運輸工程學

什麼是運輸工程?字典定義運輸爲”一個活動、過程及運輸或已運輸的實例”，運輸的動詞意義爲”由一個地方到另一個地方的運送或移動”，工程的定義爲” 係藉用數學及科學原理使自然界的能量資源及事務性質能應用，且能被人類在結構、機械、產品、系統及程序等應用”。故運輸工程解釋爲人類在運送旅客及貨物的使用方式，係藉用數學及科學原理使自然界的能量資源及事務性質的應用結果，如此的運輸工程定義爲明顯的簡易及清楚地表示，有關運輸專業或運輸工程師的工作內容。

運輸工程係具有多樣性及富麗性的最新工程分支，與土木工程、區域規劃及經濟等專業相關。運輸工程推動經濟活動係藉由安全條款、經濟的、有效的及環境永續模式等獲得，運輸工程內容與車輛、駕駛者/乘客及路權等相關，其階層係基礎建設之規劃、設計、施工、營運及維護等項。運輸工程是土木工程的專業之一，技術目標係確保人員及貨物的有效移動及安全。

運輸工程的規劃內容與都市計畫相關，包含專業的預測決策與更技巧的行政因素。乘客旅行的專業預測，通常包括四步驟的都市運輸規劃，涵蓋旅次產生的估算(旅次數)、旅次分配(目的地選擇)、運具選擇(使用的交通工具)及路線分配(使用的街道或路線)。更精細的預測包括其他旅行者的決策觀點，涵蓋車輛所有者、旅次鏈(個別旅次連結爲一個旅次的決定)、居住或商業位置的選擇(爲土地使用預測)。

運輸工程的設計內容包括運輸設施的規模(車道數或設施的容量) 、路幅或軌道的幾何設計(平面及縱面線形)、鋪面結構的厚度及採用的材料，營運及管理包括交通工程、以及道路或軌道流暢的移動，較老的技術包括標誌、號誌及標線，較新的技術涵蓋智慧型運輸系統(ITS)，計有先進的旅客資訊系統(ATIS)例如變動資訊號誌，及先進的交通控誌系統(ATCS)例如匝道儀控，人類因素係運輸工程的重要內容，特別是駕駛者與車輛介面以及道路號誌、號誌及標線的使用者介面。

運輸工程是一個讓人激勵及快速發展的領域，永續及有效的都市區域發展需要新的智慧型運輸技術研發、長短期基礎建設及都市規劃的已改良方法、與有效公共運輸及商業車輛營運的設計。運輸工程包括許多運輸模式，機場、港口、運河、船運路線及道路等選線及設計，大眾運輸的規劃及設計(公車、地鐵及通勤鐵路)與自行車設施等皆是運輸工程師的責任。

運輸系統

運輸系統有數種分類方法，其分類基準有：藉用的技術型式、功能或所提供的服務、建置及營運的責任或擁有等等。依據種種的類型學審閱運輸系統由不同觀點到可作區分的應用，係依據不同型式的運輸及相關的決策。已知的運輸系統定義係最早可明確地區分乘客及貨物運輸，人員及貨物運輸的需求皆是滿足人類生活需要，且人員及貨物運輸組成與該國的國民生產毛額(GNP)有明顯相關。

運輸系統可被定義爲固定設施、流動的實體及控制系統等組成，人且允許員及貨物克服地理阻隔及即時符合被要求的活動，前述定義可協助您認識運輸工程的範圍，及區分描述簡介章節的目的及範圍的。運輸系統的功能構成（固定設施、流動的實體及控制系統）及簡化運輸爲提供其他社會間容易相互影響連結的事實。

固定設施

固定設施是運輸系統實體在空間的構成要素，組成運輸系統網路的路段（道路路段、鐵路軌道及管線）及結點（交叉口、交流道、捷運站、海港及航空站）。他們設計係傳統地土木工程的專業範圍，包括土壤及基礎工程、結構設計、排水系統設計及幾何設計等，皆與固定設施單元實體相稱。雖然幾何設計與其他設計觀念不同（結構設計係與結構強度相關，且足夠抵抗預期的力及載重），但在別處則涵蓋標準的土木工程課程。

流動的實體及技術

流動的實體係穿越固定設施的單位，包括車輛、聯結車、鐵路車輛等等。在公路系統情況，固定設施係容納預期的各式車輛，由自行車到全聯結車等組成。爲幾何設計的目的，美國洲公路運輸官員協會已經制訂設計車輛組，描述公路車輛的標準分類。

流動的實體僅針對車輛總特性討論（如尺寸、重量及加減速能力）多於車輛設計的特定技術（正常即所謂的車輛機械及電器工程師），車輛運轉及車流公式的決定係由車輛總變數及應用數車輛技術間得到總關係。

控制系統

控制系統包含車輛控制及車流控制，車輛控制係依據個別車輛在固定設施指引的技術方法，車輛控制分爲手動及自動。在公路系統情況，固定設施的正確幾何設計必須結合車輛外觀、運轉及控制等特徵，車輛運轉皆以手動控制，包括駕駛者特徵爲駕駛者對不同刺激的認知及反應時間及人類因素；在自動控制系統情況，同樣需對駕駛者對不同刺激的認知及反應時間作更精確的定義。

車流控制系統的組成方式爲車流運轉流暢及有效與降低車輛間的衝突，此系統包括不同標誌標線及號誌系統與運轉規則的認知。

運輸需求

依據運輸專家對運輸系統最早的討論，運輸系統的組成既不是純工程創造的表現，亦不是純藝術品質的表現，係依據人類的經濟、社會及人文活動提供服務。根據經濟家的專業用語，運輸需求的起源爲人員的旅行及貨物運送，在於滿足人類日常生活的需要，例如上學、工作、購物及訪友等。相同理由，工人在早上及下午尖峰時間置身於擁擠交通，不是工人自身願意的係因上班需求。運輸工程師依據專業考量分配社經活動，採有效的

方式及滿足居民方便移動的需要。依據前述對運輸系統的定義，社會認爲重要的就是在不同衝突的運輸需求能保持平衡，運輸需求包括及不限：成本考量、方便、環境品質保護及個人權力保護等，依據不同課題其優先順序有所不同，運輸工程師通常結合經濟專家、規劃者及社會專家等回應居民地日常的運輸需求。

高度發展及工業化國家的運輸系統是一個複雜及寬廣的固有需求，發展中國家需要人員及貨物的快速移動性，一個經濟增加所導致的工業化程度，其在基本產品工業有明確的變更，有時稱爲主要工業，並可擴大服務到第二、第三及第四等工業的特徵。主要工業對貨物運輸有很大需求，在服務範圍內的工業顯示貨物及廣泛人員的移動性皆是需要的，每一個國家的經濟大多靠非主要工業，已發現需提供世界級的運輸系統很複雜及寬廣，增加需求的固定壓力在擴大，國家性的移動性是空前的需求，甚至先前國家的遙遠範圍，此種需求不僅是不同運具的運輸，亦包含次系統運具間的複雜介面。

關於客運與貨運的運具與通路之最佳配置和營運管理原理與方法的一門學科，主要包括道路運輸、鐵路運輸、水路運輸、航空運輸、管道運輸和綜合運輸等，研究對象是各類運輸系統的功能、運具與通路之最佳配置和營運管理，以及多種運輸綜合運輸系統互相間的協調配合，探求隨地區條件發揮各類運輸自身的以及互相協調的優勢和最佳運輸效率的科學技術措施。

Transportation engineering

What is transportation engineering? The dictionary defines transportation as “an act, process, or instance transporting or being transported,” and the verb to transport means “to transfer or convey from one place to another”. Engineering is defined as “the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to man in structures, machines, products, systems, and processes”. Thus transportation engineering is presumably the application of science and mathematics by which the properties of matter and the sources of energy in nature are utilized to convey passengers and goods in a manner which is useful to mankind. While such a definition may have appeal in its apparent simplicity and conciseness, it really says very little about the profession of transportation engineering or the work which transportation engineers are engaged in.

The transportation engineering is one of the newest branches of engineering-one, to convey the richness and diversity of the subject, which lies at the interface of civil engineering, regional planning, and economics. Transportation Engineering drives the economy through provision of safe, economic, efficient and environmentally sustainable ways to get around. The content of transportation engineering is concerned with vehicles, driver/passengers and rights of way. The phase of transportation engineering is associated with the planning, design, construction, operation and maintenance of the infrastructure. The transportation engineering is a sub-discipline of civil engineering which aims to ensure the safe and efficient movement of people and goods (transport).

The planning aspects of transportation engineering relate to urban planning, and involve technical forecasting decisions and more difficult political factors. Technical forecasting of passenger travel usually involves what is called a four-step urban transportation planning model, requiring the estimation of trip generation (how many trips for what purpose), trip distribution (destination choice, where are you going), mode choice (what mode is being taken), and route assignment (which streets or routes are being used). More sophisticated forecasting can include other aspects of traveller decisions, including auto ownership, trip chaining (the decision to link individual trips together in a tour) and the choice of residential or business location (known as land use forecasting).

The design aspects of transportation engineering include the sizing of transportation facilities (how many lanes or how much capacity the facility has) , designing the geometry (vertical and horizontal alignment) of the roadway (or track), determining the materials and thickness used in pavement.Operations and management involve traffic engineering, so that vehicles move smoothly on the road or track. Older techniques include signs, signals, and markings. Newer technologies involve Intelligent Transportation Systems, including Advanced Traveler Information Systems, such as variable message signs, and Advanced Traffic Control Systems, such as ramp meters. Human factors are an important aspect of transport engineering,

particularly concerning driver-vehicle interface and user interface of road signs, signals, and markings.

Transportation engineering is an exciting and rapidly developing field. The development of sustainable and efficient urban areas requires research into new intelligent transportation technologies, improved methods for long-range and short range infrastructure and urban planning, and the design of effective public transit and commercial vehicle operations. Transportation engineering concerns many modes of transportation. Locating and designing airports, seaports, canals, shipping ways, roadways, as well as all planning and design for mass transit (bus, subway, and commuter rail) and bicycle facilities are the responsibilities of transportation engineers.

The Transportation System

Transportation systems can be categorized in several ways. For example, they may be classified according to the types of technology they employ, according to the function or type of service they provide, according to who owns or is responsible for their implementation and operation, and so forth. Each of these diverse typologies views transportation systems from a different perspective and is useful in making distinctions that are relevant to different types of transportation related decisions. The definition of the transportation system given earlier makes a distinction between passenger and freight transportation. Both are needed to satisfy human needs and both constitute a significant portion of the gross national product (GNP).

The transportation system may be defined as consisting of the fixed facilities, the flow entities, and control system that permit people and goods to overcome the friction of geographical efficiently in order to participate in a timely manner in some desired activity. However, this definition helps you to appreciate the breadth of transportation engineering and to delineate the purpose and scope of the introductory text. It identifies the functional components of a transportation system (the fixed facilities, the flow entities, and control system) and encapsulates the fact that transportation provides the connectivity that facilitates other societal interaction.

Fixed Facilities

Fixed facilities are the physical components of the system that are fixed in space and constitute the network of links (e.g. roadway segment, railway track, pipes) and nodes (e.g. intersection, interchange, transit terminals, harbors, and airports) of the transportation system. Their design, which has traditionally been within the realm of civil engineering, includes soil and foundation engineering, structural design, the design of drainage systems, and geometric design, which is concerned with the physical proportioning of the elements of fixed facilities. Although related, geometric design is different from other aspects of design (e.g. structural design, which is concerned with the strength of structures to withstand efficiently the

expected forces or loads), which are covered elsewhere in the typical civil engineering curriculum.

Flow Entities and Technology

Flow entities are the units that traverse the fixed facilities. They include vehicles, container units, railroad cars, and so on. In the case of the highway system, the fixed facilities are expected to accommodate a wide variety of vehicle types, ranging from bicycles to large tractor-trailer combinations. For the purposes of geometric design, the American Association of State Highway and Transportation Officials (AASHTO) has specified a set of design vehicles, each describing a typical class of highway vehicles.

In this book, flow entities are considered only in terms of their generic characteristics (such as size, weight, and acceleration and deceleration capabilities) rather than in term of their specific technological design, which is normally undertaken by mechanical and electrical engineers, thus vehicular motion and vehicle flow equations are expressed as general relationships between the generic variables and can be applied to many vehicle technologies once their specific attributes and determined.

Control System

Control system consists of vehicular control and flow control. Vehicular control refers to the technological way in which individual vehicles are guided on the fixed facilities. Such control can be manual or automated. The proper geometric design of the fixed facilities must incorporate, in addition to the characteristics of the vehicle, the characteristics of the vehicular control system. In the case of highway facilities, where the vehicles are manually controlled, these include driver characteristics, such as the time a driver takes to perceive and react to various stimuli; examples of such human factors are included in this book. In the case of automated systems, similar but more precisely definable response times exist as well.

The flow control system consists of the means that permit the efficient and smooth operation of streams of vehicles and reduction of conflicts between vehicles. This system includes various types of signs, marking, and signal systems and the underlying rules of operation.

Transportation Demand

The definition of a transportation system given earlier addresses another consideration that is of concern to transportation specialists: transportation systems are constructed neither as pure expression of engineering ingenuity nor as monuments of purely aesthetic quality. They are built to serve people in undertaking their economic, social, and cultural activities. In the jargon of the economist, the demand for transportation is derived, or indirect, meaning that people do not normally travel or move their possession for the sake of movement but to fulfill certain needs, for example, to go to school, to work, to shop, or to visit with friends, by the

same token, workers do not place themselves in the middle of the morning and evening rush hours because the enjoy traffic congestion but because their work schedules require it. Transportation engineers are among the professional concerned with accommodating these social activities by providing efficient ways to satisfy the population's needs for mobility, as used in the foregoing definition of transportation system, the word efficient stands for the balancing of the a variety of often conflicting requirements that society in general considers to be important. These requirements include, but are not limited to, cost considerations, convenience, protection of environmental quality, and protection of individual rights, which may have a variable priority, depending on the issue. To be responsive to these needs, transportation engineers often cooperate with other professionals, including economists, planners, and social scientists.

An inherent need of highly developed and industrialized nations is a sophisticated and widespread transportation system. In developed nations there must be an easy mobility of persons and goods. As the degree of industrialization of an economy increases, there is a change in preponderance from basic production industries, sometimes called primary industries, to service industries of a secondary, tertiary, and quaternary character. Primary industries have a great need for freight transportation. Industries in the service area display a need for both freight and extensive personal mobility. The each nation, whose economy depends greatly on non-primary industries, has found a need to provide the world's most sophisticated and widespread transportation system, which is expanding under the constant pressure of increasing demand. Because of the unprecedented need for nationwide mobility, even in the previously remote areas of the country, there is a requirement not only for various modes of transport but also for increasingly sophisticated interfaces between the modes of subsystems.