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COURSE 6 : Transportation

Cargo, i.e. merchandise being transported, can be moved through a variety of transportation means and is organized in different [shipment categories](#). [Unit loads](#) are usually assembled into higher standardized units such as: [ISO containers](#), [swap bodies](#) or [semi-trailers](#). Especially for very long distances, product transportation will likely benefit from using different transportation means: [multimodal transport](#), [intermodal transport](#) (no handling) and [combined transport](#) (minimal road transport). When moving cargo, typical constraints are maximum [weight](#) and [volume](#).

Operators involved in transportation include: all train, road vehicles, boats, airplanes companies, [couriers](#), [freight forwarders](#) and [multi-modal transport operators](#).

Merchandise being transported internationally is usually subject to the [Inco terms](#) standards issued by the [International Chamber of Commerce](#).

&- Definition and modes

Transport or **transportation** is the movement of humans, animals and [goods](#) from one location to another. [Modes of transport](#) include [air](#), [land](#) (rail and [road](#)), [water](#), [cable](#), [pipeline](#) and [space](#). The field can be divided into [infrastructure](#), [vehicles](#) and [operations](#). Transport is important because it enables trade between people, which is essential for the development of [civilizations](#).

Transport [infrastructure](#) consists of the fixed installations including [roads](#), [railways](#), [airways](#), [waterways](#), [canals](#) and [pipelines](#) and terminals such as [airports](#), [railway stations](#), [bus stations](#), [warehouses](#), trucking terminals, refueling depots (including fueling docks and [fuel stations](#)) and [seaports](#). Terminals may be used both for interchange of passengers and cargo and for maintenance.

Vehicles traveling on these networks may include [automobiles](#), [bicycles](#), [buses](#), [trains](#), [trucks](#), [people](#), [helicopters](#), [watercraft](#), [spacecraft](#) and [aircraft](#). Operations deal with the way the vehicles are operated, and the procedures set for this purpose including financing, legalities, and policies. In the transport industry, operations and ownership of infrastructure can be either public or private, depending on the country and mode.

Passenger transport may be [public](#), where operators provide scheduled services, or [private](#). Freight transport has become focused on [containerization](#), although [bulk](#)

[transport](#) is used for large volumes of durable items. Transport plays an important part in economic growth and [globalization](#), but most types cause [air pollution](#) and [use large amounts of land](#). While it is heavily subsidized by governments, good planning of transport is essential to make traffic flow and restrain [urban sprawl](#).

Humans' first means of transport involved walking, running and swimming. The [domestication](#) of animals introduced a new way to lay the burden of transport on more powerful creatures, allowing the hauling of heavier loads, or humans riding animals for greater speed and duration. Inventions such as the wheel and the sled helped make animal transport more efficient through the introduction of [vehicles](#). Water transport, including rowed and sailed vessels, dates back to [time immemorial](#), and was the only efficient way to transport large quantities or over large distances prior to the [Industrial Revolution](#).

The first forms of [road transport](#) involved animals, such as [horses](#) ([domesticated](#) in the 4th or 3rd millennium BCE), [oxen](#) (from about 8000 BCE) or humans carrying goods over [dirt](#) tracks that often followed [game trails](#). Many early civilizations, including [Mesopotamia](#) and the [Indus Valley Civilization](#), constructed paved roads. In [classical antiquity](#), the [Persian](#) and [Roman](#) empires built stone-paved roads to allow armies to travel quickly. Deep roadbeds of crushed stone underneath kept such roads dry.

The medieval [Caliphate](#) later built [tar-paved](#) roads. The first water craft were [canoes](#) cut out from [tree trunks](#). Early water transport was accomplished with ships that were either rowed or used the [wind](#) for propulsion, or a combination of the two. The importance of water has led to most cities that grew up as sites for trading being located on rivers or on the sea-shore, often at the intersection of two bodies of water. Until the Industrial Revolution, transport remained slow and costly, and production and consumption gravitated as close to each other as feasible.



The [Wright brothers](#)' first flight in 1903

The [Industrial Revolution](#) in the 19th century saw a number of inventions fundamentally change transport. With [telegraphy](#), communication became instant and independent of the transport of physical objects. The invention of the [steam engine](#), closely followed by its application in [rail transport](#), made land transport independent of human or animal muscles. Both speed and capacity increased rapidly, allowing specialization through manufacturing being located independently of natural resources. The 19th century also saw the development of the [steam ship](#), which sped up global transport.

With the development of the [combustion engine](#) and the automobile around 1900, road transport became more competitive again, and mechanical private transport originated. The first "modern" highways were constructed during the 19th century with [macadam](#). Later, [tarmac](#) and [concrete](#) became the dominant paving materials. In 1903 the [Wright brothers](#) demonstrated the first successful controllable [airplane](#), and after World War I (1914–1918) aircraft became a fast way to transport people and express goods over long distances.

After World War II (1939–1945) the automobile and airlines took higher shares of transport, reducing rail and water to freight and short-haul passenger services. Scientific spaceflight began in the 1950s, with rapid growth until the 1970s, when interest dwindled. In the 1950s the introduction of [containerization](#) gave massive efficiency gains in freight transport, fostering [globalization](#). International air travel became much more accessible in the 1960s with the commercialization of the [jet engine](#). Along with the growth in automobiles and motorways, rail and water transport declined in relative importance. After the introduction of the [Shinkansen](#) in Japan in 1964, high-speed rail in Asia and Europe started attracting passengers on long-haul routes away from airlines

Mode

A mode of transport is a solution that makes use of a particular type of vehicle, infrastructure, and operation. The transport of a person or of cargo may involve one mode or several of the modes, with the latter case being called intermodal or multimodal transport. Each mode has its own advantages and disadvantages, and will be chosen for a trip on the basis of cost, capability, and route.

Human-powered



[Human-powered transport](#) remains common in developing countries.

Human powered transport, a form of [sustainable transportation](#), is the transport of people and/or goods using [human](#) muscle-power, in the form of [walking](#), [running](#) and [swimming](#). Modern [technology](#) has allowed [machines](#) to enhance

human power. Human-powered transport remains popular for reasons of cost-saving, [leisure](#), [physical exercise](#), and [environmentalism](#); it is sometimes the only type available, especially in underdeveloped or inaccessible regions.

Although humans are able to walk without infrastructure, the transport can be enhanced through the use of roads, especially when using the human power with vehicles, such as bicycles and [inline skates](#). Human-powered vehicles have also been developed for difficult environments, such as snow and water, by [watercraft rowing](#) and [skiing](#); even the air can be entered with [human-powered aircraft](#).

Animal-powered

Animal-powered transport is the use of [working animals](#) for the movement of people and commodities. Humans may ride some of the animals directly, use them as [pack animals](#) for carrying goods, or harness them, alone or in [teams](#), to pull [sleds](#) or wheeled [vehicles](#).

Air[



An [Air France Airbus A318](#) lands at [London Heathrow Airport](#).

A [fixed-wing aircraft](#), commonly called **airplane**, is a heavier-than-air craft where movement of the air in relation to the wings is used to generate lift. The term is used to distinguish this from [rotary-wing aircraft](#), where the movement of the lift surfaces relative to the air generates lift. A [gyroplane](#) is both fixed-wing and rotary wing. Fixed-wing aircraft range from small trainers and recreational aircraft to large [airliners](#) and military cargo aircraft.

Two things necessary for aircraft are air flow over the wings for [lift](#) and an area for [landing](#). The majority of aircraft also need an [airport](#) with the infrastructure to receive maintenance, restocking, refueling and for the loading and unloading of crew, cargo, and passengers. While the vast majority of aircraft land and take off on land, some are capable of take-off and landing on ice, snow, and calm water.

The aircraft is the second fastest method of transport, after the [rocket](#). Commercial jets can reach up to 955 kilo metres per hour (593 mph), single-engine aircraft 555 kilo metres per hour (345 mph). Aviation is able to quickly transport people and limited amounts of cargo over longer distances, but incurs high costs and energy use; for short distances or in inaccessible places [helicopters](#) can be used As of April 28, 2009, *The*

Guardian article notes that, "the WHO estimates that up to 500,000 people are on planes at any time.

Land

Land transport covers all land-based transportation systems that provide for the movement of people, goods and services. Land transport plays a vital role in linking communities to each other. Land transport is a key factor in [urban planning](#). It consists of 2 kinds, rail and road.

Rail



[InterCityExpress](#), a German [high-speed](#) passenger train



The [New York City Subway](#) is the world's largest [rapid transit](#) system by length of routes and by number of [stations](#).

Rail transport is where a [train](#) runs along a set of two parallel [steel rails](#), known as a railway or railroad. The rails are anchored [perpendicular](#) to [ties](#) (or sleepers) of timber, concrete or steel, to maintain a consistent distance apart, or [gauge](#). The rails and perpendicular beams are placed on a foundation made of concrete or compressed [earth](#) and [gravel](#) in a bed of ballast. Alternative methods include [monorail](#) and [maglev](#).

A train consists of one or more connected vehicles that operate on the rails. Propulsion is commonly provided by a [locomotive](#), that hauls a series of unpowered cars, that can carry passengers or freight. The locomotive can be powered by [steam](#), [diesel](#) or by [electricity](#) supplied by [trackside systems](#). Alternatively, some or all the cars can be powered, known as a [multiple unit](#). Also, a train can be powered by [horses](#), [cables](#), [gravity](#), [pneumatics](#) and [gas turbines](#). Railed vehicles move with much less friction than rubber tires on paved roads, making trains more [energy efficient](#), though not as efficient as ships.

[Intercity](#) trains are long-haul services connecting cities; modern [high-speed rail](#) is capable of speeds up to 350 km/h (220 mph), but this requires specially built track. [Regional](#) and [commuter](#) trains feed cities from suburbs and surrounding areas, while intra-urban transport is performed by high-capacity [tramways](#) and [rapid transits](#), often making up the backbone of a city's public transport. [Freight trains](#) traditionally used [box cars](#), requiring manual loading and unloading of the [cargo](#). Since the 1960s, [container trains](#) have become the dominant solution for general freight, while large quantities of bulk are transported by dedicated trains.

Road



The [Harbor Freeway](#) is often heavily congested at rush hour in [Downtown Los Angeles](#).

A **road** is an identifiable [route](#), way or [path](#) between two or more [places](#). Roads are typically smoothed, [paved](#), or otherwise prepared to allow easy travel; though they need not be, and historically many roads were simply recognizable routes without any formal [construction](#) or [maintenance](#). In [urban areas](#), roads may pass through a [city](#) or [village](#) and be named as [streets](#), serving a dual function as urban space [easement](#) and route.

The most common road vehicle is the automobile; a [wheeled](#) passenger vehicle that carries its own [motor](#). Other users of roads include [buses](#), [trucks](#), [motor cycles](#), [bicycles](#) and [pedestrians](#). Road transport offers a complete freedom to road users to transfer the vehicle from one lane to the other and from one road to another according to the need and convenience. This flexibility of changes in location, direction, speed, and timings of travel is not available to other modes of transport. It is possible to provide door to door service only by road transport.

Automobiles provide high flexibility with low capacity, but require high energy and area use, and are the main source of [noise](#) and [air pollution](#) in cities; buses allow for more efficient travel at the cost of reduced flexibility. Road transport by truck is often the initial and final stage of freight transport.

Water



Built by the Dutch to transport spices, now used by the local fishermen to get to the sea, [Negombo Dutch canal](#), [Sri Lanka](#)



Automobile ferry in [Croatia](#)

Water transport is movement by means of a [water craft](#)—such as a [barge](#), [boat](#), [ship](#) or [sail boat](#)—over a body of water, such as [sea](#), [ocean](#), [lake](#), [canal](#) or [river](#). The need for buoyancy is common to watercraft, making the [hull](#) a dominant aspect of its construction, maintenance and appearance.

In the 19th century, the first [steam ships](#) were developed, using a [steam engine](#) to drive a [paddle wheel](#) or [propeller](#) to move the ship. The [steam](#) was produced in a [boiler](#) using wood or [coal](#) and fed through a steam [external combustion engine](#). Now most ships have an [internal combustion engine](#) using a slightly refined type of [petroleum](#) called [bunker fuel](#). Some ships, such as [submarines](#), use [nuclear power](#) to produce the steam. [Recreational](#) or [educational](#) craft still use wind power, while some smaller craft use [internal combustion engines](#) to drive one or more [propellers](#), or in the case of jet boats, an inboard water jet. In shallow draft areas, [hover craft](#) are propelled by large pusher-prop fans.

Other modes



[Trans-Alaska Pipeline](#) for [crude oil](#)

[Pipeline transport](#) sends goods through a [pipe](#); most commonly liquid and gases are sent, but [pneumatic tubes](#) can also send solid capsules using compressed air. For liquids/gases, any chemically stable liquid or gas can be sent through a pipeline. Short-

distance systems exist for [sewage](#), [slurry](#), [water](#) and [beer](#), while long-distance networks are used for [petroleum](#) and [natural gas](#).

[Cable transport](#) is a broad mode where vehicles are pulled by [cables](#) instead of an internal power source. It is most commonly used at steep [gradient](#). Typical solutions include [aerial tramway](#), [elevators](#), [escalator](#) and [ski lifts](#); some of these are also categorized as [conveyor](#) transport.

[Spaceflight](#) is transport out of Earth's atmosphere into [outer space](#) by means of a [spacecraft](#). While large amounts of research have gone into technology, it is rarely used except to put satellites into orbit, and conduct scientific experiments. However, man has landed on the moon, and probes have been sent to all the planets of the Solar System.

[Suborbital spaceflight](#) is the fastest of the existing and planned transport systems from a place on Earth to a distant "other place" on Earth. Faster transport could be achieved through part of a [low Earth orbit](#), or following that trajectory even faster using the propulsion of the rocket to steer it.

Elements

Infrastructure



Bridges, such as [Golden Gate Bridge](#), allow roads and railways to cross bodies of water.

Infrastructure is the fixed installations that allow a vehicle to operate. It consists of a roadway, a terminal, and facilities for parking and maintenance. For rail, pipeline, road and cable transport, the entire way the vehicle travels must be constructed. Air and watercraft are able to avoid this, since the [airway](#) and [seaway](#) do not need to be constructed. However, they require fixed infrastructure at terminals.

Terminals such as airports, ports, and stations, are locations where passengers and freight can be transferred from one vehicle or mode to another. For passenger transport, terminals are integrating different modes to allow riders, who are interchanging between modes, to take advantage of each mode's benefits. For instance, [airport rail links](#) connect airports to the city centers and suburbs. The terminals for automobiles are [parking lots](#), while buses and coaches can operate from simple stops. For freight, terminals act as [transshipment](#) points, though some cargo is transported directly from the point of production to the point of use.

The [financing](#) of infrastructure can either be [public](#) or [private](#). Transport is often a [natural monopoly](#) and a necessity for the public; roads, and in some countries railways and airports are funded through [taxation](#). New infrastructure projects can have high costs and are often financed through [debt](#). Many infrastructure owners, therefore, impose usage fees, such as [landing fees](#) at airports, or [toll plazas](#) on roads. Independent of this, authorities may impose [taxes](#) on the purchase or use of vehicles. Because of poor forecasting and overestimation of passenger numbers by planners, there is frequently a benefits shortfall for transport infrastructure projects.

Vehicles



A [Fiat Uno](#) in 2008

A vehicle is a non-living device that is used to move people and goods. Unlike the infrastructure, the vehicle moves along with the cargo and riders. Unless being pulled/pushed by a cable or muscle-power, the vehicle must provide its own propulsion; this is most commonly done through a [steam engine](#), [combustion engine](#), [electric motor](#), a [jet engine](#) or a [rocket](#), though other means of propulsion also exist. Vehicles also need a system of converting the energy into movement; this is most commonly done through [wheels](#), [propellers](#) and [pressure](#).

Vehicles are most commonly staffed by a [driver](#). However, some systems, such as [people movers](#) and some rapid transits, are fully [automated](#). For [passenger](#) transport, the vehicle must have a compartment, seat, or platform for the passengers. Simple vehicles, such as automobiles, bicycles or simple aircraft, may have one of the passengers as a driver.

Operation



[Incheon International Airport](#), South Korea

Private transport is only subject to the owner of the vehicle, who operates the vehicle themselves. For public transport and freight transport, operations are done

through [private enterprise](#) or by [governments](#). The infrastructure and vehicles may be owned and operated by the same company, or they may be operated by different entities. Traditionally, many countries have had a [national airline](#) and [national railway](#). Since the 1980s, many of these have been [privatized](#). International shipping remains a highly competitive industry with little regulation, but ports can be public-owned.

Freight

Freight transport, or shipping, is a key in the [value chain](#) in manufacturing. With increased specialization and [globalization](#), production is being located further away from consumption, rapidly increasing the demand for transport. Transportation creates place utility by moving the goods from the place of production to the place of consumption. While all modes of transport are used for cargo transport, there is high differentiation between the nature of the cargo transport, in which mode is chosen. [Logistics](#) refers to the entire process of transferring products from producer to consumer, including storage, transport, transshipment, warehousing, material-handling, and packaging, with associated exchange of information. [Inco term](#) deals with the handling of payment and responsibility of [risk](#) during transport.



[Freight train](#) with [shipping containers](#) in the [United Kingdom](#)

[Containerization](#), with the standardization of [ISO containers](#) on all vehicles and at all ports, has revolutionized [international](#) and [domestic trade](#), offering huge reduction in [transshipment](#) costs. Traditionally, all cargo had to be manually loaded and unloaded into the haul of any ship or car; containerization allows for automated handling and transfer between modes, and the standardized sizes allow for gains in [economy of scale](#) in vehicle operation. This has been one of the key driving factors in international trade and globalization since the 1950s.

[Bulk transport](#) is common with cargo that can be handled roughly without deterioration; typical examples are [ore](#), coal, [cereals](#) and [petroleum](#). Because of the uniformity of the product, mechanical handling can allow enormous quantities to be handled quickly and efficiently. The low value of the cargo combined with high volume also means that economies of scale become essential in transport, and gigantic ships and whole trains are commonly used to transport bulk. Liquid products with sufficient volume may also be transported by pipeline.

[Air freight](#) has become more common for products of high value; while less than one percent of world transport by volume is by airline, it amounts to forty percent of the value. Time has become especially important in regards to principles such as [postponement](#) and [just-in-time](#) within the value chain, resulting in a high willingness to pay for quick delivery of key components or items of high value-to-weight ratio. In addition to mail, common items sent by air include [electronics](#) and [fashion](#) clothing.

Impact

Economic



Transport is a key component of growth and globalization, such as in [Seattle, Washington](#), United States.

Transport is a key necessity for [specialization](#)—allowing production and consumption of products to occur at different locations. Transport has throughout history been a spur to expansion; better transport allows more [trade](#) and a greater spread of people. [Economic growth](#) has always been dependent on increasing the capacity and rationality of transport. But the infrastructure and operation of transport has a great impact on the land and is the largest drainer of energy, making [transport sustainability](#) a major issue.

Due to the way modern cities and communities are planned and operated, a physical distinction between home and work is usually created, forcing people to transport themselves to places of work, study, or leisure, as well as to temporarily relocate for other daily activities. Passenger transport is also the essence of [tourism](#), a major part of [recreational](#) transport. Commerce requires the transport of people to conduct business, either to allow face-to-face communication for important decisions or to move specialists from their regular place of work to sites where they are needed.

Planning

Transport planning allows for high utilization and less impact regarding new infrastructure. Using models of [transport forecasting](#), planners are able to predict future transport patterns. On the operative level, logistics allows owners of cargo to plan transport as part of the [supply chain](#). Transport as a field is also studied through [transport economics](#), a component for the creation of regulation policy by authorities. [Transport engineering](#), a sub-discipline of [civil engineering](#), must take into account [trip generation](#), [trip distribution](#), [mode choice](#) and [route assignment](#), while the operative level is handled through [traffic engineering](#).



The engineering of this [roundabout](#) in [Bristol](#), United Kingdom, attempts to make traffic flow free-moving.

Because of the negative impacts incurred, transport often becomes the subject of controversy related to choice of mode, as well as increased capacity. Automotive transport can be seen as a [tragedy of the commons](#), where the flexibility and comfort for the individual deteriorate the natural and urban environment for all. [Density of development](#) depends on mode of transport, with public transport allowing for better spatial utilization. Good land use keeps common activities close to people's homes and places higher-density development closer to transport lines and hubs, to minimize the need for transport. There are [economies of agglomeration](#). Beyond transportation some land uses are more efficient when clustered. Transportation facilities consume land, and in cities, pavement (devoted to streets and parking) can easily exceed 20 percent of the total land use. An efficient transport system can reduce land waste.

Too much infrastructure and too much smoothing for maximum vehicle throughput means that in many cities there is too much traffic and many—if not all—of the negative impacts that come with it. It is only in recent years that traditional practices have started to be questioned in many places, and as a result of new types of analysis which bring in a much broader range of skills than those traditionally relied on—spanning such areas as environmental impact analysis, public health, sociologists as well as economists—the viability of the old mobility solutions is increasingly being questioned.

Environment



[Traffic congestion](#) persists in [São Paulo](#), Brazil, despite the no-drive days based on license numbers.

Transport is a major use of [energy](#) and burns most of the world's [petroleum](#). This creates air pollution, including [nitrous oxides](#) and [particulates](#), and is a significant contributor to [global warming](#) through emission of [carbon dioxide](#), for which transport is

the fastest-growing emission sector. By subsector, road transport is the largest contributor to global warming. [Environmental regulations](#) in developed countries have reduced individual vehicles' emissions; however, this has been offset by increases in the numbers of vehicles and in the use of each vehicle.¹ Some pathways to reduce the carbon emissions of road vehicles considerably have been studied. Energy use and emissions vary largely between modes, causing [environmentalists](#) to call for a transition from air and road to rail and human-powered transport, as well as increased [transport electrification](#) and [energy efficiency](#).

Other environmental impacts of transport systems include [traffic congestion](#) and automobile-oriented [urban sprawl](#), which can consume natural habitat and agricultural lands. By reducing transportation emissions globally, it is predicted that there will be significant positive effects on Earth's [air quality](#), [acid rain](#), [smog](#) and climate change

To sum up: modes of transportation are:

Road

Road transportation is one of the most basic and historical means of transportation from one place to another. There are many different types of automobiles found on roads, although trucks and carriers typically are used for carrying or delivering freight. Road transportation incurs a relatively lower cost than other logistic forms and has a widely recognizable and flexible route. However, transport by road takes a relatively longer period of time than other possible means of transportation, and it offers a limited capacity. Road transport is most often used for relatively inexpensive, non-perishable items or for shorter distances.

Rail

Rail transport uses freight trains for the delivery of merchandise. Freight trains are usually powered by diesel, electricity and steam. Since the late 1900s container trains were considered to be the dominant solution for bulk quantities of freight, but as they lack the flexibility of road transport and incur an additional transshipment cost, this logistics method has become a little less popular in recent times. However, using rail transport can be less expensive if freight is large and heavy and the pickup point as well as the delivery point is near the rail head.

Water

Water transport uses ships and large commercial vessels that carry billions of tons of cargo every year. Developed in the 18th century, steam engines have been a long favorite choice for making ships move, although now a little more refined type of petroleum referred to as bunker fuel is used instead. Sea, lake or river transport is particularly effective for significantly large quantities of goods that are non-perishable in nature and for cities or states that have water access. Moreover, transport via water is considerably less expensive than other logistics methods, which makes it one of the most widely used choices of transport for merchandise.

Air

Merchandise is carried in cargo holds within passenger airlines and/or via aircraft designed to carry freight alone. Although air transport is more expensive than all other means of transportation, it is undeniably most time-efficient. Perishable merchandise like fruits and vegetables are mostly sent by air.