TRL2603 – Exam Prep (S2-2015)

Extracts from Tutorial Letters

"Due to the various ways in which questions can be set, the whole of the study guide is covered and no part of the study guide can therefore be omitted from your exam preparations. The **types of questions asked are similar to those at the end of each study unit and it will be to your benefit to use these questions in your exam preparation.** It will also be to your benefit to work through the specimen examination paper as well as the self-evaluation questions that were posed. "

Format of the Oct/Nov 2015 Exam:

- Provisional Date: 20 October 2015 @ 11:30
- Duration: 2 Hours
- Marks: 70
- Type of Question: Compulsory Short Questions = 20 marks
  Long & Short Questions - to answer only any 2 of the 3 given = 25 marks each

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(**PE**^{x} = Number of times a question featured in the previous ten exams, excl. 2011's)
(LO = Learning Outcome)
(SEQ = Self-Evaluation Question)

Question Bank from Self-Evaluations, Exams & Outcomes

STUDY UNIT 1, PAGE 1

1) [LO] Differentiate between transport and logistics. [Ref. Par. 1.2 & 2.6]

Transport Movement & Economic Activities

- Helps us travel from one destination to another;
- Encourages economic progress by moving goods from one location to another;
- Essential to everyday life;
- Determines where economic activity takes place:
    - Industries need access to raw materials & the market place
    - People: access to work in cities → residential areas develop where transport can take them
    - Commercial areas: access to high volumes of people → high demand makes store worthwhile.

Logistics integrated systems & control of flow

- Role in providing customer services → adds value to a product/service.
- Systems approach wherein transport & production systems are closely intertwined.
- Integrated control of flow of goods & info from original producer to final consumer
- Defined as the design & operation of the physical, management and information systems necessary to ensure that goods are delivered at the right place at the right time.

2) [PE^{x3}] Discuss various economic benefits/functions of transport found in transport theory. **(14)** [Ref. Par. 1.3]

Memory Rhyme: An Economic Wish Is that: Many Men Daily Envision New Price Cuts

Extensive Market
- Raw Materials → Transport → Processed into Finished Goods → Transport → To where finished goods are to be consumed.
- One big world market (even perishables)

Mobility of Labour & Capital
- ↓ Immobility of factors of production.
- labour migration to places with better job opportunities.
- Developing transport, ↑ capital invested in foreign countries

Specialisation & Division of Labour
- Enables regions to make optimum use of national resources by concentrating on producing goods for which its resources are best suited.
- ↓ resource wastage & production costs. [comparative advantage]

Economies of Scale Production
- Procurement of raw materials, large number of workers & sale of finished goods.
- Facilitates large-scale production = ↓unit cost of production

Stability of Prices
- Transport from surplus & low prices to scarce places with high prices.
- Keep county's prices level & equalise world prices

Benefits to Consumers
- Access to goods produced in other parts of country/far away.
- Helps ↓ cost of goods to consumers, ↑ their purchasing power

Employment Opportunities & Increased National Income
- Various means of transport provide employment.
- Economic development depends on improved means of transport; contributes substantially to national income

3) [SEQ] What is the difference between the functional and economic nature of transport? **(5)** [Ref. Par. 1.4; 2013-S2-Assign.01]

Society has basic need for translocation of people/goods to be at certain places at certain times.
Transfer of people & goods satisfies society's need for place utility and time utility = derived need of transport

Broad **functional context**: transport involves all activities necessary to transfer people & goods between point of departure (origin) & point of arrival (destination).

Economic sense: but transport also comprises all support activities, with the same translocation goal, for which users must pay as activities use scarce economic resources [E.g. processing passengers at airports]
Place Utility [value added/allows consumption]; Time Utility [product provided when needed] and Quality Utility [product arrives undamaged & usable]

4) [PE[x4]] [SEQ] Define / Discuss how the concepts of movement, traffic and transport differ from each other? Use practical examples. (6) [Ref. Par. 1.4]

Movement: transfer of an object/person from one geographic point to another.

Traffic: total *guided movements* of people/goods along infrastructure in a *given period* in a geometrically or geographically *demarcated area*. [E.g. total transfer of passengers/freight in a year from Johannesburg to Durban.]

Transport: satisfaction of the need for spatial transfer of people/goods by technical means, comprising the means of transfer & infrastructure.
Primary concern is not physical movement as such, but the transfer of people/goods in order to satisfy a variety of human needs whilst using large number of scarce resources → economically oriented system.

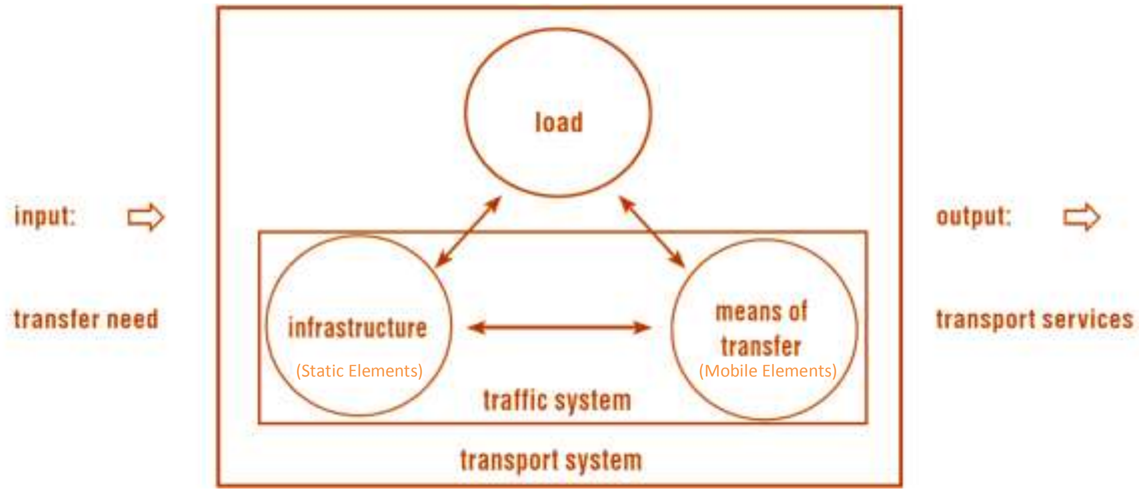
5) [SEQ] Do you think it makes sense to speak of a transport system? Give reasons for your answer. [Unsure]

Transport system, unlike the physically oriented traffic system, can be regarded as an economically oriented system comprising three basic elements, namely

- the ever-present traffic infrastructure,
- the durable transfer means and
- the load/object of transfer as the temporary element

6) [SEQ] Describe the transport system and its operation by using a schematic representation of the system. [Ref. Par. 1.5.1]

- Basic system input = community's widely divergent transfer needs, served by the system.
- *Support inputs* i.e. energy, auxiliary equipment & materials, labour, and info.
- Output = transport services: meaning translocation of people/goods from one place to another.
- There are certain demands according to the particular transfer need the system has to satisfy. From:
  - Transport user's perspective referred to as *user requirements*
  - Operator's perspective: demand is *quality requirements* that service has to meet e.g.: frequency, speed, regularity, reliability, suitability, safety and convenience.
- To ensure continued & efficient operation system output should agree closely as possible to system input.
- Great variety of transfer needs should be reflected in a variety of services of different quality and prices.



7) [SEQ] Distinguish between part-systems & subsystems of the transport system. Illustrate using examples. [Ref. Par. 1.5.2]

[As from fig. 1.1] Traffic = **part-system**: involves limited number of *elements & interactions* from transport system
Difficult to distinguish E.g. transport object & means of transfer one & the same: pedestrians / fluid in pipelines.

In contrast **subsystems** have same system elements as the total system, but the *variety* of system inputs and outputs are more limited.

8) [PE x2] Name & discuss 3 approaches to adopt in identifying subsystems of transport system. **(6)** Ref. Par. 1.5.2

Type of Load [passenger / goods]

- Different kinds/categories of loads reflect different kinds of *transfer needs*, each represented by a separate subsystem e.g. different subsystems for goods & passenger transport. Except air transport where both are combined.
- Goods transportation: type of load determines further subdivision into lower-order subsystems, namely:
  - bulk transportation of goods
  - transportation of general freight

Also refrigeration transportation & abnormally heavy cargo

- Continuous changes in system in-&outputs → continuous changes in & improvements to handling of goods.
  - Freight-unit packaging: involves consolidation of a number of individual items (goods) to form one large consignment unit. Containerisation and palletisation are examples of freight-unit packaging.

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Infrastructure

- Facilities used for the operation of transport. Significant financial investment in fixed assets.
- E.g. roads, railway, harbours, interchange facilities, associated dedicated power & communication systems.

Type of Technology [methods, procedures, use of computers]

- "Technology:" way resources are combined to provide products/services.
- All technical means & transport process activities are aimed at spatial translocation of people and goods
- However technology of different transport processes differs greatly from one instance to the next.
- Obvious difference between various forms of transport i.e. land, air and sea transport where tech. is adapted to the medium in/on which transportation takes place.
- Forms of transport are subdivided into diff. transport modes: road, rail & pipeline modes for land transpo.
- Particular technology used & operating circumstances determines economic & operating characteristics.

Operating process or Strategy used to satisfy transfer needs [route & scheduling]

- E.g. *regular* service system: transport services on fixed routes with fixed operating points at fixed times.
- Vs. *Irregular* services do not comply with above requirements.

9) SEQ Indicate the interaction of transport and logistics by means of practical examples. [Unsure]

STUDY UNIT 2, PAGE 7

10) [SEQ] Explain briefly, through practical examples, what the transport process entails. [Ref. Par. 2.1.1]

Transport process: a closed series of activities which forms a whole with the purpose to transfer people/goods. These activities can be

- Spatial [/related to transfer of the object.] E.g. Loading & offloading freight, transporting cargo, operating the vehicle
- Static E.g. drawing up freight documents & vehicle clearance
- Varying in Duration E.g. time to transport freight by road depends on travelling distance & traffic conditions
- Consecutive, normally as a rule.
- Simultaneous E.g. small repairs taking place on a ship while at the same time it is being loaded.

11) [SEQ] What is meant by "the cyclic nature" of the transport process? Does the nature of the need for transport in any way influence the cyclic nature of the transport process? Substantiate your answer **(10)** [Ref. Par. 2.1.1 & Par. 2.3; 2013-S1-Assign.1]

A **cycle** involves a number of *related activities* or procedures which form an *entity*, occur within a given period of *time* and occur *periodically*. Four elements stand out in this definition, that a cycle:

- Is multifunctional meaning a variety of functions are performed within a cycle.
- Is complex: it is an entity comprised of a number of activities and procedures.
- Has a clear relationship between activities & procedures that make up a cycle.
- Lasts for a certain period of time & is repeated periodically.

Each transport cycle comprises several separate interrelated activities, each aimed at transferring people/goods Series of activities that makes up the transport cycle is referred to as the transport process.

Need for transport manifests cyclic characteristics. Repetitive, cyclic nature of human needs gives rise to a repetitive, cyclic need for transport. The cyclic nature of transport needs relates to natural cycles and the provision of transport largely has to adjust to this

12) [SEQ] Name the factors influencing the transport process & explain how each influences the process. [Ref. Par. 2.1.2]

Space: Transport systems cover large geographic areas. [Where: Place Utility] & **Time**: [When / How Long: Time Utility]
Technical Factor: Technical means is a prerequisite for transport production. [Technology / How]
Economic Factor

- Activities in transport process require use of scarce/expensive means of production e.g. labour and energy.
- Transport enterprise must recover production costs of its services through prices it asks for these services.

Others: Environmental demands. Coordination: Either by Government or Market Mechanism

13) [SEQ] Give a practical explanation of a transport chain. [Ref. Par. 2.2, Act 2.2]

Sea & air transport serve sparse networks. Their smooth functioning depends on good connections with denser networks such as road & rail transport. Pursuit of smooth connections gave rise to so-called "transport chains". Transport nodes are an indispensable part of these transport chains.

Transport process consists of a closed series of nonhomogeneous activities also referred to as *transport chain*. Defined as a technical & organisational linking together of coordinated transport, loading & storage facilities and processes, extending from the origin to the destination.

14) **[PE[x2]]** [SEQ] Fully discuss the duality of the transport process. Distinguish clearly between supply & usage cycles. Use appropriate diagrams to explain your answer **(25)** [Ref. Par. 2.3]

A cycle of transport means - **Supply cycle**

- Analyse transport process from operators / transport enterprise's point of view
- Emphasis on technical & technological elements (i.e. rotation of transport means).
- Responsible for supplying transport services → transport production.

- Transport production: creation of *carrying capacity* - has to do with various operations & economic variables such as economic growth, inflation, interest rates and economic cycles.

A cycle of freight and passenger transport - **Usage cycle** (a.k.a. cycle of transport object)
- Analysis made from user's perspective
- Technical processes are also essential for transfer of people/goods but
- Commercial, economic & legal matters more N.B than mere spatial transfer (transport production).
- Represents the satisfaction of the demand for transport services.

Duality of transport process requires different interpretations with regard to **time**
- Duration of supply & usage cycles (i.e. goods' delivery time & passengers' travelling time), should be analysed separately.

Despite their differences, these two cycles are not separate; they **overlap** in certain stages & activities.
Fig. 2.2 takes into account stages & activities in the transport process that can be subdivided as follows:

- Activities falling exclusively within the supply cycle, not occurring in the usage cycle (e.g. placing a railway truck at specific place / cleaning it). *a* indicates activities before loading & carriage and *d* activities after carriage & offloading.

- Activities occurring exclusively in usage cycle (consignment), not in supply cycle (e.g. dispatch activities and storage) b indicates activities before loading and carriage, *e* indicates activities after carriage and offloading.

- Activities occur during both the supply & usage cycle (e.g. carriage, loading, offloading & handling loaded vehicles) *c* and c_1 indicates activities that occur simultaneously in both cycles

- Activities in *a* & *b* are known as the <u>initial activities</u>.
  Those in *d* & *e* as the <u>final activities</u>.
  c and *c*1 always correspond, while *a, b, d* & *e* contain differences.

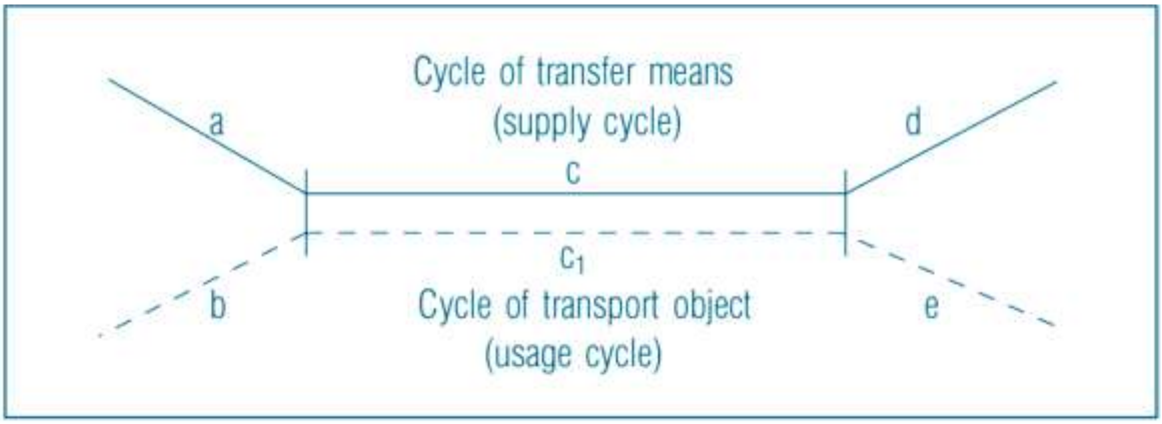


FIGURE 2.2: The transport cycle

[I don't think question intends for a discussion of combined process / multimodal transport & figure 2.4]
[Or even fig 2.3 for that matter, however I have included it & its concepts briefly]

Don't equate the carrying stage with the supply cycle. "Transport" and "carriage" are not synonyms:
- *Transport*: wider meaning. Includes carrying activities as a basic stage & also several other stages & activities.
- *Carriage*: a partial process in relation to the transport process in its wider sense. Occurs in both cycles. Only forms part of the transport process. Loading & unloading activities are excluded.

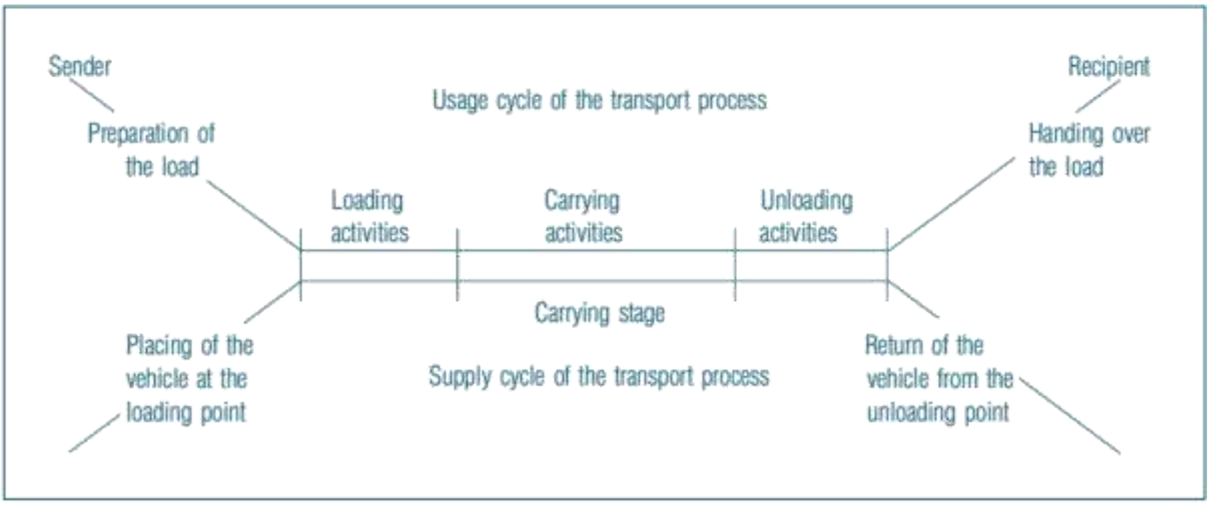


FIGURE 2.3: Distinction between the transport process and carrying stage

15) **[PE[x2]]** Discuss the reasons for the existence of multi-modal transport chains **(5)** Ref. Par. 2.4.2

- **Divergent penetrative abilities** of different transport subsystems, through which a door-to-door transport service cannot be provided by a single transport subsystem.
- **Consolidation** & **deconsolidation** of transport streams where the transfer of freight between different transport means occurs because of
  - vehicle size and density savings;
  - logistically desirable interruption of flow of goods as a result of globalisation of production, the regionalisation of sales and the shifting of decoupling points.
- **User requirements** may require the combination of one or two modes, to create a transport service with other characteristics with regard to transport time, price, reliability, etc.
  Can link up with a specific transport need meaning a new segment can be served in the transport market.

16) **[PE[x3]]** Discuss the advantages of multi-modal transport chains **(5)** Ref. Par. 2.4.2.1

Advantages of multimodal transport
- Provides door to door services
- Allows for combining different cargoes into one cargo
- It is flexible and can use different modes of transport
- Larger capacities can be transported by rail and water, at a lower cost
- Offers the shipper the possibility to rely on a single transport service provider

Disadvantages of multimodal transport Added as a precaution / additional info
- Variety of documents & information needs to be exchanged between shippers
- Safety and security
- Facilitation
- Legal aspects and market access

17) **[PE[x4]]** Discuss the 4 major functions of intermodal transport chain & illustrate with a graph **(14)** Ref. Par. 2.5; 2015-S2-A.01

Involves transportation of freight in an intermodal container/vehicle, using multiple modes of transportation (rail, ship, truck), without handling the freight itself when changing modes. 4 Major functions are:

Composition also referred to as the "first mile" [Process of Assembling load]
- Process of assembling & consolidating freight at a terminal offering an intermodal interface between a local/regional distribution system and a national/international distribution system.

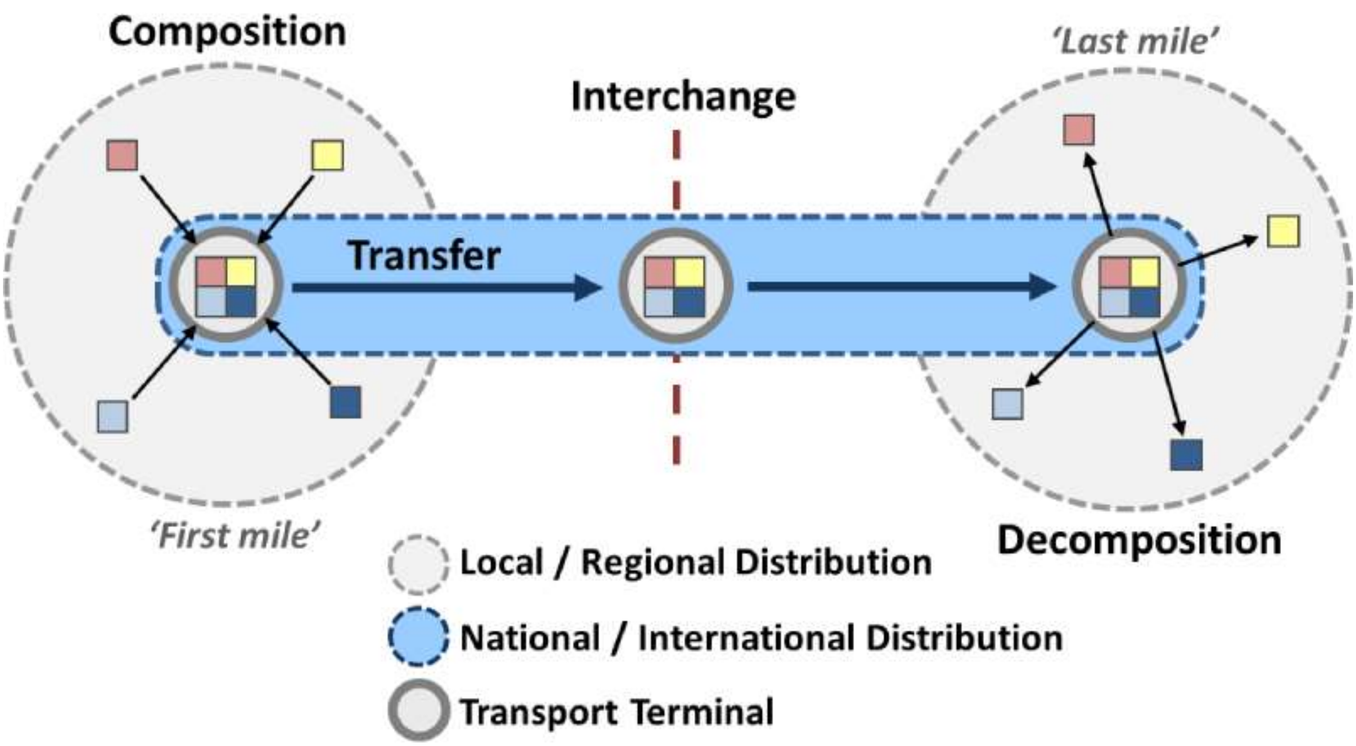
- Loads of freight from different suppliers assembled at distribution centres to be forwarded to high-capacity modes of transport e.g. freight trains &and ships.
- Dominant mode for this process tends to be trucking as it offers flexibility and door-to-door services.
- Includes activities closely linked with the function of production e.g. packaging & warehousing.

Connection / Transfer [goods in transit / movement]
- Involves consolidated modal flow e.g. freight train, container ship, fleets of trucks, between at least two terminals
- Takes place within national/international freight distribution systems.
- Efficiency of connection is derived from economies of scale e.g. double-stacking, post-panamax container ships coupled with adequate frequency of service.

Interchange [between the modes]
- Major intermodal function takes place at terminals where purpose is to *provide efficient continuity* within a transport chain.
- Terminals are dominantly within national/international freight distribution systems, e.g. ports (transshipment hubs).

Decomposition also referred to as the "last mile" [final destination / offloading]
- Upon reaching terminal close to destination, load of freight has to be fragmented & transferred to local / regional freight distribution system.
- Often represents most difficult segment of distribution.
- Linked with the function of consumption, dominantly occurs within metropolitan areas & involves unique distribution problems, also known as urban logistics.

Figure 2.5: Intermodal Transport Chain



18) **[PE[x1]]** SEQ Use e.g. to indicate the difference between multimodal & intermodal transport chains. **(4)** Ref. Par. 2.5.1

Use of two or more modes in one door-to-door transfer is unavoidable in many instances.
However, doesn't mean homogeneous transport service (as regarded by user) is being provided.

Transport user regards either (a) a sequence of isolated transport services or (b) a single transport service.
More it's regarded as a single, integrated service, the more multimodal chain assumes intermodal character
Concerning unit loads, intermodal is a component of multimodal.

Extent determined by effort "chain manager" takes to make links link up seamlessly with each other, in order to come as close as possible to a homogeneous door-to-door transport service.

Multimodal	Possible Example?	Intermodal
- Use own car to drive from house to park at Gautrain station - Take Train to Airport - Airplane to Cape Town - Rent car to get to hotel	Vs. See activity 2.3	With one ticket: - Use bus/minibus service - All driven to airport - Airplane to Cape Town - Bus/Taxi to hotel arranged

19) [PE^{x2}] SEQ What do you understand under the concept "transport integration"? **(2)** Ref. Par. 2.5.1

Transport integration = the pursuit of homogeneity.
Sometimes transport operators take over this job from freight forwarders, thereby brining different transport modes together in one enterprise
Offers users a *single transport product*, for one transport price, all included in one transport document.
Transport integration has organisational & technical function as it involves mutual adjustment of transfer means, infrastructure & the type of freight to be transported.

20) SEQ Name the elements of the transport process & explain how each influences the transport process. Ref. Par. 2.7

Elements are factors that are essential to the process. Absence of any of these factors prevents the transport process from taking place. They can be interpreted in a narrow or broad context.

Narrow context: limited to objective component (the labour & transport object):

Typical of Transport Process	*Some Other Authors*	*USA / West-European Authors*
Routing	Transport Network	The Route
Carriage	Transport means & human resources	Stations
Clearance	Transport Object	The Vehicle
Auxiliary Functions		Traction

Broad context considers sources of the transport process (demand for transport) & organisational, human, time factors.

- Transport needs: determine what is to be transported (object), the points of departure and destination, and the requirements that have to be satisfied in the process of translocation.
- Transport means: includes roads, vehicles, loading & unloading equipment, technical infrastructure, etc.
- The forces that propel and break the vehicles and other equipment
- Transport and communication points
- The time necessary to effect translocation
- The organisation of translocation
- The human factor

STUDY UNIT 3, PAGE 20

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21) **[PE^{x1}]** SEQ Define Transport technology **(5)** Ref. Par. 3.1

- "Technology" refers to the way in which resources are combined to provide products/services.
- Transpo.Tech. not only comprises techniques/technical means used, but also methods & procedures of the production/operations process.
- All technical means & transport process activities are aimed at spatial translocation of people and goods
- However technology of different transport processes differs greatly from one instance to the next.
- Transport forms i.e. land, air, sea transport where tech. is adapted to the medium in/on which transport takes place.
- Forms of transport are subdivided into diff. transport modes: road, rail & pipeline modes for land transpo.
- Different transport forms have different technological, economic and operating characteristics and render services with different quality characteristics.

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22) **[PE^{x5}]** SEQ What are the functions of technical means of transport? Discuss each in detail **(6)** Ref. Par. 3.2

Functions primarily concerned with movement of objects by means of vehicles, vessels, or aircraft are:

- Give **mobility** to object to be transported without damaging it i.e. being carried. [Create Mobility]
- To **control direction** & **speed** of objects being moved by applying forces necessary to accelerate & decelerate, overcome normal resistance to motion & to guide the object without damaging it. [Control Movement]
- P**revent** object from **deteriorating** / being **damaged** as a side-effect of its being moved. Especially N.B in case of living things/perishables that require the maintenance of suitable environmental temperature, pressure, humidity etc. [Prevent spoilage or damages]

Remaining functions relate to the **handling** of objects being transported (e.g. un-/loading cargo or processing passengers), and the **organising** of the movement of vehicles, vessels or aircraft, that is, organising and regulating traffic.

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23) **[PE^{x1}]** LO SEQ Name & discuss the elements of the technical functions, especially the application thereof to the different modes of transport **(12)** Ref. Par. 3.3

Support: Vertical contact between vehicle & surface/medium on/in which it moves.
- *Land* transport: rubber wheels on concrete/asphalt surfaces, steel wheels on steel rails
- *Water* transport: hull (usually steel) of the vessel on the water surface
- *Air* transport: aircraft's interaction between the air and its hull and wings.

Guidance: Steering vehicles through the application of counterforces.
- Driver steers road vehicle using frictional forces between vehicle's wheels & relevant supporting surface. Steer trains & similar transport units by the forces between flanges & conic surfaces of steel wheels & rails.
- *Water & air*: Vessels & aircraft are controlled by manipulating counterforces between the vehicle & the medium through which it moves.

Propulsion: Type of propulsive unit & the method of transferring accelerating & retarding forces.
- *Land & water*: Diesel engines in road vehicles, trains & ships. Also steam, gas / electrically propelled units
- *Air* transport makes use of a wide range of propulsive units, all of which consume petroleum fuels.
- Methods used to transfer tractive power: *Land* consists mainly of the application of friction/adhesive forces In w*ater & air* = counterforces. Best-known method of relaying power: applying torque to wheels, with wheel/pathway friction providing the necessary counterforces.
- Deceleration/braking action: internally by propulsive unit itself (less wear) or by an external braking system.

Control: Methods of directing the movement of one or more vehicles/vessels in the traffic system.
- *Land*: N.B is control of longitudinal spacing of transport units in traffic lanes & at crossings e.g. railway signal systems & traffic light systems in urban areas.

- *Water & Air*: Navigation & traffic control systems
- All forms of transport require a right of way [RoW] along which vehicles, vessels, aircraft can be operated with the aid of the applicable control technology. *Road & Rail* transport right of way is subdivided into 3 categories, on basis of the degree of separation between types of traffic:
    - Grade separation / Exclusive right of way: Fully controlled right of way without a level intersection or any other legal entrance for other vehicles/people. Exceptional cases → widely spaced level intersections with preferential signals or gates which protect the way
    - Right of way physically separated longitudinally from other traffic (using kerbing, permanent barriers, grade separations etc.), but with level intersections for vehicles and pedestrians, including ordinary street intersections.
    - Surface streets with mixed traffic. Preference can be given to transit (buses, taxis, etc.) through lanes reserved by means of painted stripes/special signs or all the traffic may be mixed.
- *Air*: runways & air space used as the way. Tech. used for intensive control (flight plans, schedules, radar monitoring) is N.B.
- *Water*: water = the way. Risk of accident not as great as in air transport as ships travel fairly slowly Radar makes it possible to follow the movement of other ships in the vicinity, and to act accordingly.

Body & coachwork of transport units: Performs a function as containers.
- Corrosion-resistant new metals & anticorrosive agents, making them relatively maintenance free
- Vehicles carrying refrigerated goods & chemicals make longer product life possible.
- New types of steel & improved welding techniques = construction of giant tankers
- Light & heavy composites = design of lighter and larger aircraft.

Freight handling: N.B to transport process as it directly aims to transfer the objects being transported.
- Equipment functions range from goods (un)loading & transhipment to movement of goods in a warehouse.
- Improved handling equipment ↓ turnaround time & help transport process run more smoothly.

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24) SEQ There are different types or groups of technical transport means. List them and discuss how they are involved in the transport process Ref. Par. 3.4

Technical means together constitute the physical transport system/traffic system which supports the transport process, and which can generally be subdivided into the following four groups:

Infrastructure: Fixed part of the transport system. Comprises:
- The way (road, rail),
- Terminals (harbours, airports, stations, other traffic terminal points) &
- Control systems (traffic lights, signal systems, air traffic controls, etc.).
- Fixed facilities providing access to such terminals also form part of the infrastructure.

Vehicles: The moving elements of the transport system. Consist mainly of motorcars, trucks, aircraft and ships.

Control systems: Used to ensure safe & orderly movement of vehicles on/through traffic infrastructure. Include:
- Road traffic control, signalling, air traffic control & navigational systems.

Handling equipment: Equipment used
- to load & unload the objects that are being transported at the terminals,
- to transfer them from one vehicle to another & to move objects inside terminal facilities, warehouses, etc.
- Handling equipment includes cranes, forklifts, trolleys and chutes.
- Permanent packaging equipment such as containers and pallets can also be included in this group.

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25) SEQ What do you consider to be the differences between terminal technology and handling technology? Ref. Par. 3.5.1

Terminal technology defined in terms of the fixed facility at which freight/passenger & vehicle are united.
- Distinction made between terminal facilities for passenger transport & freight transport.

- Passenger terminals: e.g. reservation & waiting facilities (incl. eating and toilet facilities)
- Freight transport terminals provide the necessary facilities for loading and unloading goods.

- Terminals can be used for both, though terminal should be divided according to the section's purpose

Handling technology defined in terms of the equipment required for loading activities. E.g. cranes

- Directly aimed at the transfer of the objects (freightage) being transported.
- Improved handling equip. can ↓ turnaround time & help transport process run more smoothly.
- Packaging of goods directly influences way they are handled, and hence the equipment required.

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26) [Act. 3.2] Do you think freight-handling technology provides some solutions to the manufacturers of goods, transporters and customers? Give reasons for your answer. [Ref. Par. 3.5.3.2.a-c] [d addressed in questions that follow]

Freight-Handling technology defined in terms of the equipment required for loading activities. E.g. cranes

- Directly aimed at the transfer of the objects (freightage) being transported.
- Improved handling equip. can ↓ turnaround time & help transport process run more smoothly.
- Packaging of goods directly influences way they are handled, and hence the equipment required.

Freight-unit packaging [a. Intro]

- Goal = rationalisation of movement of goods; sending large consignments door-to-door with min. bother.
- Entire process is mechanised = advantage throughout transport process (door to door)
- Motivation: to reduce transport costs / curb cost increases.

Unit packaging

- Defined: consolidation of a number of individual items (goods) to form a single big consignment unit.
- Goods handling may be in- / external. Applies to various commodities ranging from bulk products such as coal, ore and grain, to small individual consignments of consumer products.
- Goal = rationalise movement of goods. Only achieved with improved organisation, planning & integration of all transport, and use of mechanisation.
- Specialised vehicles and handling equipment are used in this process.
- Repetitive handling is eliminated.

Development of unit packaging

Packaging performs 3 functions: inclusion, protection & identification. In transport (dispatch), pay attention to:

- protecting goods against breakages, distortion and contamination
- reducing freight tariffs by reducing volume (cubic content)
- facilitating handling
- reducing theft
- facilitating storage
- facilitating transport

- Attempt to eliminate each factor as a problem area by improving packaging methods & packing materials.
- Maintain balance between requirements laid down for packaging to eliminate problems & costs involved.
- Economic problem to which positive benefit-cost ratio should provide the answer. Factors to consider:
  - the duration and type of movement involved, as well as its influence on the consignment
  - the type of commodity to be transported (fragility, perishability, volume, mass, etc)
  - the handling and storage method used
  - the unit value of the goods and therefore the extent to which packaging can be afforded
  - the sensitivity of the goods to exposure
  - the need for identification
  - limitations in respect of doors, lifts, et cetera
  - legal requirements
  - insurance requirements

- Highly adaptable system necessary to handle the variety effectively and with ease.
- Problems arose that can only be solved by means of rationalisation and standardisation.
- Homogeneous mass products (ore, petroleum, etc.) easily handled & transported because of custom-made transport means (tankers)
- Unit packaging attempts the same by means of improved packaging methods, to also combine packets in manageable homogeneous units.

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27) SEQ Discuss the various methods of unit packaging and explain how they affect freight handling. **(10)** Ref. Par. 3.5.3.2

Palletisation

- Pallet: unit load platform with or without a superstructure, on which goods are loaded.
- Represents a method of homogenising freight. Using a flat loading platform on which a variety of articles can be placed and then handled as one article.
- Must be strong & solid: to carry freight loaded onto it & be suitable for mechanical handling.
- Two kinds of pallets: those with a superstructure/framework, and those without.
- Using pallets without superstructure: restrain loaded goods with belts if their shape & mass is unstable.
- Mechanised apparatus, commonly forklifts, is used to handle (load/unload) pallets.
- Sometimes need to secure pallets with freight inside the transport means by fastening it to the transport means itself.
- Pallets made mainly of wood. Sometimes cardboard, plastic / steel
- Manufactured for single/multiple trips, depending on durability & disposability of their construction.
- Pallet size varies since size depends on a variety of factors such as:
  - the transport mode: road, rail or air transport
  - the type and nature of the commodity
  - the intrinsic characteristics of the pallets
  - the handling facilities used

Variety of problems encourages use of specific sizes. International Standards Organisation (ISO) has made recommendations about the establishment of specific sizes.

Containerisation

- Sophisticated methods of unit packaging & not a new principle
- Logical consequence of palletisation as a method of unit packaging
- Characterised by *international development*; accepted by both the suppliers & users of transport services.
- Containers are boxes made of steel / combination steel, aluminium & fibre glass.
- (ISO) stipulations, a container can be defined as transport equipment with the following characteristics:
  - *Permanent* & therefore used for many different purposes.
  - Transports goods by means of *one or more forms* of transport, *without repackaging*.
  - Supplied with *necessary apparatus* to make it transferring between transport forms manageable.
  - Easily filled & emptied.
  - *Internal volume* of at least $1m^3$.

- Containers' size standardised but containers are not uniform. Different *kinds* e.g. general goods transport, specially designed for commodities requiring refrigeration / isolation.

- N.B to consider pros & cons of *lease-lending* containers and carefully choosing the type of container. The following factors should be taken into account:
  - Initial cost of containers; depreciation; maintenance costs & facilities; insurance; storage & handling; volume & stability of goods flow; cost of sending back empty containers, etc.
  - Type of construction, mass, handling features, cost-handling methods, security factors and ease of maintenance

28) [PE[x1]] [SEQ] Discuss the advantages & disadvantages of palletisation **(10)** [Ref. Par. 3.5.3.2.d.i]

Advantages of pallets

- Better vehicle & storage *space utilisation* = ↓ Loading & unloading times & cost savings. Also pallet loading activities aided by mechanised equipment has certain advantages [e.g. improved turnaround time, ↓ labour & damage].
- Individual packages can be collected by hand on a pallet and placed on manually operated *pallet trolleys*. Trolleys: inexpensive; operated by unskilled labourers, are taken to the storage place or the consignment vehicle where forklifts load or unload them quickly, efficiently and economically.
- Many goods loaded onto pallets as a unit & ensured as a *unit* = ↓ *risk of damage & theft*
- ↓ Transport costs: often discount on delivery because of *easier and quicker handling*.

Disadvantages of pallets

- *Not standardised*. Consigner picks size → large variety of pallets requiring highly adaptable transport system = unnecessary problems.
- *No sides* = loadability relies on form of packaging of the goods loaded on to them.
- Provides *no additional protection* except good's own packaging & belts used to fasten them. Plastic/canvas can be used to provide a certain amount of protection.
- Need certain amount of *labour* to get individual packages onto palletised unit
- Not always represent economically transportable unit → transfer palletised units to larger platforms.
- If not of *disposable construction*: durable pallets belong to consigner → have to be returned = fairly costly.

29) [PE[x5]] [SEQ] Discuss the advantages & disadvantages of containerisation **(anything from 2 to 10)** [Ref. Par. 3.5.3.2.d.ii]

Advantages of containers (& in some cases pallets):

- ↓ Cost of transferring goods from one vehicle to another → more than one form of transport can be used
- ↓ Door-to-door consignment time.
- Quicker loading & unloading = quicker delivery of goods & quicker further use of available transport means.
- ↓ Freight & handling costs.
- ↓ Handling in transit = ↓ risk of damage or theft, while normal packaging is adequate for protection.
- ↓ Packaging costs in some cases by using container itself as packaging material.
- Largely eliminates incorrect, faulty loading & consignments.
- ↑ Utilisation of capital equipment because of the uniform freight.
- Requires less documentation.
- ↓ Storage & inventory-holding costs.
- Packaging & sealing take place at consignor's plant.
- ↓ Delays in transfer loads from one transport form to another.

Disadvantages of containers (& in some cases pallets):

- High capital cost of providing containers, special vehicles & handling facilities.
- ↑ the tare (mass of containers) in the transport process.
- Not all commodities are suitable for transportation in containers.
- Requires a high loading factor (full containers) to make it economical.
- Have to be packed carefully, especially when more than one transport form is used.
- Cost of empty returns and/or obtaining freight for return consignments is high (loss of time and handling).
- Risk of damage is high in the case of faulty packaging.
- The required handling apparatus is not available at certain forwarding or terminal points. This means that containers can only be sent to centres with the necessary facilities.

30) [PE[x2]] [LO SEQ] Is there any relationship between transport technology, economies of transport & design. Substantiate your answer. **(6)** [Ref. Par. 3.6]

Transport technology involves the optimisation of the relationship between physical factors such as resistance to motion, speed and mass.

Transport economics involves the optimum use of scarce resources to satisfy the demand for transport.

The task of the designer of a vehicle, vessel or aircraft is to combine technology and economy by producing technologically feasible designs which meet economic requirements of operators & users. Usually done by adapting the design characteristics of the vehicle to the operating conditions under which it will be used.

- Each technologically feasible design comes at a given capital cost.
- Possible to produce different vehicles at the same capital cost by varying the design characteristics [e.g. propulsion]
- Provision of transport services requires 3 types of inputs: capital [(vehicle time)], labour [(crew time)] and energy [(fuel)]. Therefore if capital input is specified, the remaining inputs are a combination of labour and energy.
- In final analysis, selecting vehicle's design characteristics the aim is to obtain the lowest combination of (annual) capital & operating costs which can be traded off. Two factors significantly influencing the choice of a capital/operating costs ratio are:
  - annual operating distance [↑ economically justifies inclusion of capital-intensive design characteristics that ↓ running costs]
  - levels and ratio of labour & fuel costs.

- Operating circumstances determines extent of vehicle's utilisation & characteristics req. for high utilisation.
- Increases in labour & fuel costs increase operating costs in proportion to capital cost; and to counteract this cost increase, it may be necessary to increase capital costs, which will be reflected in the price of the vehicle.
- Simultaneous optimisation of technology and economy in the design of a vehicle therefore requires a careful analysis of the operating circumstances under which and the purpose for which the vehicle will be used.

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31) **[PE[x1]]** [SEQ] How does transport technology affect transport productivity? **(5)** [Ref. Par. 3.7; 2013-S1-Assign.01; ?Fig. 2.1?]

Productivity is defined as the ratio of input to output. A change in productivity is effected by changing inputs in relation to a particular output. Inputs do not necessarily have to change in direct proportion to each other, as in the case of changes in scale. Productivity improvements can only be brought about by improved technology or the training of staff.

Improved technology and improvement of the labour force (through training) are the only components that can influence the productivity of a transport enterprise. The influence of transport technology on the transport industry can therefore also be reflected in the influence of technology on productivity and therefore the profitability of the specific transport operation.

STUDY UNIT 4, PAGE 30

32) **[PE[x2]]** [SEQ] Define a transport network **(3)** [Ref. Par. 4.1 & 4.2]

A **transport network** is nearly any structure which permit either vehicle movement or flow of some commodity

- A specific geometric figure/graph made up of connected points (Nodes) and lines (Links);
- represented by a route map drawn up by a transport operator;
- used to provide his/her specific transport service.
- Links represent segments of various transport routes. It incl. flow (no. of units using link) & friction (usage cost/problem)
- All transport modes are usually included in a transport network i.e. roads, street, pipelines, railways, power lines

33) **[PE[x4]]** [SEQ] Explain / What are the components of transport demand forecasting? **(8)** [Ref. Par. 4.3]

Trip generation: The number of person-trips ending in a specific zone is estimated according to land-use patterns, the population & economic activities.

- Determines the total number of trips in the region and also where the trips start and finish.
- A <u>person-trip</u> is a trip undertaken by one person, with an origin and a destination/trip end.
- Variables used in est. trip ends in residential areas: income, ownership of motor vehicle & household's size.
- Est. of trip ends in non-residential areas based on: employment, floor space & land area.

Trip distribution: estimate made of the places to which trips are made.

- Est. no. of trips starting in a particular zone & ending in another. Meaning origin & destination are paired.
- Result = table of zone-to-zone trips representing the interaction between zones.
- This stage in the process of transport demand forecasting requires a large number of computations.

Modal distribution: proportional distribution of the total number of person-trips between different methods of transport or modes.

Traffic assignment: The routes that the trips follow are estimated.

- End product = estimated list of no. of vehicles using each link in the main road & no. of passengers using each link in the transport network.
- Computer program can provide a summary of total travelling time, no. of people getting on/off at a particular stop & other statistics.
- These elements are key inputs in evaluation. E.g. compare vol. with link's capacity to determine whether there is going to be congestion.

34) **[PE[x4]]** [SEQ] Name & discuss various elements that are considered important for the configuration of air, road, rail & water transport networks **(6 or 15 or 20)** [Ref. Par. 4.4; 2015-S1-Assign.01]

Water transport network configuration: the linking together of destinations, whilst considering the location of continents. Ships don't necessarily follow the same routes as the presence of other ships sometimes causes deviations. Radar generally used to detect ships in the areas. Route planning is based on *shortest distance*.

Road transport

Distinction is made between freight & bus transport because of the different markets served by the various services, which tend to influence the variability of routes.

<u>Freightage</u> serves a market with a *known demand* and therefore *fixed delivery points*. The provider of the service draws up the configuration of the network and he/she *may change the routes* if the delivery point is moved and/or there is a change in the delivery time of the freight.

<u>Bus transport's</u> demand may be variable because the action of passengers is *unknown*. E.g. on rainy day, various passengers may decide to use own cars rather than bus. Users of bus transport are also constantly aware of the routes and *time schedules followed*. Routes along which service is provided cannot, like freightage, summarily be changed, and usually need to be researched beforehand to meet passengers' needs → *route not flexible.*

Rail transport

Most rail transport routes, be they suburban/light/heavy rail transport, are *radial* and end at or pass through a city centre. This is because the market for rail transport is situated in the city or town centre. Circle or circumferential rail transport routes usually generate sufficient revenue to justify such an investment.

Many rail transport networks have branching routes i.e., radial lines that are subdivided into two or more lines outside the central business district. The advantage of branches is that they can serve a larger area and more passengers are therefore within walking distance of the station.

Air transport

Configuration of networks does not simply involve departure & exit points. Also requires careful planning to maintain high safety standard [high speeds & safe distances involved]. Airspace is free from physical constraints.

The configuration of an airline network as the organisation of the airline flight schedule at an airline's 'airport' resulting in a given number and quality of indirect connections offered through that airline's airport. Number & quality of indirect connections through the station can be enhanced by concentrating the flight schedule.

Here are some of the elements of air transport configurations:

- the minimum connecting time for continental and intercontinental flights;
- the maximum connecting times;
- the maximum number of flights that can be scheduled per time period

Additional from Assign. **Analysing the interactions between the five elements within each mode** *Answer will differ from each other*.

In terms of Air and Water transport networks, there is no physical construction of the airspace and water ways. Rail & road transport are inland – somehow they interact on a regular basis, take Gautrain as a perfect example.

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35) [PE[x1]] Explain how you would design a transport service route using the following subheadings (Bus transport routes, Type of transport routes, Rail transport routes) **(20)** [Ref. Par. 4.5]

Bus Transport Routes should follow arterial streets if possible & avoid smaller/side streets.

- Arterial streets: wider, designed to ↑ flow → facilitate bus movements & maintain higher avg. speed.
- Greater likelihood of parked vehicles blocking side streets, while buildings with a high rate of trip generation, are usually situated along arterial streets.
- Ideally route should be straight & direct → easier for passengers to understand & faster trip from start to finish, though buses stop at places that generate high traffic → these objectives conflict; find compromise.
- Route deviations, going past trip generators [e.g. schools, hospitals, office buildings & shopping centres,] are generally introduced.
- Route following detours extends travelling time → may discourage passengers from using bus
- Make effort to introduce any deviations at the end of the route.

Type of Routes

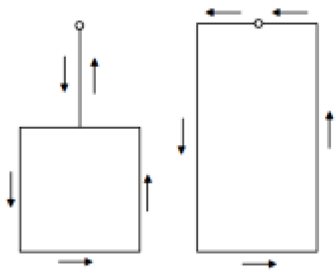
E.g. Bus route ending in central business district - Instead of bus turning around, following same route, a through route (to the other side of the city) has certain advantages:

- Routes on opposite sides of central business district are paired. Each bus alternates between the routes.
- However, length of such a route may be restrictive because ↑ probability of delays in the schedule.

Circle routes used in low-density areas. Instead of riding up & down along the same route, buses ride in same direction, but in a loop i.e. bus is outbound on one half of route & inbound on other. Disadvantage:

- Bus has to ride around the loop = ↑ Travelling time of passengers wishing to be on opposite side.
- Thus justified only in areas requiring a minimum service & where demand for such routes is low.

Balloon route: compromise for the above. Bus rides mostly back & forth. At route's end it follows a small one-way loop. On route map, pattern resembles a balloon tied to a piece of string. Figure 4.6: Balloon Route



Rail Transport Routes: Passenger Transport

- Location: Mostly determined by availability of right of way.
- Problem: individual passengers only interested in those stations where they can get on/off. Because individual requirements differ, many stations are involved → find balance between stations that should be available & the demand of the individual.
- Be as straight as possible → detours mean delays for most passengers. If unavoidable, make effort to ensure few passengers as possible are delayed. One railway line forces passengers to follow unavoidable detours → hamper the efficiency of the system. Branched line may be the best alternative in such a situation.
- Attempt to ensure that passengers do not have to change modes of transport. Main line through central business district ↑ no. of changes between modes = ↑ probability of delays.
- Avoid train services on very long routes as delays tend to escalate = trains cannot keep to the schedule. Also terminal station is underutilised = uneconomical operation of the track. Preferable to design a feeder bus service than to transport rail transport passengers to the station by rail.
- Situate stations at/close to areas with high-density activities so that potential passengers are within walking distance of them. E.g. business centre, universities, hospitals and sports stadiums

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36) **[PE x2]** LO SEQ Briefly discuss designing a bus route & explain the types of routes **(10)** Ref. Par. 4.5; 2013-S2-Assign.01

See Question 35 Above for "Bus Transport Routes" & "Type of Transport Routes"

You have to consider the following factors when designing your route:

- Types of routes – the beginning and ends of the routes
- Speed limit to be maintained in different areas
- Clear directions – stations along the routes must be indicated
- Population density

STUDY UNIT 5, PAGE 40

37) Name & discuss the factors to be considered in the flow of traffic over time Ref. Par. 5.2.2

- Definition: Notion of "dynamic flows" or "flows over time" which comprises both temporal features
- Continuous vs. discrete time. Amount of flow sent into an arc within this interval. E.g. illustrate discrete flows over time by associating each arc with a conveyor belt which can grasp one packet per time unit.
- Flow conservation constraints. When considering flows over time, flow conservation constraints also must be integrated over time to prohibit deficit at any node which is not a source.
- Time-expanded networks. It observes that flow-over-time problems in a given network with transit times on the arcs can be transformed into equivalent static-flow problems in corresponding time-expanded network.

38) SEQ What do you understand by the following concepts: Ref. Par 5.3 & Act. 5.1

a) Traffic Flow: Ref. Par 6.1

Study of *interactions* of vehicles, drivers & infrastructure (incl. highways, signage and traffic control devices), with the aim of understanding and developing an optimal road network with *efficient movement* of traffic and minimal *traffic congestion* problems.
Task of the traffic economist is to improve the flow of traffic on road facilities in the most economical way.

b) Traffic Analysis: Ref. 2015-S1-Assign.02

The process of intercepting and examining the movement of vehicle in order to deduce information from patterns in traffic movement. Traffic analysis can be performed in the context by means of computational applications. Traffic analysis tasks may be supported by dedicated computer software programs. Advanced traffic analysis techniques may include various forms of traffic analysis networks.

c) Traffic Congestion: Ref. Par 5.2 & 5.2.1

"Congestion" captures the fact that travel times increase with the amount of flow on the roads. Is inherent to car traffic, but also occurs in evacuation planning, production systems & communication networks. Traffic engineers have studied congestion in static traffic networks over a long period. It models the rush-hour situation in which flow between different origins and destinations is sent over a longer period of time.

Traffic congestion is a condition on road networks that occurs as use increases. Characterised by: slower speeds, longer trip times, increased vehicular numbers queuing even road rage.

As demand approaches capacity of road / intersections along road, extreme traffic congestions sets in

d) Traffic Planning: Ref. Par

e) SEQ City Street Network: Ref. Par 5.3.1 & Act. 5.1

- Streets of a city provide a simple example of a network. To provide a geographic representation of the street system, a city street network is defined in terms of nodes & links between nodes.
- Nodes = street intersections & links = roads between nodes.
- N.B. to distinguish between one- & two-way traffic when using a network to describe traffic movement.

f) [PE^{x1}] SEQ Main Road Network: **(2)** Ref. Par 5.3.2 & Act. 5.1

To conduct a macroscopic study of the movement of traffic through an extensive area, divide area into subareas & concentrate on main routes. Subdivision of area of study is done in stages:

i. Divide area into a number of sectors
ii. Sectors into smaller districts
iii. Districts into zones. Zone: the basic subarea used in transport studies. Chose in such a way that it has fairly uniform land-use characteristics.

Assumed traffic's origin & destination through zone is concentrated at specific point = a centroid
Each centroid is linked to main routes by a dummy link.
Main road system, together with centroids & dummy links forms the main road network.
Main road network is sufficient to study total movement of traffic through an extensive area. However, the main road network must be coded, and should be interpreted carefully.
Using a main road network, transport planner associates various parameters with links and nodes

g) SEQ Traffic Desire Network: Ref. Par 5.3.3 & Act. 5.1

Traffic problems analysed in a specific region, traffic movements are usually described as trips between origin & destination. Trips between all points of a traffic zone & all points in another zone, may be summed / aggregated to represent the traffic desire between the two zones. This traffic desire can be indicated by a directed or undirected line – a straight line connecting the centroids of the zones.

In traffic desire network, the nodes represent the centroids' zones & links the desire lines. Nodes are geographically significant, links don't represent roads/traffic routes; crossing of desire lines = no significance

Desire network is an example of a complete nonplanar network. 'Complete' because each pair of nodes is connected by a link/two directed links & 'nonplanar:' cannot be represented on a level of non-crossing links
Useful representation of the traffic desire if there are few zones.

h) **[PE^{x2}]** SEQ Spider Web Network: **(3 or 2)** Ref. Par 5.3.4 & Act. 5.1

Large regions not ideal to aggregate different zones & place them on desire lines. Preferable to assign trips to a spider web network. A spider web network is made up of zones representing centroids and links representing the desire lines between adjacent zones. Because the links do not cross, the spider web network is a *planar* network. When assigning an individual zone-to-zone desire, the choice of a route from the origin node to the destination node, via adjacent nodes, should be based on a criterion such as the shortest distance. The spider web network with the accumulated traffic desire is useful because it reflects general traffic flow patterns

39) **[PE^{x2}]** SEQ Is there any relationship between a traffic network & the transport planning process. Substantiate your answer **(5 or 10)** Ref. Par. 5.3 & 5.4; 2013-S1-Assign.01

When traffic problems are analysed in a specific region, traffic movements are usually described as trips between origin and destination. Trips between all the points of a traffic zone and all the points in another zone may be aggregated (summed up) to represent the traffic desire between the two zones. This traffic desire can be indicated by a directed or undirected line — a straight line connecting the centroids of the zones.

The general objective of a transport study of a metropolitan area is to develop a comprehensive long-term transport plan. This requires estimating the future private and public traffic and therefore establishing an efficient and economical transport system that will satisfy the anticipated traffic patterns. The underlying principle is that an urban population usually follows certain routines that follow certain patterns in respect of the movement of people and goods.

Transport planning process is influenced by the analysis of the characteristics of these networks. It is advantageous to distinguish between the four phases of the planning process

40) Name the four phases of transport planning [Ref. Par. 5.4.2]

- Phase 1: Base-year Inventory (Divided into 3 separate inventories: of main roads & transport services; of travel patterns; of planning factors)
- Phase 2: Model Analysis (Entails determining base-year calibrations of mathematical models: trip generation; Trip distribution; Traffic Assignment)
- Phase 3: Travel Pattern Forecasts (Travel pattern of design year predicted using planning factors & maths models with estimated model parameters)
- Phase 4: Network Evaluation (Alt. future transport systems are evaluated & most appropriate one is chosen, using a 4 step process)

STUDY UNIT 6, PAGE 50

41) **[PE[x1]]** Define capacity of a road & explain what capacity analysis entails **(7)** Ref. Par.6.3

Capacity of a road: *max hourly rate* at which vehicles can be expected to move past a *particular point* of a roadway during a *given time period* under the prevailing road traffic and control conditions.
Any change in prevailing conditions will result in a change in capacity of the road → Assume favourable weather and pavement conditions (ie.road surface) exist.

Capacity analyses

- Time period in most capacity analyses is 15 minutes - shortest interval during which a stable flow can exist.
- Aims to est. max amount of traffic that a road can accommodate, while still maintaining the prescribed operational standards.
- Set of procedures used to estimate traffic-carrying capacity of roads under certain operational conditions
- Provides tools for the analysis & improvement of existing roads and for planning & design of future ones.
- The road, traffic and control conditions used in capacity analyses, are described as follows: measures
  - Roadway condition: geometric characteristics of street/highway, with due consideration of number of lanes in each direction, lane and shoulder widths, lateral clearance, design speed and the horizontal and vertical alignments.
  - Traffic condition: characteristics of the traffic stream using the roads. These are defined by the distribution of the different types of vehicles in the traffic stream, by the amount and distribution of traffic in the available lanes of the road, and by the directional distribution of the traffic.
  - Control conditions: control measures and traffic regulations in force on a given road. The type, location and timing of traffic signals are critical to capacity. Other important control measures include stop and yield signs, lane-use restrictions, etc.

42) **[PE[x1]]** What factors should be considered in measuring road capacity. Discuss in detail **(10)** Ref. Par.6.3?

[Unsure] **See "Conditions" in Question 41 Above;** From discus. slide "Measured: Roadway, traffic & control conditions"

43) SEQ What do you understand by "interrupted flow" and "uninterrupted flow"? Ref. Par.6.2

Uninterrupted flow facilities have no fixed traffic control elements i.e. no time limit on use of roadway. E.g. Freeway.
Interrupted flow facilities contain fixed elements causing periodic interruptions in traffic flow. E.g. traffic lights, stop signs
Devices cause traffic to stop periodically / significantly slow down regardless of the traffic volume.

Un- &interrupted flow are terms describing type of facility Constant component, not quality of traffic flow

44) **[PE[x1]]** LO SEQ How do you differentiate between the concepts "capacity" and "level of service"? Support your answer with practical examples. **(20)** Ref. Par.6.3 & 6.4

See Question 41 Above for definition etc. on capacity

Level of Service: quantitative measure describing operational conditions within traffic stream & the way traffic users perceive these conditions. Generally described in *factors* of speed & travel time, freedom to manoeuvre, traffic interruptions, comfort & convenience and safety.

Six levels of service are defined for different operational conditions on roads Primarily for uninterrupted flow; *A* represents the best operating conditions and *F* the worst:

- *A*= free flow. Individual users virtually unaffected by presence of others in traffic stream.
- *B*= steady flow, but presence of other users in traffic stream becomes noticeable.
- C = See = Vigilant *C*= steady flow, movement of individual users begins to be significantly affected by interactions with others
- *D*= high-density but stable flow.

- *E*= traffic conditions at/near capacity level.
- *F*= operations within a queue or forced/breakdown flow (flow associated with vehicle breakdowns). Amount of traffic approaching point exceeds amount that can pass it.

45) SEQ What measures would you use to measure traffic flow? Ref. Par.6.5

- Speed (distance covered per unit time)
- Volume and/or Rate of Flow (See Question 46 Below for the two definitions)
- Density (number of vehicles occupying a given length of lane or roadway, averaged over period of time)

46) Additional Name and discuss each measures of traffic flow in detail? Ref. Par.6.5; See formulas & activities in study guide

Speed: distance covered per unit time. Average speed calculated based on vehicle sampling over a period of. Speed by time as reference = time mean speed; measured by space reference it is called space mean speed.

Different speed parameters can be applied to a traffic stream.

- Average running speed.
- Avg. travel speed.
- Time mean speed
- Space mean speed.

Volume & **Rate of flow [RoF]**: quantifies amount of traffic passing a point on a lane/highway during a certain period of time. These terms are defined as follows:

- Volume: total no. of vehicles passing over given point/section of a line/highway during a given time period. Expressed in terms of annual, daily or hourly volume, or smaller periods may also be used.

- Rate of flow. Equivalent hourly rate at which vehicles pass over a given point/section of lane/roadway during a given time interval of less than an hour (usually 15 minutes).

Density: no. of vehicles occupying given length of lane/roadway, averaged over period of time. Expressed as vehicles per kilometre (vehicle/km). In traffic flow: critical density & jam density

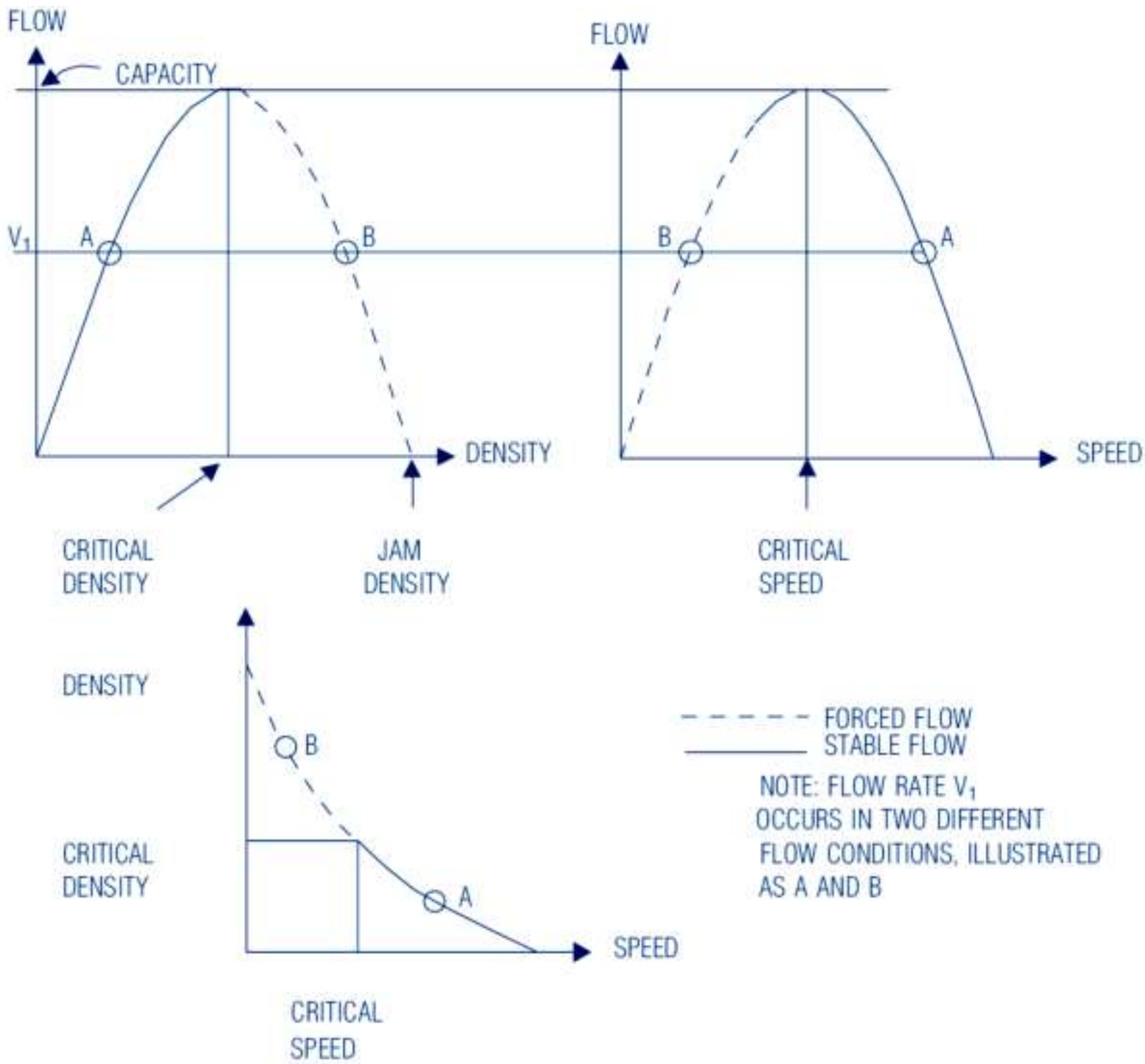
47) **[PE^{x7}]** LO SEQ Is there any relationship between speed, density & rate of flow on uninterrupted flow/traffic facilities? Explain using ratio / sketches. **(3 or 6 or 25)** Ref. Par.6.6; 2013-S1-Assign.02

- Rate of flow indicates *relationship between parameters* that describe an uninterrupted traffic stream.
- RoF relationship: (v = S x D) a given RoF to occur at an indefinite number of combinations of speed and density,
- Add. relationships restrict variety of flow conditions existing at any given location.
- **Figure 6.1** indicates relationship's general form; Curve shapes similar for all uninterrupted flow facilities Exact shapes depend on prevailing traffic & roadway conditions

- **To summarise Conditions**
  - When D = 0, RoF = 0 [No vehicles & Speed is theoretical]
  - D reaches certain max, S = 0 therefore RoF = zero i.e. traffic is jammed & movement is impossible.
- D ↑ from 0 to max. Vehicle interaction: Speed ↓ negligible then rapidly. RoF ↑ until max ↑D x ↓S = reduced RoF. Where after ↓ to 0 when density is at a maximum.

- Max. RoF for any given roadway is its capacity. This occurs at critical density & critical speed.
- Fig. 6.1 shows that any RoF, except capacity, can occur in two different conditions:
  - high speed & low density
  - high density & low speed.
- High-density, low-speed side of curve is considered unstable. This represents forced or breakdown flow.
- Low-density, high-speed side of curve is the stable flow region.

Figure 6.1: Relationships between speed, density and rate of flow on uninterrupted flow facilities:



48) [PE[x1]] Discuss traffic flow theory under (a) road capacity & (b) traffic assignment **(25)** Ref. Par.6.3 & 6.7

See Question 41 Above for definition etc. on capacity

Traffic Assignment

Traffic flow aims to *create & implement model* enabling vehicles to reach destination in *shortest possible time* using *max. roadway capacity*. 4-step process; cycle repeated until solved:

- **Generation**: est. how many trips would be generated. Program req. statistical data of residential areas by population, location of workplaces etc.
- **Distribution**: traffic flow differs from Origin to Destination (OD) because of the difference in step 1's location. complications collecting short-interval-traffic data from routers → Difficult to measure short-interval-traffic vol.
- **Model Split / Mode Choice**: system decides % of population to split between different modes of transport such as cars/buses/rail
- **Route Assignement**: routes are assigned to the vehicles based on minimum criterion rules

Two main approaches to tackling this problem with the ultimate objectives:

System optimum: assumes routes all vehicles use would be controlled by the system & that rerouting would be based on max resource utilisation & min travel time.

- System optimum routing algorithm: all routes between a given OD pair has the same marginal travel time.
- Method gives a better routing solution, but is difficult to implement.

User optimum: assumes every user chooses own route to his destination.

- Users wait until travel time using a certain freeway equals travel time using city streets.
  Case reaches user/Nash equilibrium
- Say that in user equilibrium all used routes between a given OD pair have the same travel time.

Using **Time delay** to solve them, both user optimum & system optimum can be subdivided into two categories:

- Predictive time delay: system/user knows when congestion point is reached/delays on freeway = delay on city streets → decision for route assignment is taken in time. Better results than reactive delay method.
- Reactive time delay: system/user waits to experience the point where delay is observed → route diversion is a response to that experience.

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49) **[PE^{x5}]** Most traffic analysis procedures involve 3 different computational applications. Name & discuss those three computational applications. **(9 or 10 or 11 or 16)** Ref. Par.6.8; 2015-S1-Assign.02

Operational analysis

- detailed & flexible
- traffic flow rates & characteristics compared with highway descriptions to est. expected level of service.
- detailed input info on traffic characteristics (e.g. volumes & traffic compositions) and geometric conditions (incl. no. & width of lanes, shoulder clearances, design speeds, grades, and horizontal & vertical alignments.)
- All existing traffic control measures specified in detail
- Req. same info for planned/future act. - then based on traffic projections, not field-measured data.
- Evals level of service or alternative spot & section improvements to existing roadway.
- Operational effect of different improvement measures can be est. & compared → make rational decision.
- Est. value of performance/operational parameters e.g. est. density & speed of traffic stream on a freeway
- Alternative use = to determine service flow rates permissible on varying level-of-service assumptions.
- Eval. sensitivity of service flow rates to various design or level-of-service assumptions.

Design analysis: determines *noc. of lanes* required on particular roadway in order to make provision for a *specified level of service*.

- Also determine effect of design variables such as lane and shoulder width, lateral clearance, grades and other characteristics.
- Req. Detailed data on expected traffic volumes & characteristics

Planning computations objective: determine no. of lanes required to provide a given service level.
Rough est. at earliest planning stages when info qty., detail & accuracy is limited.
Refine planning applications as more info becomes available later in planning & design processes.

STUDY UNIT 7, PAGE 61

50) [PE^{x4}] SEQ What does frequency of transport service mean. **(4)** Ref. Par. 7.1

Frequency of service: regularity with which services are rendered.

- Movement is either regular or irregular.
  For passengers, frequency of service means the number of services available to them at a given time.
- Affects quality of service provided to users & service provider's operating costs.
- Frequency of service & headways/spacing of routes are interrelated.

51) SEQ How can the optimal frequency of services be quantified? Ref. Par. 7.2.2

See Activities 7.1 & 7.2 in Study Guide p.62-65 for calculations

52) SEQ What are the factors that could influence passenger volumes at the optimal frequency of service? Ref. Par.

[Unsure] Bus might be full; passengers arrive at random…?

53) [PE^{x1}] Discuss the influence of transport capacity on frequency of service in the four modes of transport (Bus, size, Train length, Aircraft Size, Size of ships) **(20)** Ref. Par. 7.3; 2013-S2-Assign.02
SEQ Is there any relationship between vehicle size & frequency of service? Support answer with practical examples

Determine peak-period frequencies according to the number of passengers to ensure that everyone has a seat. Off-peak periods → fewer passengers; vehicles underutilised → oversupply → ↑ average operating cost.

Bus Size - Specifically Seating Capacity

- Determines investment & operating cost. Larger bus = ↑ investment & operating cost.
- Labour cost unaffected by bus size as no. of staff remains the same.
- High service quality: trade-off operating costs vs. time passengers spend waiting & riding.
- Bus transport enterprises use large buses less frequently in an effort to save operating costs → possibility of many empty seats → Passenger pays penalty i.e. time wasted
- Drastic increases in fuel costs → incentive to use smaller buses

Train Length

- No. of carriages determined by Operating staff & Technical factors
- Train length should be comparable with platform length & loading areas.
- Keep no. of carriages scheduled constant = ↓ headways & passenger's waiting time.
- Shorter platforms ↓ construction costs vs. Longer trains ↓ operating cost.
- Efficiency of longer trains is attractive, if there is a demand for it.
- Easily add/remove carriages → directly effects capacity → no noticeable effect on operating cost.

Aircraft Size

- 2 Parameters determine aircraft's max gross mass. ↑ *pay-load* & *flying distance* req. → ↑ surface area of wings & fuel capacity. Hull size depends on desired pay-load & passenger/cargo distribution.
- Larger aircraft benefits direct operating-cost elements: ↑ fuel & crew. But ↑ capacity = ↓ cost per seat-km
- Fewer flights with a larger aeroplane may offer same capacity as previously, which also has cost advantages.

Size of Ship

- Limited by Technical factors: Bigger as ship-building technology improved.
- ↑ avg. ship size; ↑ productivity of marine transportation, particularly because
  - cost of investing in shipbuilding & usage now smaller part of the operating cost;
  - ↑ individual vessels' capacity & greater safety at sea = ↓ no. of ships in use

STUDY UNIT 8, PAGE 68 [No Self-Eval. Questions, the ones there are repeats from SU 7's]

54) Additional Discuss the five phases of the operating cycle in detail. Ref. Par. 8.2; See Study Guide for formulas / calculations

Acceleration: rate of change of speed measured in kilometres per hour per second or meters/second^2

- Speed remains constant; acceleration rate = 0.
- Speed ↑ at constant rate; acceleration rate = constant
- Vehicle starts to move using full power; max acceleration rate takes place.
- Rate ↓ continually until = 0. At vehicle's max design speed: power of acceleration = the force of resistance
- Vehicles accelerating slowly take a long time to reach top speed.
- Stops so close together vehicle cannot reach top speed before braking = misfit between vehicle & distance
- Short distances between stops → Req. vehicles with high acceleration rates &
  Low acceleration rates for long distances between stops

Cruising speed: vehicle moves at a constant speed.

- Vehicles rarely move at their max designed speed
- Road/Rail: Topography & legal constraints necessary for safe operation of transport restrict max speed.
- Air transport not subject to above constraints, but do experience technical (air resistance) & economic constraints
- Ships restricted by the resistance of the water to their velocity.

Coasting: When vehicle's engine is switched off and vehicle runs on momentum.

- Little opportunity for road/aircraft/ships to coast (coefficient of friction between vehicle & medium upon/in which it moves), while
  Trains have plenty opportunity (because of momentum, there is a low coefficient of friction between the steel wheels and steel tracks).
- Convert electric motors to generators → by coasting train generates power → sent back to power station.
- Desired coasting pattern: maintain balance between applying power & coasting (i.e. turning power on/off).
- Coasting can save energy and should be encouraged by transport management.

Deceleration is approximately linear, i.e. change of speed per second is constant. Two forces balance out:

  - 1st Braking of the vehicle becomes more effective if speed is reduced
  - 2nd Aerodynamic drag decreases with a decrease in speed which reduces force that stops the vehicle.

- As with acceleration, a deceleration rate of 4,8 km/h per second is within the safety and comfort boundaries of passengers under normal conditions. In an emergency, a higher deceleration rate is feasible

Station dwell is time during which a vehicle stops at a stop to load and unload passengers or goods.

- Duration of station dwell determined by different factors.
- In passenger transport consider width & number of doors in a vehicle. A standard bus has two doors for passengers to board at the front door & leave at the back door.

55) [PE x1] Scheduling comprises 3 steps. Briefly discuss these steps in a transport context (6). Ref. Par. 8.3.1 to 8.3.5

Timetable indicating the trips on each route must be prepared.

- Decision-making about time interval between trips.
- Specifies when trip *starts & ends* and the time at which a vehicle should pass a certain point along the route.
- Include *layover* time at the end of a trip before vehicle starts next one. Gives leeway, if there are any delays along the route. Then delays are not passed on from one trip to the next.
- Decide on *time of day* at which service should start & end.
- Scheduling frequency of services depends on demand (e.g. short headway during peak periods & longer during off-peak).
  Require more employees during peak periods, meaning they have to work shifts.
- Keep vehicles' headways uniform over longer periods → easier to remember schedule & reduces waiting time for passengers caused by irregular headways.

Assignment of vehicles: according to trips on the timetable.

- Block: Number of trips undertaken by one vehicle.
  A block starts with the vehicle "pulling out" of the garage and ends with it "pulling into" the garage.
- Number of vehicles directly influence operating cost therefore design blocks to minimise no. of vehicles req.
- E.g. bus routes can be paired; one bus alternates between routes. Changing train lengths for peak/off-peak

Assignment of personnel / staff to vehicles is the most difficult step

- Long-distance transport, block exceeds staff's working hours → block is then further subdivided into pieces.
- Piece: block section that a single staff member staff can handle. Takes place at *relief points*
- Assign pieces according to daily work schedule for individual members of staff.
- Assignment results in the drawing up of a *roster* → piece may comprise one, two or three parts (or runs).
- Seasonal changes influence no. of trips passengers undertakes → service fluctuations on a specific route.
- Computerised scheduling → more efficient scheduling ↓ number of vehicles required.
- Computer programs can be used during labour negotiations to determine the effect of changes.
- Schedules are published in small cities, but not necessarily in larger ones

Adhering to the schedule → efficient transport service

- Time table should be known by users
- Make provision for sudden disruptions that an acceptable percentage of scheduled services are maintained.
- Transport enterprises should have personnel & vehicles on standby for when:
  - bus driver is absent or on leave
  - bus driver does not arrive on time to do a trip
  - bus driver falls ill during a trip and has to leave
  - vehicle breaks down and a replacement is sent out

56) **[PE[x1]]** Name & briefly explain service patterns that can be used in rail transport **(4)**. Ref. Par. 8.3.6 Possible variations on question

Zone system

- Train stops only at stations in a specific zone (inner or outer zone).
- Certain degree of overlapping to enable passengers to transfer from one train to another.
- Outer stations of the inner zone and the inner stations of the outer zone are the same (see fig 8.1).
- Advantages:
  - Outer zone passengers quickly reach central business district as train stops only at inner zone stations.
  - Cover short distances in inner zone → lower operating costs.
  - Trains serving both inner & outer zone have faster turnaround → ↓ train equipment & their investment
- Disadvantages:
  - ↑ headway at each station except station where all trains stop → may ↑ passengers waiting time.
  - Passenger travelling between outer & inner zone must transfer at station common to both zones → extra line may be needed if trains are close together.

Skip-Stop System

- Designate as alternate stations A (where train A stops) & B (where train b stops), station in between is AB (Used for transfers)
- Can handle divergent travel patterns.
- Ideal for intercity transport systems.
- System does not require extra railway lines, unless the headways are extremely short.
- Advantages:
  - Higher train speed → benefits passengers.
  - Less equipment is required to provide the service.
- Disadvantages:
  - *Doubles headways* at stations A & B, because trains A & B take turns to stop there.
  - Travelling between stations A & B means *transferring* at station AB, which requires careful planning.

- Plan for Low vol. passengers at A & B stations and high volumes of passengers for the AB station.

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57) **[PE^{x1}]** Zone system is one service pattern found in scheduling rail transport services. Discuss 3 advantages & 2 disadvantages **(5)**. Ref. Par. 8.3.6.2

See question 53 above

Additional **Scheduling**:

- One of the main priorities of transport management
- Has direct influence on *operating costs* & *service quality*
- Gives direction & guidance to users & operators
- Adds value to business

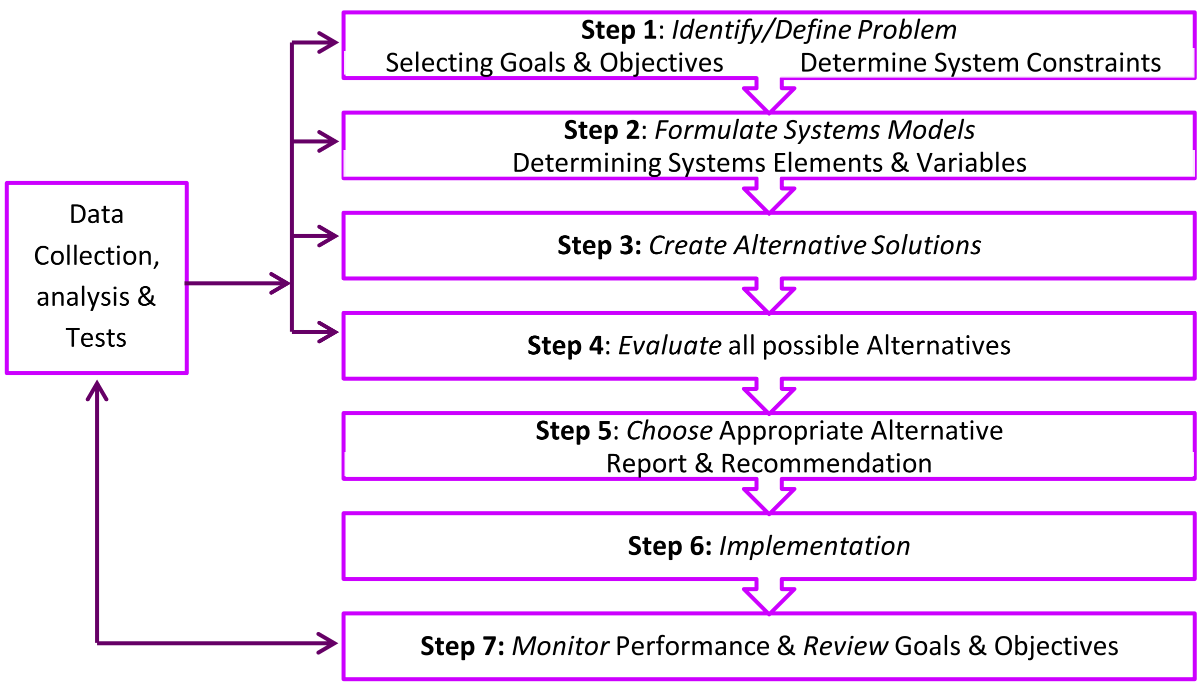
Additional **Network Operation**: Process vehicle takes from moment it leaves one stop until moment it arrives at the next

STUDY UNIT 9, PAGE 75

58) [SEQ] Explain what Transport Systems Analysis (TSA) is, and [PE[x1]] discuss its potential benefits. **(5)** [Ref. Par.9.3]

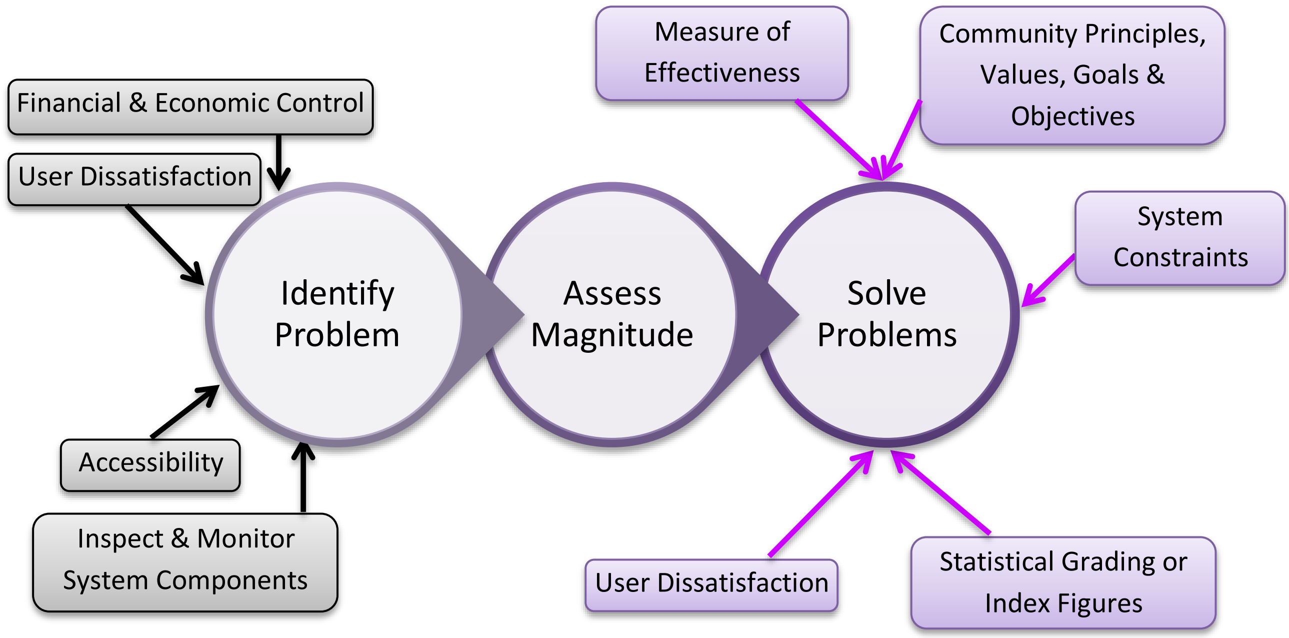
- **Systems analysis**: dynamic problem-solving & decision-making process; a prediction of flows
  Considers various alternative solutions to a problem & approaches to overall design to arrive at acceptable system with optimum performance in terms of specific criteria.
- **TSA's aim**: effect optimum combination of all transport facilities & their operating inputs in a given area.
- **Characteristics of transport systems** that complicate their operation and necessitate a systematic & systems-orientated analysis:
  - Regions served include thousands/millions of person trips & freight consignments.
  - Large number of transport technologies & different ways they may be operated, regulated & priced → infinite number of methods to change a transport system in a region.
  - Numerous objectives attained by improving transport → often difficult to measure & explain.
- **Benefits**
  - Clearly *defines objectives* & *identify steps* needed to achieve them.
  - Predict *future demand* in terms of interaction between economic and social factors.
  - Determine *procedures* to find alternative solutions & methods to assess them.
  - *Optimisation techniques* must be designed to select favourable solutions.
  - *Decision-making strategies* to choose between alternatives are proposed.

59) [PE[x1]] [SEQ] Illustrate using a graph the seven steps of TSA. Discuss each step in detail **(14)** [Ref. Par.9.4, Fig. 9.1; 2015-S2-Assing.02]



Step 1: Diagnose Problem & Assessing Magnitude

- Identify the Problem:
  - Users *dissatisfied* with service standard & system components → no longer meets users' expectations
  - Potential system users are hampered by a lack of *access* to it.
  - Formal diagnosis: inspection & monitoring by officials investigating the functioning of separate system components and the coordination between components.
  - Financial and economic control.



<u>Assess magnitude</u> of problem to:

- Determine *priority* in problem solving process.
- Determine extent of *remedial action* or solution.
- Determine if remedial action should provide for *initial excess capacity*.
- Provide *guideline* when searching for alternative solution

- <u>Solving problems</u> on basis of role of community
- *Set goals* to attaining community value
- *Formulate Objectives*: must be attainable & directly/indirectly measurable. Often contradictory
- *Measures of effectiveness* should be appropriate, address actual problem & satisfy 3 basic requirements:
  - Measure effectiveness of whole system.
  - Be quantifiable / expressed numerically.
  - Be statistically reliable & collected within relatively short period at a reasonable cost
- *System constraints* prevent selection of specific solutions to a problem. E.g.:
  - Economic and financial
  - legal & bureaucratic restrictions
  - existing system resistant to alternative solutions → improvements need to harmonise with system

Step 2: Systems modelling

System models: representation / abstract simulation of real world circumstances empowering analysts to observe consequences of planning, design & resource allocation actions.
Simplified system providing better understanding of the system being analysed.

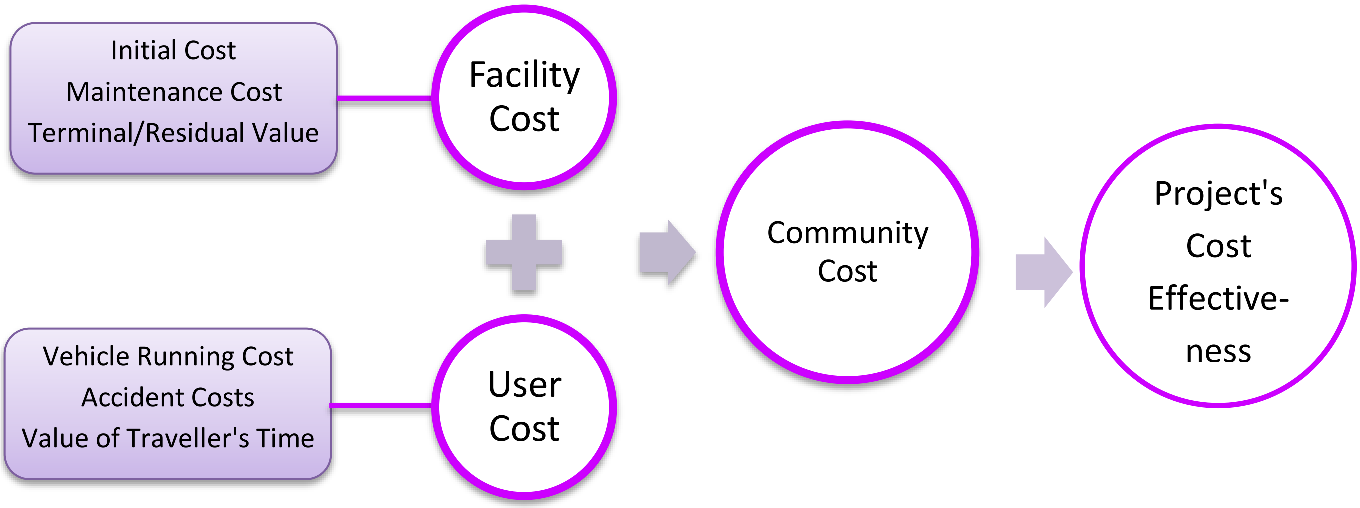
See Question 62 Below for Physical, Conceptual & Analytical types of models that differ in their construction

Step 3: Create Alternative solutions

- Multidisciplinary team applies innovative & creative skills to generate alternatives.
- *Constraints* serving as elimination & preliminary selection process to proposals.
  - Economic viability
  - Capable of achieving goals & objectives.
  - Align with specifications imposing certain physical constraints – Safety & regulations issues, environ.

- Within limited framework, search is directed by *economic guidelines*:
  - Availability of raw materials & budgetary limits
  - Focus analytical studies on alternatives with most productive potential.

Step 4: Evaluate alternative solutions



- Road transport improvements aims to ↑accessibility & mobility to ↓road user & maintenance cost = savings
- Evaluation aims to determine extent these objectives are met → justify cost of additional facilities
- Road user cost savings imply increased government spending → exerts upward pressure on project costs
- Funds required to satisfy constant demand for transport, roads & their improvement always exceed supply

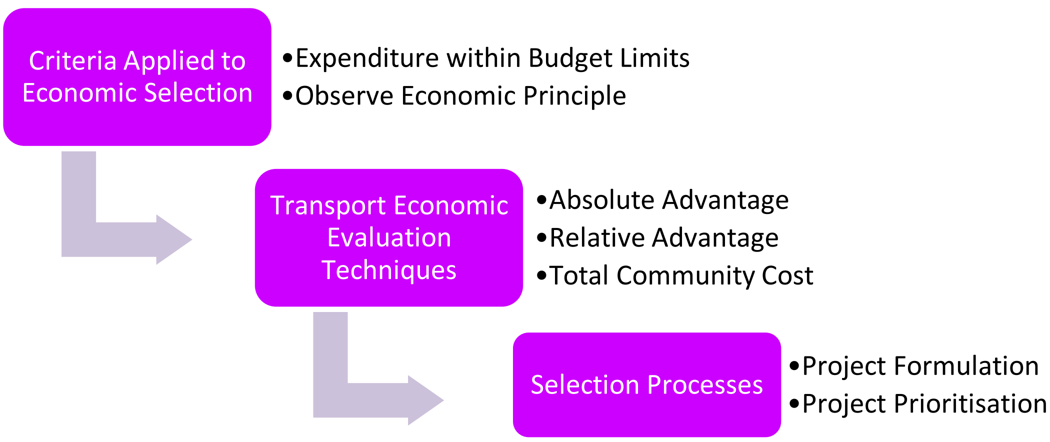
- Relevant Facility costs include:
  - Initial cost (all capital costs related to creating the facility)
  - Maintenance cost (all maintenance costs related to keeping road negotiable & maintaining traffic flow)
  - Terminal/residual value (*terminal* value: re-use/salvage value of any road component & value of basic reserve at end of road's service life. *Residual* value: remaining value of road & value of basic reserve at end of analysis period if road's service life is not yet over)

- Road user costs where the following are relevant:
  - vehicle running costs (fuel consumption, tyre wear, engine oil consumption, vehicle capital cost and maintenance cost)
  - accident costs
  - the value of travellers' time

- Evaluation is aimed at predicting area's potential economic development & growth as a result of road construction. Considering factors: anticipated multiplier & acceleration effect in the economy of the region.

- Three transport economic evaluation techniques to determine microeconomic viability of proposed projects:
  - absolute advantage: using net present value method
  - relative advantage: using either benefit/cost ratio method or the rate of return method
  - minimum total community cost: determined by the present worth of costs method

Step 5: Project selection



- Criteria applied in the economic selection of projects - Consider projects that best meet requirements:
  - Project expenditures must remain within the limits of the budget.
  - Strictly observe Economic principle i.e. cost of service, value of service, available resources etc.

- Transport economic evaluation techniques determines viability based on three criteria: (from Step 4 above) absolute advantage, relative advantage and total community cost.

- Economic selection involves two processes:
  - Project formulation is the selection of the best of a number of mutually exclusive alternatives. Mutually exclusive projects have the same goal,

  - Project prioritisation: arrange all functionally independent projects according to their microeconomic viability until capital budget is exhausted.

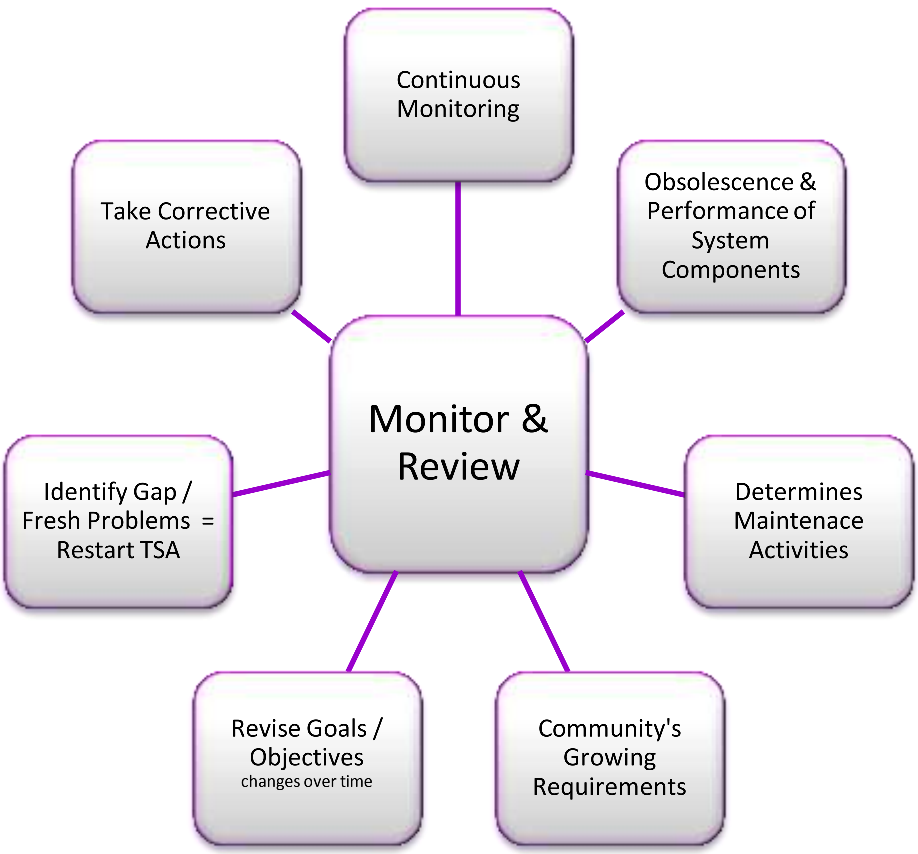
Step 6: Implementation

- Before implemented certain tasks should have been scheduled.
  - Clarity about which tasks to fund & when
  - Factors such as task programming, critical route methods, project management and hence the timing of transport capital budgets play a vital role in the implementation of projects.

- Untimely drying up of funds or temporary inadequate supply of capital interrupts project implementation. This has the following disadvantages:
  - Longer implementation is delayed, more acute original problem in existing transport facility becomes.
  - Inflation, budgetary discontinuity = even greater budget problems.
  - Additional implementation costs: factors of production go partly unemployed / unutilised.
  - Opportunity cost negatively influenced as asset investment already occurred before interruption.

- Implementation should be timely from the angle of the user needs, entail the lowest possible cost for the supplier, and cause the least possible interruption for the community as a whole.

Step 7: Monitoring performance and reviewing objectives and goals



60) SEQ What is the importance of community values in TSA? Ref. Par. 9.4.1.2 [Unsure]

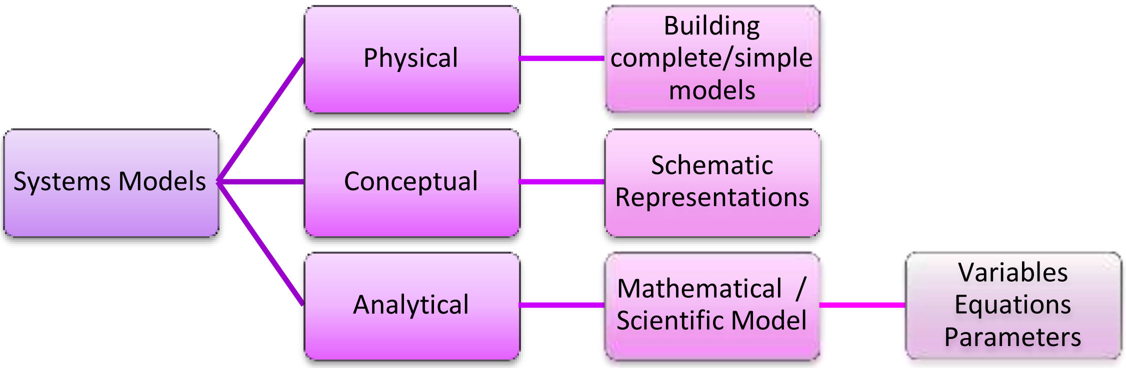
Provides a set of hierarchical community principles, values, goals & objectives that determines most desirable situation after problem has been solved → Crucial for problem identification as well as measures for rest of TSA

Objectives represent spectrum of conditions for the attainment of goals. Thus objectives are indicators of which alternative projects would best solve the identified problems.
Each planned/envisaged system component has consequences in the form of certain sets of values.

61) **[PE[x1]]** Discuss steps of Transport Systems Analysis (TSA) under subheadings: Step 1 Diagnosing the problem & assessing magnitude, Step 2 system modelling, Step 4 evaluation of alternative solutions. **(25)** Ref. Par.9.4, Fig. 9.1

See Question 55 above

62) **[PE[x3]]** System modelling is Step 2 of the transport system analysis (TSA). Fully discuss 3 basic types of models found in Step 2 of transport system analysis **(15 or 16)** Ref. Par.9.4.2.1



Physical Models
- Physical constructions with reduced size & complexity to represent a system.
- Describe physical systems, not social/behavioural systems.
- Simplification depends on analyst's available knowledge → more known → more eliminates characteristics not relevant to problem = considerable simplification of model & reduction in cost of construction.
- No previous knowledge → little simplification = building a complete model to study system harbour example pg. 81
- Use of time & resources depends on trade-off between construction costs & amount of information.
- Suitable for systems based on physical design in transportation engineering
- Used to evaluate system component designs e.g. highway intersections, interchanges, airports and harbours.

Conceptual Models:
- Describe nonphysical systems & involve no physical construction.
- Abstraction of a real system, rearranged a conceptual manner using simplified schematic representations
- Useful for logical relationships between systems components & causal relationships between phenomena.
- Explain these relationships & guide construction of analytical models used in systems analysis.

Analytical Models: most frequently encountered in transport systems analysis;
- Constructed to assisting analysis of a systems.
- Varied in nature, from complete summaries & computer simulations to rigid mathematical formulations.

- Mathematical models, type most commonly used
- Maths efficient in simplifying complex relationships & presenting them in concise forms
- Mathematical model made up of three parts:
  - *Variables* represent system components, environment, events and other internal & external influences.
  - *Equations* represent relationships between various components described by the variables.
  - *Parameters* represent magnitude of relationships between variables and their effect on one another.
- Used in different ways, depending on type of systems analysis: descriptive, forecasting or planning models.

STUDY UNIT 10, PAGE 87 For the purposes of this course, you are not expected to know the mathematical formulas used in this study unit.

63) SEQ What do you understand by the term "model"? Ref. Par. 10.1

Model: representation of a system developed by examining relationships between different variables seen as N.B. to the functioning of a particular total system.

- So designed that should one variables change, the influence upon the total system can be measured.
- Express model's relationships as graph / words / numbers (formulas)
- If numbers = mathematical (analytical model).
- Mathematical model indicating relationships between a set of mutual factors, provides simple & manageable picture of the working of the total system.

64) **[PE[x1]]** Discuss the advantages SEQ and constraints of analytical transport system models **(5)** Ref. Par. 10.2; 2013-S2-Assign.02

Advantages of Analytical Transport System Models

- Develop alternative methods of action. Allows for more precise decision making
- Models' formulation emphasises importance of functional interactions
- Make analyst aware of sensitive interactions in total system. Leads to complete reformulation of problem.
- Computer tech. relieves intensity of quantifying models → large variety of variables can be introduced at a relatively low incremental cost.
- Mathematical models use several formulas, of which the basic relationships are explanatory.
- After working out correct formula, obtain required answers through simple substitution of values.
- Basic formula enables analyst to assess present value according to historical data. Adjust formula if assessment differs from observed current situation → make future projections with greater certainty

Constraints of Analytical Transport System Models

- All relationships & related variables must be determined unambiguously.
- Determine relationships strictly according to mathematical methods
- All relevant variables must be quantifiable.
- Therefore requires a great quantity of data.
- Practical problems related to gathering, storage & handling data before storing in computer data bank.
- Costs & computer programming involved can hamper models' development - should be carefully considered.

65) **[PE[x6]]** Discuss / explain 3 types of analytical models found in transport systems modelling. Indicate different possibilities for their application in transport **(6 or 9 or 12)** Ref. Par. 10.4

Descriptive models: used to describe systems' behaviour

- Purpose: Reveals characteristics existing in systems' functioning
- Describes performance of similar systems by replicating functioning of observed system.
- Not heavily reliant on logical & causal relationships
- Construct using empirical anaylis - observing sufficient regularity in the system (E.g. historical data indicating correlation)
- Statistical analysis is helpful. Techniques incl. regression analysis (est. parameter values), correlation analysis (what variables to include) & factor analysis
- Description can be done in two directions.
- Both independent & dependent variables in descriptive model can be replaced

Forecasting models: predictive in nature

- Purpose: forecast system's performance at future time/under hypothetical conditions.
- "*Forecasting*": statement, invovleing probability, about possible occurrence of phenomena in the future
  Use e.g. simple extrapolation of past trends (e.g. time series analysis) or complex causal models (commonly known as econometric models).
- Models req. logical/causal relationship between variables & Stability of relationships among observed variables
- Forecasting can only be done in one direction.
- Cannot replace both independent & dependent variables
- Understanding of relationship between form and process becomes crucial
- Used to extrapolate trends / provide forecasts of response variables on basis of exogenous forecasts of the causal variables.
- Special case of conditional forecasting is impact analysis. Interest is focused on the consequences that should be expected to follow a specific exogenous impact if environment were otherwise undisturbed.

Planning models: used to derive strategies for systems planning

- Indication of how system should work / what should happen to the system.
- Useful in analysis of alternative systems.
- Evaluates various courses of action in terms of planning objectives and performance measures.
- Normative in nature.
- 2 Major groups:
  - Optimisation models: derive systems-operating or design strategies by describing system's objective
  - Called "*Objective function*" & usually a function of system operating variables
  - Model derives values of operating variables that optimise (minimise or maximise) objective function.
  - Construction Techniques incl. calculus, simulation & mathematical programming.
- Equilibrium models: used to derive operating strategies for behaviour systems
  - Rely on good descriptive models of the system.
  - Used for systems that has a response characteristic such that the response depends on the operating conditions of the system.
    E.g. demand & supply equilibrium analysis in transport demand modelling.
  - Used to describe the assignment of capacity to traffic links

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66) [PE[x1]] What are the characteristics one should strive for when constructing models? **(14)** Ref. Par.10.5

- Models should make sense.
- Common sense & logic is important in choosing model.
- Other model **characteristics** include:
  - Behavioural content:
    Models should truly represent the manner in which the systems they represent behave.
  - Empirical requirements
    Construct models in such a way that they do not require large amounts of data.
  - Analytical simplicity
    Uncomplicated models are easier to understand, less open to error and cheaper to calibrate & validate.
  - Exogenous control
    Constructing model that analyst knows meaning & implications of all variables & parameters allows possibility of exogenous control (i.e. modify/vary some parameter values in order to achieve better fit between the model & the real world).

Remember

"A BEE"

- Model building should follow a **systematic procedure**, including the five steps described below:

Identify Domain (Time / Space / Both)

- Identify boundaries of system being modelled

Define & Select Variables (Based on model's domain)

- Trade-off: All significant variables vs. less variables & simpler analysis

Establish Causal Relationship

- Reflects analyst's understanding of system. Represent using conceptual arrow diagram

Determine Exogenous (independent) & Endogenous (Dependant) Variables

- Distinction between system & environment variables.
- Exogenous: causal, input variables representing influence of environment on system's behaviour.
- Endogenous: system performance itself - reflect influence of response variables & indicate system's effectiveness

Define Structural Equations

- Mathematical representations of the relationships between variables using empirical analysis

- Use experimentation, measurement & statistical mathematical forms to test various mathematical forms.
- Model forms can be mathematically transformed into linear functions
  Transformation simplifies subsequent analysis and model manipulation