

Traffic Engineering
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Lecture No. 01

Traffic Engineering – Objectives and Role of Transportation Demand & Land-use

Hello friends, welcome to this NPTEL online certification course on Traffic Engineering. This is Module A. In the first lecture today, we shall discuss about traffic engineering objectives, role of transportation and transportation demand and land-use.

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Introduction

Traffic Engineering

- A branch of civil engineering which deals with **safe and efficient** movements of people and goods along roadways in a multi-modal system
- ✓ The most common unit used by a traffic engineer is **'vehicles'**: Transportation systems are **planned, designed and operated** to move vehicles **safely and efficiently** from place to place
- ✓ But, the main goal is the **movement of people and goods** that occupy vehicles

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What is really traffic engineering? This is a branch of civil engineering which deals with safe and efficient movement of people and goods along roadways in a multi-modal system. Let us carefully note some of the important points. First, we are talking about safety and efficiency. That's number one point. So, we are talking about safety and efficiency. Second, movement of people and goods, both. That's the second point, along roadways.

There are different modes of, different types of transportation system, road transportation system, rail transportation system, water transportation system, air transportation system. But here, we are talking about roadways and in a multi-modal system. That means not talking about a single mode of transport within roadways, but there are multiple modes which are using the roadways, and traffic engineering is trying to deal with all those modes, that means in a multi-modal system.

So, there are four components which you should remember carefully. First, we are talking about safety and efficiency. Second, we are talking about movement of people and goods.

Third, we are talking about roadways, road transportation system. And fourth, we are talking about multi-modal system on roadways.

If you look at the traffic engineering perspective, most of us traffic engineers, the most commonly used unit is 'vehicles'. Because, transportation systems are planned, designed and also operated to move vehicles safely and efficiently. End of the day, we try to ensure safety and efficiency for movement of vehicle from place to place.

But, let us also remember the main objective or goal is not the movement of vehicle, but it is movement of people and goods that occupy vehicles. Why I said this thing? Because, this is important, if we always think of vehicles, then we shall miss a very crucial step or crucial aspects of transportation system that is the modal distribution or the modal distribute mode choice analysis.

So, different modes are used. So, ultimately, how we will be able to carry people and goods from one place to another place, it depends a lot on what kind of modes we are using or what kind of modes people are using. So, traffic engineering terms, end of the day, we yes, we talk about vehicles only and safety and efficiency of vehicles.

But, let us remember at the back of the mind that our main goal is movement of people and goods and vehicles are only a medium to achieve that, right. Because ultimately goods and people get packed into different vehicles and that vehicle load comes on the road system.

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Introduction

- Traffic engineering is used for designing **public and private sector** transportation solutions duly considering all elements such as traffic flow, road geometry, sidewalks, bicycle facilities, shared lane markings, traffic signs, traffic lights, etc.

Providing **safety and efficiency** became a complex job for a traffic engineer in **multimodal system**

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Traffic Engineering is used for designing both public and private sector transportation solutions. There are many transportation problems. We shall see, we shall discuss all those

over time. Some of the transportation problem you already know, because, you might have done other courses related to transportation engineering, say for example, urban transportation systems planning, where we talked at length about various transportation problems.

So, traffic engineering is used for designing public and private sector transportation solutions, duly considering all necessary elements. What are those elements? That means, we are not talking only about the traffic flow, but we are also talking about the roads and the road geometry, talking about the sidewalks, which are required for the pedestrians, talking about bicycle facilities that appropriate shared lanes, we are also talking, shared lane facility, even the marking part also, we are talking about traffic signs, traffic lights.

So, every component all what are required for the system to operate with higher efficiency and higher safety, all are considered. So, traffic engineering is used for designing public and private sector transportation solutions, duly considering all relevant elements. Of course, we should keep in mind and that's what is the hard reality, that providing safety and efficiency became a complex job for traffic engineer in a multi-modal system.

Because, if you see, look at our urban roads, if you have high speed vehicles, motorized vehicles, but then also pedestrians are there, pedestrians heavy number or good proportion is present in the overall traffic stream. And we need to also care for the pedestrians. Vehicles have different characteristics. If you look at the urban system, the roads are also used by bicycles or urban areas also; many places the bicycles are used.

There are different vehicle types, they have different vehicle characteristics. So, the requirements and characteristics are very different for different vehicle types, in a multi-modal system. So, satisfying the requirement vehicles want to travel at high speed, because, everybody if you are using a vehicle, you want to travel faster. But then, the high speed may very adversely impact the safety of pedestrians and by-cyclists or the general vulnerable users in general. So, it is becoming extremely complex task in a multi-modal system.

But, we have to deal with that, because most cases the urban transportation system is, even the rural transportation system is also multi-modal in nature. And the multi-modal transportation system has its own advantages. Of course, we have to take the challenges as well. We have to address the challenge that why the traffic engineers are there.

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Introduction

Person Movement

- In the context of traffic engineering, the focus is on **person movements on streets and highways** (excluding rail, air, water transportation, etc.)
- Within and between urban agglomerations people normally move in a mix of vehicles:
 - ✓ Private Vehicles
 - ✓ Bus
 - ✓ Paratransit
 - ✓ Bicycle
- **Varied level of heterogeneity** in vehicular stream prevails in developing countries

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As I said, the traffic engineering deals with movement of person and goods. I said that although often we traffic engineers, talk about vehicles, but ultimately the objective is safe and efficient movement of people and goods. So you are talking about both, person movement and goods movement. So, person movement in the context of traffic engineering, the focus is, basically, on streets and highways.

Once again, I am trying to remind you. I told this that we are talking about the roadways because in the first slide itself when I introduced, what is traffic engineering. I said that please carefully note this point also that we are talking about all these movements on roadways so that means we are not considering rail transportation, air transportation, water transportation and other modes.

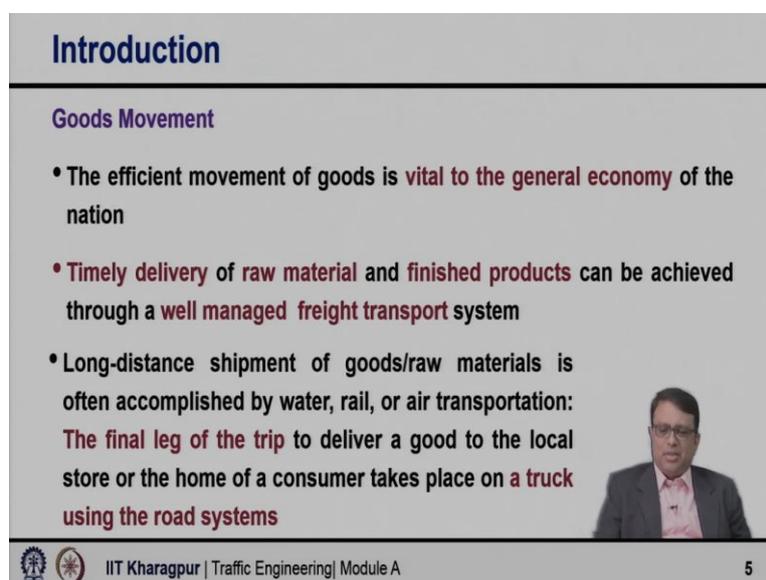
Now even if you take only the streets and highways, the road transportation, it is basically a mix of vehicles, all different modes. I have shown here a few modes, but if you look at some of the Indian cities or the cities in developing or emerging nations and emerging nations, you will find that there are several modes of transport.

You have private vehicle, you have buses, you have paratransit, you have even non-motorized mode like bicycles, and then electric bicycles to even if you consider cars, within cars also there have been so many variety of cars there, even though some cases even distinctly different in terms of their acceleration, deceleration characteristics, horsepower, and all other features essentially.

Same way, the bus is not one type of bus, there are so many different types of buses are available, right. So, it is actually within and between urban agglomerations people normally move in a mix of vehicles and there is a varied level of heterogeneity in the vehicular streams, which are prevailing in developing and emerging countries. And that is a big challenge for traffic engineers to solve or to handle.

Because, whenever we are trying to think about safety and efficiency, we have to deal with this multi-modal system or considered so, many different types of vehicles, their characteristics and all the things.

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Introduction

Goods Movement

- The efficient movement of goods is **vital to the general economy** of the nation
- **Timely delivery of raw material and finished products** can be achieved through a **well managed freight transport system**
- Long-distance shipment of goods/raw materials is often accomplished by water, rail, or air transportation: **The final leg of the trip to deliver a good to the local store or the home of a consumer takes place on a truck using the road systems**

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The other important requirement is the movement of goods. Often, we do not consider them important. If you are traveling in a car and if you get stuck in a traffic jam, and if you find there are commercial vehicles or the big trucks are there even on highways or in urban areas, wherever it is, we generally feel that they are the problems. Yes, their acceleration, deceleration characteristics are different and therefore, their vehicle characteristics are distinctly different from those of other vehicles that means, particularly cars.

But, remember that they are extremely important, because most cases, the urban transportation systems we talk, urban areas, they do not produce anything. Most cases, all food, vegetables, everything come from outside. So, even the other, whatever we are using our electric oven to even microwave oven or the fan, the light, everything, most of the things, they come from outside.

The basic thing is the food. Food part, nearly, everything comes from outside. So, the goods movement are extremely important, we must care for that. Rural areas again, the goods transportation is really important for the economy and to maintain that supply chain in a proper way. So, the efficient movement of goods is vital to the general economy of the nation and timely delivery of raw material as well as the finished products, they can be achieved through well managed freight transportation system.

So, as the passenger transportation is important, freight transportation is equally important. And we have learned, during this pandemic or COVID 19 outbreak, that even people could not go to office, people could not go to work, but they could manage, they could stay, they could survive for some time, but without food people will not survive. So, you need the supply.

So, there you realize that how important goods transportation is and therefore, the approach to goods transportation should be very positive, that we need them. They are actually essential for our in a way survival and for living the life with a required quality. Although in many cases the long distance shipment of goods and raw material is often accomplished by other modes, say for water transport, rail transport, air transport some cases, but the final leg of the delivery once it comes to the port or once it comes to the up to the railway station or the air terminal, then the final leg of delivery is always through road transport.

And most cases you will find, there are various types of truck, maybe small vehicle, big vehicle, there are variety of goods vehicle are also there, plying on both urban and rural roads. So, the goods movement, finally, the dependency door-to-door delivery or the final leg of the trip is always through road transport. Because directly rail and air and water will not give door-to-door delivery.

So, finished product door-to-door delivery and even the raw material it may not be able to take up to the point, where it is required. So, often the the final leg is, basically, the road transportation system and using the trucks. So, both goods and passenger transport are important.

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Traffic Engineering Objectives

Objectives

- **Primary Objective**
 - ✓ Safety
- **Other Objectives**
 - ✓ Speed
 - ✓ Economy
 - ✓ Comfort
 - ✓ Environmental Compatibility
 - ✓ Convenience



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Now, what are the objectives of traffic engineering? The primary objective is no doubt the safety. That's the most important thing. But, there are a number of other objectives which also we need to care about. See for example, speed, the comfort, the convenience, specially, for passenger transportation system, these are very important, the economy, the environmental compatibility, very very important this is.

So, these are all the objectives, we want high safety, we want speed wise good, high comfort, convenience, economical and environmentally compatible transportation systems. So, that is the job of traffic engineer. So, these are all the objectives for traffic engineer.

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Traffic Engineering Objectives

Safety (Primary Objective)

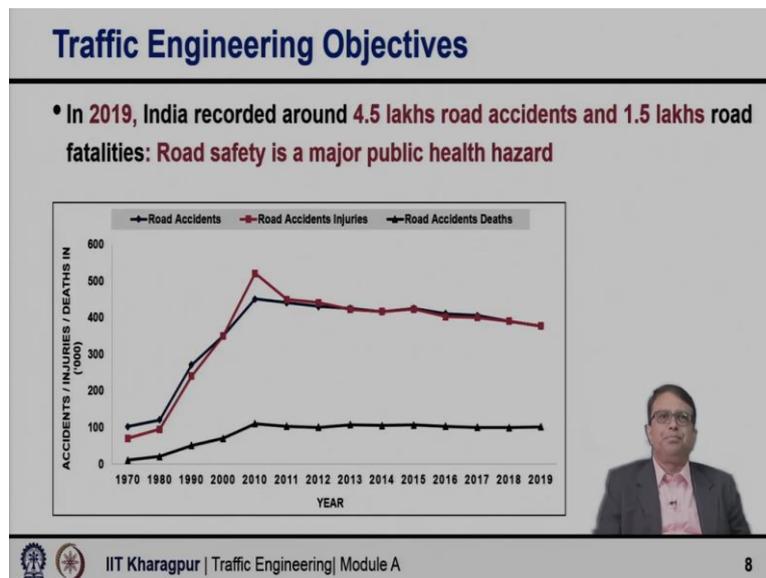
- The **principal goal** of a **traffic engineer** is to provide a **safe transportation system** for public
- Globally, approximately **1.35 million** people die each year as a result of road **traffic crashes**
- **93%** of the world fatalities on the roads: **Low and middle income countries**



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Now, safety is obviously the primary objective or primary goal of a traffic engineer. Because, if you see, why we are focusing so much on safety? Because, globally, approximately 1.35 million people die every year. It's a huge number. 1.35 million. You can imagine. And next is even more important. More than 90 percent of the fatalities are in low- and medium-income countries. So, India also is included there. So, 93 more than 90 percent is the share of low- and medium-income countries. So, if you see the worst affected segment, because of the road safety, is actually the low- and medium-income countries. So, we need to care for that.

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In 2019, alone, India recorded around 4.5 lakhs road accidents, and nearly one and a half lakh road fatalities. You can imagine one and a half lakh road fatalities means if you divide it by 365, it is more than 400 people dying every day on Indian roads. It is almost equivalent to one air crash that shortly say. So, it's really a major public health hazard and the safety is the top priority for traffic engineers and we cannot neglect this. That should be our priority, how to make the transportation system safer both in rural and also in urban area.

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Traffic Engineering Objectives

- India ranks 1st among 199 countries in road accidents
- Each year about 3% to 5 % of the country's (India) GDP is lost due to road accidents
- The objective of safe travel is always number one and is never finished for the traffic engineer



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India ranks one among 199 countries in road accident and the loss of because of road accident and fatality, injury various levels, the loss is about 3 to 5 percent of the GDP. So, how much we are struggling to maintain the growth of GDP and 3 to 5 percent of the country's GDP is lost because of the road accident.

So, we have a lot of responsibility in terms of, in that way, right, to to help the country to go faster, and to ensure that we have better facilities and lesser number of road accidents and fatalities. So, I would say that this objective of safe travel is always number one and is never finished for the traffic engineer.

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Traffic Engineering Objectives

Other Objectives

- Relate to self-evident desires of the travelers
- People want their trips to be fast, comfortable, convenient and cheap (in terms of fare or out-of-pocket expenses)
- Other aspects of economy (excluding fare) and environmental compatibility are also important from the point of view of the society
- Balancing these objectives against each other and against primary objective of safety is a challenge



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If you look at the other objective comfort, convenience, all other things, cost, they relate to self-evident desires of travel. Anybody would like to have that. For example, people want to travel from one place to another; obviously, they want to travel very fast, shortest possible time. They want to, they desire to have high comfort level, convenient system and also cheap, in terms of out-of-pocket expenses.

So, other aspects of economy including the fare, because the overall economic impact is also very important. Whatever you do, any improvement you do, any investment you will do to improve the transportation system or the traffic systems, the overall other aspects of economy are also important. And the environmental compatibility. As I said most of the cities you will find the pollution level is very high. So, the environmental compatibility is no doubt an important consideration.

Now, the basic challenge come, how to balance these objectives against each other and against primary objective of safety. That means, if you want to make the system more comfortable, then it may be more expensive, fare will be high, say in case, if you want a normal bus or vis-a-vis we say, an air-conditioned service.

So, obviously air-conditioned services, more comfortable, but the fare also will be very high. So, how to kind of trade off between or among these secondary objectives, I will say, and also against the primary objective. If you want the travel time to be faster, but we need faster but without compromising the safety, and high speed is really a major cause of fatality.

And in our cases, the infrastructure is many were deficient. And we have land acquisition issue, we have heterogeneous traffic, we have high proportion of non-motorized users or non-motorized modes like pedestrians, bicyclists and so on. So, how to balance this objectives against each other and also against the primary objective of safety that is a big challenge.

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Traffic Engineering Objectives

- Speed
 - ✓Travel speed is needed for **faster** movement of vehicles: **Restricted** by transportation **technology**, **human characteristics** and **safety** consideration
- Comfort
 - ✓Relates to **physical characteristics** of vehicles and roadways, travel conditions (say, **crowding** in public transport) and depends on **user perception**



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Say speed travel. Speed is needed for faster movement of vehicles and how we determine what speed is acceptable. Obviously, one part is, what is the technology. If you see a typical 3-wheeler or a slow-moving vehicle, it cannot travel very fast because the capability, the technology is very different. Whereas you take a fast, modern, new technology car, it can travel at a very high speed. So, whatever a new car, new technology car, whatever speed it can achieve, a commercial vehicle like a truck or some of the smaller slow-moving vehicle, cannot even achieve that. So, the transportation technologies one consideration.

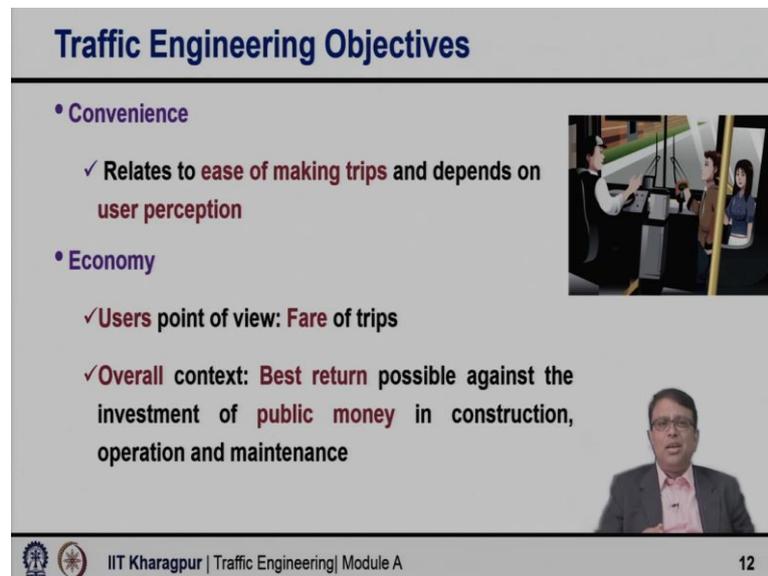
Human characteristics driver, all drivers again are not same, right. So, the driver characteristics, human characteristics will come. And most importantly, again going back, safety consideration. So, what should be the safe speed limit is not only decided by the kinds of roads what we are providing or the vehicle, but also the safety considerations. And speed, as I said, repeat again, speed is a major cause of high speed is a major cause of fatality.

So, if we need really to improve our performance in terms of the reduced number of road accidents and more particularly about the fatality, then we need to do more effective speed management on our roads. The comfort relates to physical characteristics of vehicle, because some vehicle, the cushion to everything, the suspension system is better than others. So, the vehicle technology itself can take care of that.

Road condition, you improve the road condition. So, obviously the all kinds of vehicle, the comfort level will improve, and also depend on the travel condition, sometimes, within the vehicle. So, you are traveling in a bus, so the crowding inside the public transport that inside the vehicle the level of crowding causes a lot of discomfort.

Different levels of crowding will mean different comfort level or discomfort level. So, it depends on the physical characteristics of vehicle, roadways, travel conditions. And people consider it. It more depends on the user perception. How people are perceiving the comfort level, more of the user perception.

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Traffic Engineering Objectives

- **Convenience**
 - ✓ Relates to **ease of making trips** and depends on **user perception**
- **Economy**
 - ✓ **Users point of view: Fare of trips**
 - ✓ **Overall context: Best return possible against the investment of public money in construction, operation and maintenance**

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Convenience. It against relate to ease of making trips, and again something which depends on user perception. The perception may change from one city to another city, one context to another context. Next is Economy. Economy. There are two aspects. From road user point of view, if I am using a public transport system or an intermediate public transport for my travel, so, from user point of view, it is the fare for trips. How much directly I have to pay. But the overall context is also very important, that means we are doing something, government is investing money to improve the transportation system.

Now, how this such kind of improvement can be justified. It based on the return. How much benefit is coming, how much, actually, it is a will to improve. So, we need best return possible against the investment of public money, whether you talk about construction, you talk about operation, you talk about maintenance, everywhere, it is the public money which is invested in the transport sector. So, therefore, we need the return, best return. That also relates to economy.

So, you have already studied probably some of these related terminologies that internal rate of return, benefit cost ratio, net present value, all these are commonly used for understanding the, judging the cost benefit from a project over a period of time. So, this economy, so, one is

from user point of view, it is fare; the other is the overall context whether it is the best return. So, both are important and relate to economy.

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Traffic Engineering Objectives

- **Environment**
 - ✓ **Minimizing the impact of transportation systems on the environment: Air quality and noise**
 - ✓ **Compatibility of transportation systems with physical environment-harmony of transport systems with environment by providing aesthetically pleasing facilities that fit in with the surroundings**

The slide includes three small images: a car emitting exhaust, a car with a person's head inside, and a road with a green landscape. A video inset shows a man in a suit speaking.

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Environment. Again, there are two aspects. One thing, most of the cities in developing and emerging nations including India, our cities, the air pollution is a major major problem. In several cities, the air pollutant levels are three to five times higher than what are the prescribed safe limits by World Health Organizations.

And if you look at the cities, the major contributor is transport, I will not say that other sources are not contributing, maybe contributing marginally, but the single largest contributor is the transport. So, if you want to improve the overall air pollution or air quality in the urban area, we need to focus on the transport part of it. So, that is what.

Similar is the noise. So, look at the level of noise in some of the Indian cities, it is like mad situation, mad situation really. So, minimizing the impact of transportation system on the environment. That is one of the objectives. The second is a different thing I am talking now. Compatibility of the transportation system with the physical environment.

You have a land-use. You are developing a system or infrastructure in an urban area, right. So, it has to be compatible with the land-use, with the surrounding development, that is also very important. So, I say that compatibility of the transportation system with physical environment, that is basically indicating the harmony of the transportation system with environment, by providing aesthetically pleasing facilities that fit to the surroundings.

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Traffic Engineering Objectives

- The traffic engineer is tasked with all of these goals and objectives and making an appropriate **trade-offs to optimize both the transportation systems and the use of public funds** to build, operate and maintain related infrastructure and facilities
- Transportation Systems are a major component of economy, and have enormous impact on **shape of the society and efficiency of economy**



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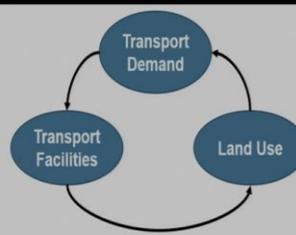
Now, the traffic engineer is tasked with all of these goals and objective and making an appropriate trade off. As I say there, it is sometimes difficult, if you want to satisfy one thing to a larger extent, you will get, you have to probably compromise that the other end, right. So, how to do the trade off to optimize both the transportation system and use of public funds.

Because, everything is invested by the government using the public fund to build, operate and maintain related infrastructure and facilities. Now, transportation system, remember that are a major component of economy, the country, economy of a country rolls on transport, and therefore transport systems have enormous impact on the shape of the society and efficiency of the economy.

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Role of Transport Demand and Land Use

- The **unprecedented growth of vehicles** (directly related to **transportation demand**): The primary concern for traffic engineers
- Transportation demand is directly related to **land-use, and available transportation systems and facilities**



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Next, role of transport demand and land-use. The basic challenge the traffic engineers we are facing are, basically, the unprecedented growth of vehicles. Everywhere, vehicle, number of vehicles is increasing and the infrastructure is not increasing at the same pace. Now, if you say unprecedented growth of vehicle, it is, basically, directly related to the transport demand, because that is the demand part of it.

Road infrastructure facilities that the supply part of it and in a transportation system, it is interaction between the demand and supply in the interface of control. So, the primary concern of traffic engineer we can say is, basically, the transport demand. The high demand and the way the demand is growing. And in that context, you can see that transportation demand is directly related to land-use and available transportation systems and facilities. These interrelations also we have to keep in mind.

For example, you have a given land-use, so, people want to travel from one point to another based on the land-use, so, that generate the transport demand. Transport demand is higher. So, you improve the transportation facilities, the transportation facilities again impact the land-use. Because land becomes more valuable, more attractive, once the transport facilities improve.

So, that again is trying to influence the transport demand. So, in a way if you see the transport demand, how much will be the demand that depends on the facility. This depends on the land-use. Both are in a way or other, contributing to the development or the growth of the transport demand.

And even the higher transportation or better transportation facility itself may induce higher travel. So, the transport demand may improve. Suppose, if you want to travel from one point to another, if there is a very good bus system or very good rail system or metro system, you will travel more frequently. So, the amount of travel will increase simply because there is a good transportation system. And also, there is an impact of the land-use. So, land-use is actually feeding to the transport demand.

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Role of Transport Demand and Land Use

- **Improvement** of transportation systems makes the nearby land more **accessible** and therefore, attract more developments
- More developments result in even **higher** transportation demands
- This **circular, self reinforcing** characteristics of traffic demand creates a **central dilemma**

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In this slide, I am trying to show that interaction, you can take, and you can consider that there is an existing land-use. So, the land-use, because of the land-use, spatially separated activities, people are living somewhere and offices are somewhere, schools are somewhere, so, the trips are generated. So, because there are more number of trips, how people will travel. So, that brings the transportation needs. So, you see that there is a lot of need for transportation system. You have developed the facilities.

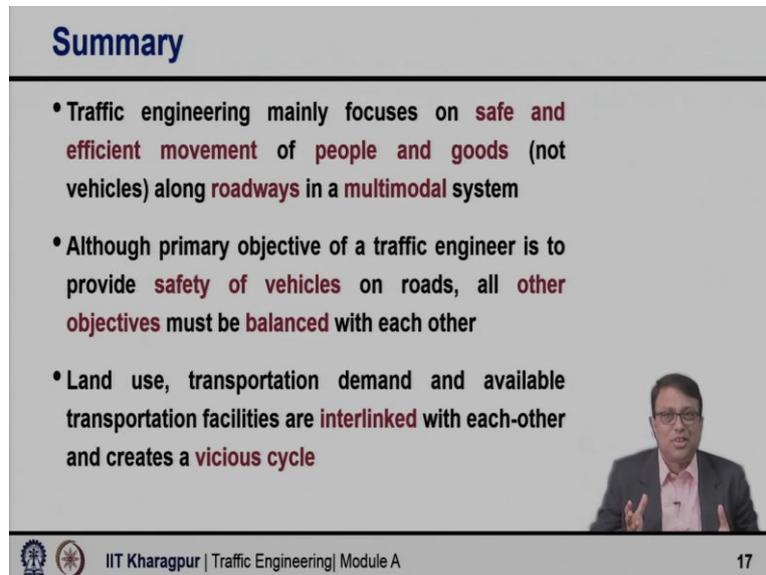
Now, once you develop the facilities and system that will improve the accessibility because overall connections, overall access to land, nearby land will improve. So, the land value will change as you know the moment you develop a road, the land value immediately increases adjacent to that road or if there is a metro line coming up near all the station the land value will shoot up like anything will go up. So, the accessibility influences the land value.

So, now that will change the land-use and the moment the land-uses change, more development, more housing, more industry, depending on the what is the nature of land-use. So, that will induce further the trips, generate additional need and go on. So, this circular self-reinforcing characteristic of transport demand creates a central dilemma. You develop the thing there is a demand. So, to satisfy that you improve the transportation system and you improve the transportation system further more and more demand gets generated because of that.

So, this interaction between the land-use and transport, land-use transport, accessibility, transportation needs, the way the whole thing actually interacts and the circular and self

reinforcing characteristics of traffic demand creates a central dilemma, that you should bear in mind or understand clearly.

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Summary

- Traffic engineering mainly focuses on **safe and efficient movement of people and goods** (not vehicles) along **roadways** in a **multimodal system**
- Although primary objective of a traffic engineer is to provide **safety of vehicles** on roads, all **other objectives** must be **balanced** with each other
- Land use, transportation demand and available transportation facilities are **interlinked** with each-other and creates a **vicious cycle**

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So, if I have to summarize, I will say traffic engineering mainly focus on safe and efficient movement of people and goods, on not really primary objective is vehicle but movement of people and goods, although end of the day traffic engineers like us, often will refer to vehicles only. But that is a different story.

So, remember that people and goods and we are talking about the road system only, not water transport, air transport, rail transport etc., and in a multi-modal system. So, again, please remember this 4-5 things, safety and efficiency, people and goods, talking about the roads and in a multi-modal system. And movement of people and goods, not the vehicles.

Second, although the primary objective of a traffic engineer is to provide safety of vehicles on roads, all other objectives are natural desire of road users. And also, the requirement of the larger society, some are like the fare, the comfort, convenience, but if you see the environment, it is the requirement of or the need for the larger society, societal requirement. So, all these are to be balanced and that is where the challenge comes to traffic engineer.

Finally, land-use. transport demand and available transportation facilities are interlinked with each other and creates a kind of a vicious cycle. So, we have to understand that, we have to keep that in mind while we are trying to improve the overall system. So, with this, I close this lecture. Thank you so much.