Highway Systems and Transport Engineering

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Table of Contents

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.

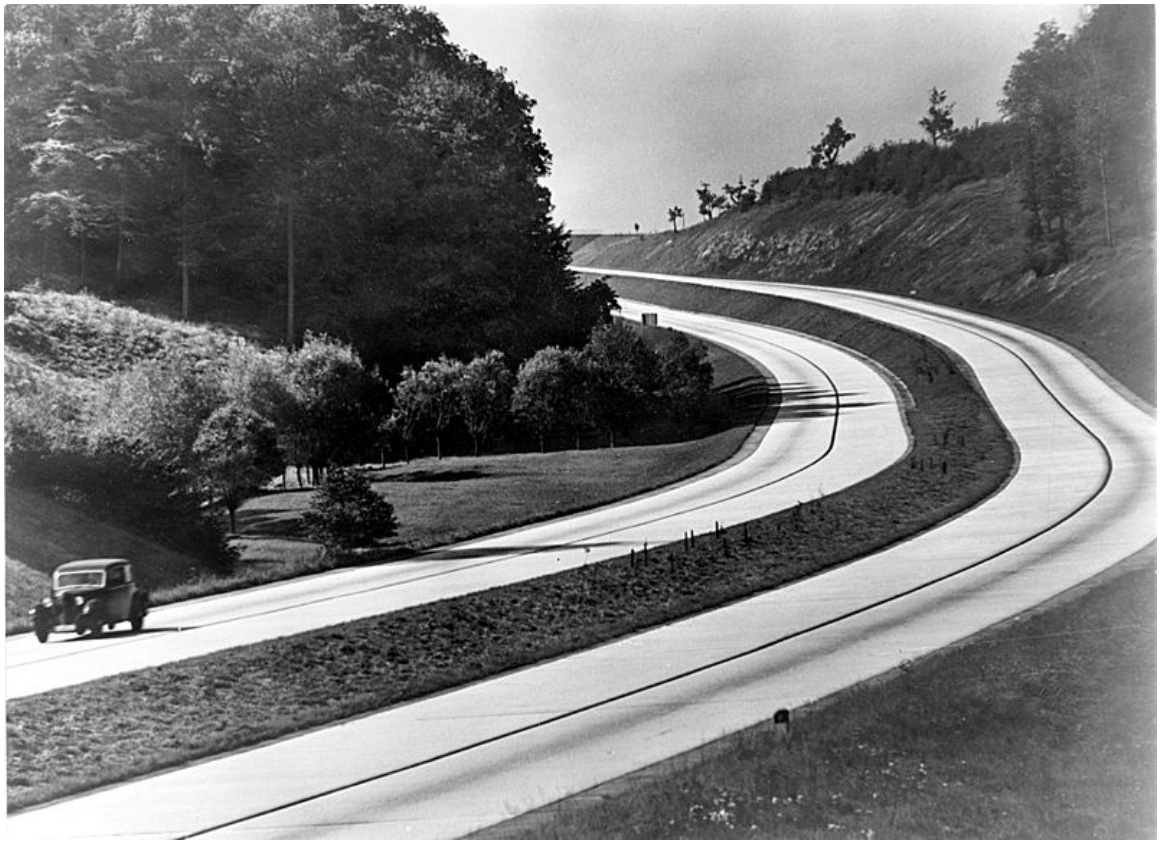
In England and Wales, a "Public Highway" is a road or footpath over which the public has the right of access, i.e. the opposite of a "private road".

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

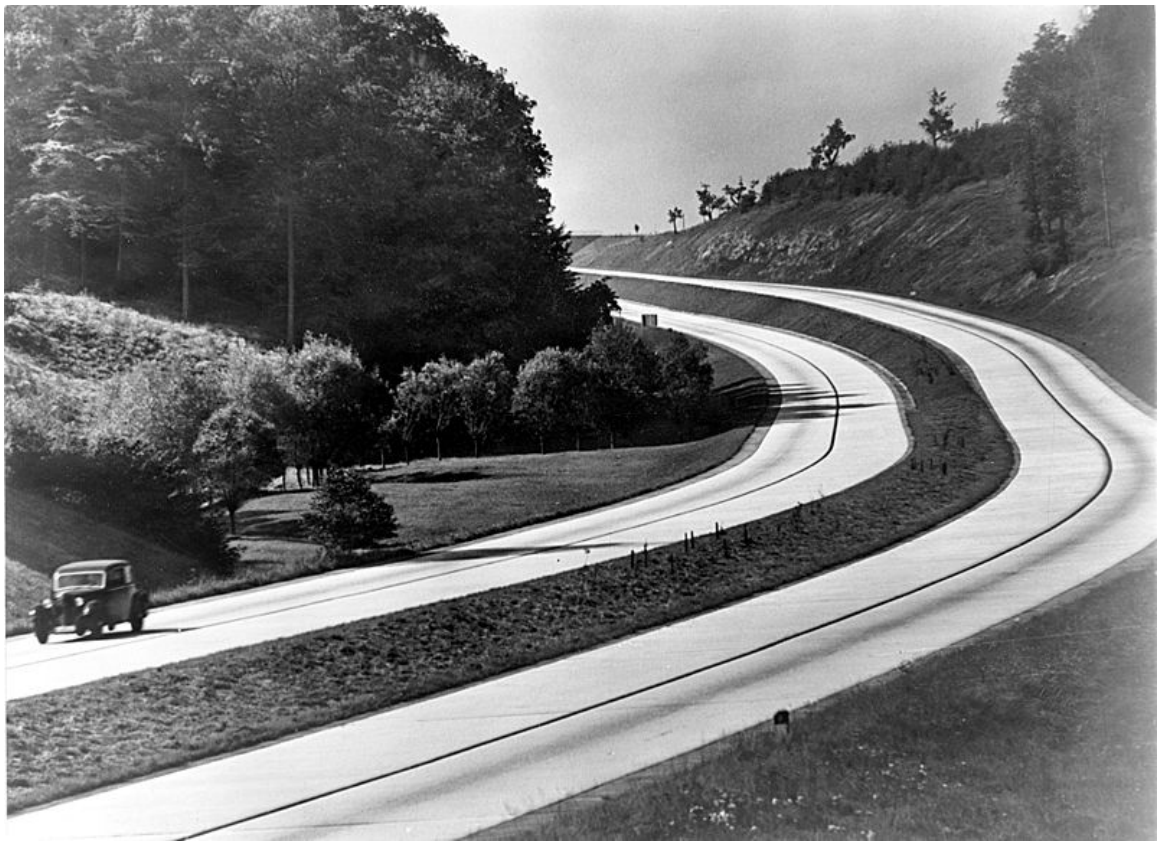
Chapter 2

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.