucharest-Nadlac highway: 127 of 620 km built (Bucharest-Pitesti); estimated completion in 2014
- A2: Autostrada Soarelui *(Highway of the Sun)*: 152 of 204 km built (Bucharest-Cernavoda); estimated completion in 2010

- A3: Autostrada Transilvania *(Transylvania highway)*: 42 of 588 km built (Câmpia Turzii - Cluj-Napoca) ; estimated completion in 2013
- A4: East-West highway: 300 km planned for completion by 2015
- A5: Autostrada Moldova *(Moldova highway)*: 314 km planned for completion by 2016

Taxes

There are no tolls for using the motorways in Romania, except Cernavodă Bridge over the Danube on the A2. Nevertheless, every car that uses a motorway or a national road in Romania must wear a sticker called a **rovinietă** on its windscreen, which can be bought at larger petrol stations.

Russia

Russia has many highways, but only small number of them are currently motorways. Examples of Russian motorways are Moscow and Saint Petersburg Ring Roads. Highways and motorways are free in Russia and only two motorways, Western High Speed Diameter and Moscow-Saint Petersburg toll motorway, currently under construction, will be first Russian toll motorways. It must be noted that Russians themselves often translate the Russian name for highway (Автомобильные дороги=automobile roads) into motorway in English, which is not a correct English name.

Saudi Arabia

Riyadh-Makkah Highway, Saudi Arabia.

Saudi Arabia has a total highway length of 173,000 km. Highways in Saudi Arabia vary from ten laned roads to small four laned roads. The city highways and other major highways are well maintained such as the roads in Riyadh. The roads are constructed so they resist the summer's extremely high heat and do not reflect the strong sun. The outer city highways such as the one linking from coast to coast are not as great as the inner-city highways but the government is now working on rebuilding those roads.

Some of the important inter-city highways include:

- Dammam - Khafji Highway (457 km)
- Jeddah - Makkah Highway (75 km)
- Makkah - Madinah Al Munawarah Highway (421 km)
- Riyadh - Dammam Highway (395 km)
- Riyadh - Qasim Highway (317 km)
- Riyadh - Makkah Highway (950 km)
- Taif - Abha Highway (950 km)

Singapore

The Bukit Timah Expressway in Singapore.

The expressways of Singapore are all dual carriageways with grade-separated access. They usually have three lanes in each direction, although there are two- or four-lane carriageways in some places. There are nine expressways, with another one, the Marina Coastal Expressway, currently under construction.

Construction on the first expressway, the Pan Island Expressway, started in 1966. The other expressways were completed in stages, with the first phase of the Kallang-Paya Lebar Expressway being the most recently completed, in 2007. Today, there are 92.5 miles (148 km) of expressways in Singapore.

South Africa

Colloquially, the terms "freeway", "highway", and "motorway" are used synonymously. There are very few references to the term "expressway" in South Africa. A freeway, highway or motorway refers to a divided dual carriageway with limited access, and at least two lanes in either direction. A central island, usually either with drainage, foliage, or high-impact barriers, provides a visible separation between the carriageways in opposite directions. As in the United Kingdom, Ireland, Australia, and Japan, South

Africans drive on the left-hand side of the road and nearly all steering wheels are on the right-hand side of vehicles.

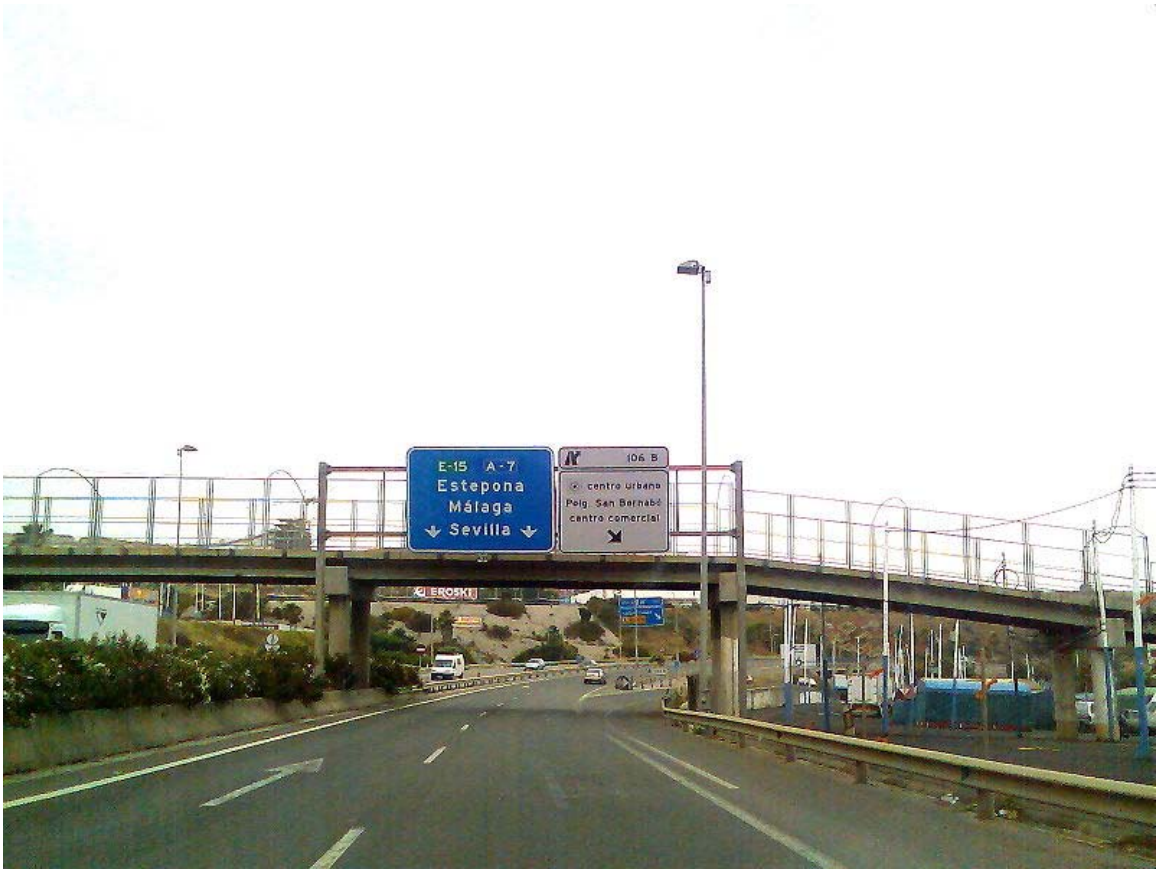
Freeways are designated with one of three labels: N (in reference to national roads), R (short for "route", in reference to provincial roads), and M (in reference to metropolitan roads). This has more to do with the location of a road and its function than anything else. In addition, "N" roads usually run the length of the country over long distances, "R" roads usually inter-connect cities and towns within a province, and "M" roads carry heavy traffic in metropolitan areas. Route markings also determine who paid for the road: "N" was paid for by national government, "R" by provincial government, and "M" by local government. In recent years, some "R" roads have been re-designated as "N" roads, so that control and funding comes from the South African National Roads Agency.

South Korea

Expressways in South Korea were originally numbered in order of construction. Since August 24, 2001, they have been numbered in a scheme somewhat similar to that of the Interstate Highway System in the United States:

- Arterial routes are designated by two-digit route numbers, with north-south routes having odd numbers, and east-west routes having even numbers. Primary routes (i.e. major thoroughfares) have five and zero as their last digits respectively, while lesser (secondary) routes have various final digits.
- Branch routes have three-digit route numbers, where the first two digits match the route number of an arterial route.
- Belt lines have three-digit route numbers where the first digit matches the respective city's postal code.
- Route numbers in the range 70-99 are not used in South Korea and are reserved for designations in the event of Korean reunification.
- The Gyeongbu Expressway kept its Route 1 designation, as it is South Korea's first and most important expressway.

Spain



An older highway in Spain

Spain's national highway system dates back to the era of King Carlos III. The roads built at this time, radiating from Madrid, form the basis for the *carreteras nacionales radiales*, numbered clockwise from I to VI, which radiate from Madrid to major ports or border crossings. In the 1960s Spain started to construct *autopistas* (toll highways) and *autovías* (freeways), and in 2007 had 14,689 km of highways, the biggest network in Europe and the third in the world, only after the USA and China.

Sweden

The first freeway in Sweden was built between the cities of Malmö and Lund in the Skåne County in southern Sweden. The Swedish roads are divided in three classes; Motorväg, which is a 4-8 lane motorway with the speed limit of 110–120 km/h. Riksväg, which is a state highway with 2-4 lanes. The Riksväg has a speed limit of 70–100 km/h. The last road is the Länsväg, which is a "county route" with 2 lanes and 70–90 km/h in speed limit. The authority which is responsible for the roads in Sweden is Vägverket.

Switzerland

The term *Autobahn* (German) / *Autoroute* (French) / *Autostrada* (Italian) is used for normal highways where there is a central physical structure separating two different directional carriageways. This is often translated into English as motorways.

In express routes where there is no central physical structure separating two different directional carriageways, but crossings are still motorway-like otherwise, and traffic lights are not present, the road is instead called an *Autostrasse* / *Semi-autoroute* / *Semi-autostrada*, usually translated into English as an expressway. Those often have a lower speed limit than motorways.

Taiwan

The construction of Taiwan's national highways began in 1971 and the design is heavily based on the American Interstate Highway System. The Northern section between Keelung City and Zhongli City was completed in 1974. The construction of the first freeway (No. 1) was completed in 1978. The freeway runs from the northern port city cf Keelung to the southern port city of Kaohsiung. There was an 8.6 km branch (No. 1A) connecting the Taiwan Taoyuan International Airport.

Construction on the other freeways began in the late 1980s. The north section of the second north-south freeway (No. 3) between Xizhi City and Hsinchu City was completed in 1997. The No. 1A Branch was extended to link No. 3 Freeway at Yingge, and renamed as No. 2 Freeway. Three other short freeways (No. 4, No. 8, and No. 10) were built to link the two north-south freeways in Taichung County (now part of Taichung City), Tainan County (now part of Tainan City), and Kaohsiung County (now part of Kaohsiung City), respectively. The entire No. 3 Freeway was completed in January, 2004.

To ease the congestion of No. 1 Freeway in the Taipei metropolitan area, a 20 km elevated bridge was built in 1997 on top of the original freeway between Xizhi City and Wugu, to serve as a bypass for traffic not exiting/entering the freeway within the city limits of Taipei.

The construction of a freeway connecting the Taipei metropolitan area and Yilan County began in 1991 and was completed in June 2006. It includes a 12.9 km tunnel (Hsuehshan Tunnel), which is the fifth longest road tunnel in the world. An extension from Yilan County to Hualian County is planned. However, its construction is being delayed due to environmental concerns.

Turkey

Turkey's main highway is E80 (former E5) runs from Edirne to the capital Ankara.

The United Kingdom

In the United Kingdom, unless a route is classified as a motorway, the term which is used for a vehicular highway may be *main road*, *trunk road*, *'A' road/'B' road*, "'C' road", "unclassified road", or, where appropriate, *dual carriageway*. However, in the law of England and Wales the term *public highway* includes all public rights of way regardless of the kind or amount of traffic they allow, including streets and public footpaths for pedestrians. The term also includes bridleways, which are for pedestrians, equestrians, and cyclists, as well as by-ways open to all traffic (for all of those users, plus vehicular traffic).

In England and Wales, the public is said to have a "right of way" over a highway. This means that, subject to statutory restrictions, the route (or "way") must be kept clear to allow travel by anyone who wishes to it. At common law, it is unlawful to obstruct a highway or to interfere with its lawful use. However, many statutory provisions provide powers to do so (for instance. to carry out roadwork).

Many public highways in the U.K. have a private owner. That is, someone can prove "title" to them, either by being the registered owner or by having conveyances showing exactly how the land has been bought and sold over a long period of time. Such ownership in no way affects the public highway rights, since the relevant "highway authority" (usually a local authority or the Highways Agency in England and Wales, or Amey Highways in Scotland) is deemed to own the surface of the highway, despite someone else's ownership of the land it passes over or under.

However, the understanding in some places is that if the road or highway is ever permanently closed and demolished, then complete control of the strip of land on which it lies reverts to the actual owner of the land. In other places, the word "easement" is used. The governmental authority has an indefinitely-long easement to use the strip of land for a road, but if the road vanishes, so does the easement that goes with it. It is possible that sometime in the far future, roads and highways will become obsolete, with people and cargo getting from here to there by some other means. Thus, some of the statements below are short-sighted and questionable.

Rights-of-way exist over all highways maintained at the public expense (the majority of roads) and also over some other ways which are not so maintained, on the principle of "once a highway, always a highway". In such cases, landowners must allow public use for "passing and repassing".

A right-of-way may be created by custom (by the way being used for a long period of time) or under the relevant Sections of the Highways Act of 1980. A right-of-way may be extinguished or diverted in a number of ways, such as by an Act of Parliament, by a magistrates' stopping-up or diversion order, or by powers given to principal local authorities. For instance, under the Channel Tunnel Rail Link Act of 1996, authority was given for the builder of this railway link to stop up certain highways that are mentioned in Schedule 3 of the act.

The opposite of a highway is a private road or pathway over which no rights-of-way exist. Any use of such private ways is subject to the consent of the owner of the land.

Richard Mabey poses the origin of the word "highway" back to the Romans in his book "The Roadside Wildlife Book", 1974: "Daniel Defoe, writing in the 1720s, describes the Fosse Way as being raised eight or nine feet in many places. Between AD 40 and 80, the Romans laid something like 6,500 miles of highway. (Were these raised roads one origin of this word?)".

The United States

Interstate 75/85 in Atlanta, Georgia, is a typical urban freeway in United States.

U.S. Route 127 in Lansing, Michigan.

In the United States, "highway" is a general term for denoting a public way, including the entire area within the right-of-way, and includes many forms:

1. a high-speed, limited-access road like expressways, freeways, and large toll highways.
2. an important road that connects cities and large towns.
3. any road or street, or a travel way of any kind, including pedestrian ways, trails, and navigable waterways, to which the public has a perpetual right of use.

Note that the phrase "right-of-way" is used differently in the United States than it is in the United Kingdom and certain other places. In the U.S. a highway or road "right-of-way" means the land on which the pavement rests, plus the shoulders beside the pavements, plus any median strip, plus any other adjacent piece of land that is designated for the purposes of the highway or road. In other words, the "right-of-way" is the strip of land for the highway or road, and a sign that say, "No Parking on Right-of-Way" means just that: don't park on the pavement or on the land adjacent to it.

Many paved highways for vehicles are part of the official National Highway System of the U.S.. Paved highways in the "U.S. Highway" system (for example, U.S. Highway 50) can vary from two lanes wide (one lane each direction), shoulderless, roads with no

access control, to multi-lane high-speed controlled-access highway, such as the Interstate Highways. These roads are usually distinguished by being important, but not always the primary, routes that connect populated areas. (Sometimes, the primary route is a State Highway.) Since their inception many decades ago, the construction of "U.S. Highways", and their major improvements, have been paid for 50% with Federal funds, especially from motor fuel taxes, and 50% with State funds from whatever tax resources that the state has. Thus, the system of "U.S. Highways" has always been an equal partnership between the Federal Government and the State governments. This was a plan that changed dramatically with the advent of the Interstate Highway system beginning in the 1950s, but do not forget that the system of "U.S. Highways" continued to be upgraded under the 50%-50% funding. Highways continue to be widened, old bridges continue to be replaces with newer and better ones, and so forth.

The term "Highways" in the U.S. even includes major paved roads that serve purposes similar to those of the U.S. Highways or Interstate Highways, but which are completely designed, paid for, and maintained by state or local governments. An example of this is Tennessee Highway 840, which is a long, partially-completed "urban bypass" of Nashville, Tenn. that is a multi-lane, controlled-access highway entirely designed and paid for by Tennessee. Much of the traffic on it will eventually come from Interstate 40, completely avoid the big city, and then return to Interstate 40. Incidentally, Tennessee-840 also has connections with Interstate 24 and Interstate 65, where both of the freeway interchanges are already finished, as well as the eastern interchange with Interstate 40.

When the Act of Congress that authorized the Interstate Highway System was passed and then signed by President Eisenhower, it was already clear that the Interstate Highways would be far more expensive, mile-for-mile, than the U.S. Highways had been. Also, the **Interstate Highways** were to be built largely, for the purposes of constitutionality, for Federal purposes which were, A. To promote and enable the National Defense by being able to move very large numbers of troops, and their equipment and supplies from place to place, rapidly, by truck and bus. Also, long stretches of the expressway would have the capability of functioning as emergency take-off and landing strips for Air Force planes in wartime. B. To promote and enable commerce between the 48 states that existed then, under the Interstate Commerce Clause of the Constitution With these being the stated purposes of the Interstate Highways (and also the source of the name "Interstate Highway", from the Commerce Clause), and because of their great cost, Congress decided to set the standard for Federal funding for the Interstate System at 90%, leaving 10% for the States to pay for.

Another monetary difference came from the fact that the Interstate Highways were to be designed to be high-speed and safe expressways. This meant that they needed to have much wider open strips of land along their sides, because this created safety zones on each side of the highways so that vehicles that were in accidents or simply lost control would have somewhere to go, to slow down gradually, and not crash into trees, boulders, light poles, buildings, parked vehicles, fire hydrants, and other kinds of obstacles that you can think of. Roadway interchanges for Interstate Highways were also to be very large (and over the decades, they became a lot larger than anyone had anticipated in the 1950s).

With so much land being taken away for the highways, the only way to justify it and to make it politically palatable was for the Federal and State governments to outright purchase all of the land. There could be no question of just having an easement for the highway and its right-of-way. All of the land within the right-of-way would be permanently owned by the governments, until such time that they decided to get rid of the highway and sell the land.

In some places, "highway" is a synonym for "road" or "street", and in some cases, the word "highway" is simply used in cases of carelessness and laziness on the part of the speaker, who believes that "street", "road", and "highway" are all synonymous and uses them accordingly. On the other hand, in another example, the California Motor Vehicle Code § 360 states: "'Highway' is a way or place of whatever nature, publicly maintained and open to the use of the public for purposes of vehicular travel. Highway includes street." The California Supreme Court has held that "the definition of 'highway' in the Vehicle Code is used for special purposes of that act," and that canals of the town of Venice, California, are "highways" also entitled to be maintained with state highway funds.

The Federal and State governments are trying to improve their national highway systems by repaving highways, widening highways, replacing bridges, and reconstructing some interchanges. Many cloverleaf interchanges are being converted to parclo interchanges. Busy Diamond interchanges are also being converted to SPUIs (single-point-urban interchange) or to parclos to reduce interchange congestion.

Arguably, the most famous United States highway is U.S. Route 66. It is immortalized in the song *(Get Your Kicks On) Route 66*, and by the legendary TV series *Route 66*. Other famous highways in songs include Highway 61 (Bob Dylan, 1965), Carefree Highway in Arizona (Gordon Lightfoot, 1974), Colorado Boulevard in Pasadena, California (Jan & Dean, also Beach Boys, 1964), the song *Ventura Highway*, named for a highway in Southern California ("America", 1972), and Blues Highway in Mississippi (Fred McDowell, 1959).