Introduction to Civil Engineering Profession

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Lecture – 16
Traffic Engineering and Transport Planning

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So, the topic that was given to me is projected here traffic engineering and planning was what is given to me. I corrected in little bit to call it as traffic engineering and transport planning ok. Why is it so? Why did I correct it?

No you are not used to answering. So, let us move on. So, what is traffic engineering is they will edit whatever they do not want from here. So, what is traffic engineering as per your understanding? I need answers. There is no way otherwise I can teach.

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Traffic engineering.

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Ok, but that what is that lifecycle include different task.

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Student: (Refer Time: 01:02)

Before construction there is one more stage.

Student: Planning.

Yes planning then construction. Ok, good you looked at this slides either ok.

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Let us come back come back so.

Student: (Refer Time: 01:19)

Stop. So, this is what I got when I searched in the Google pictures Google images what is traffic engineering. So, I see intersections, inter changes, vehicles moving what else you see. Then there is one which is having lot of text saying traffic models, traffic control, traffic monitoring, intelligent transportation systems. So, all these are covered by what we said is what I believe.

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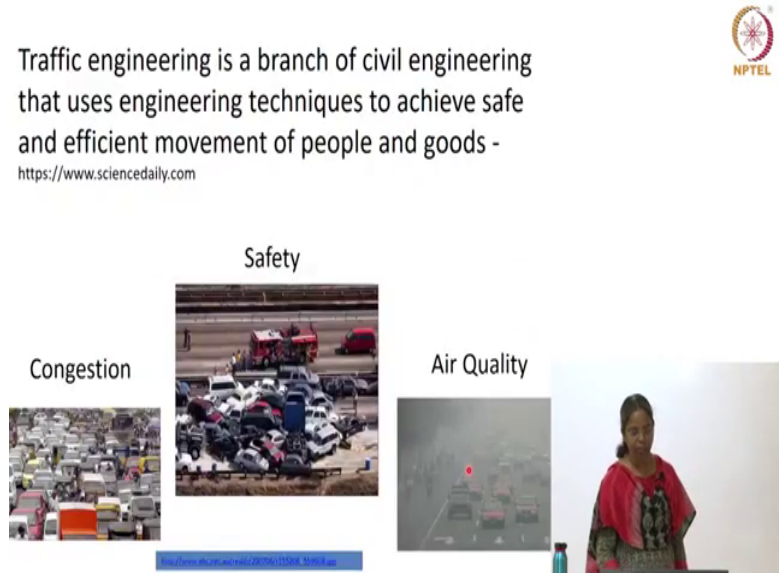

So, let me look at show you the simplest definition I saw in a website this is a very simple website. It says traffic engineering is a branch of civil engineering that uses engineering techniques to achieve safe and efficient movement of people and goods. Very simple right and it conveys what traffic engineering is all about. Its all about moving people and goods from one place to another.

The major conditions that you add is safe efficient and economic movement. So, thing is what the traffic engineering is. And why do we do this? There are mainly 3 problems which we talk about one is congestion, the other is safety, the third is pollution or you know emissions.

So, when you say we have to design this system we are talking about how do we address these problems or designs the thing such that these problems are minimized. And what is the

problem here when you are trying to minimize some of these or when you look at these objectives.

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Let me go to the next slide. So, the basic objectives you will see in any textbook any anywhere you will read is the like safe, efficient and economic movement of people and goods. So, what is the problem here. I have a problem in this 3 objectives that we are talking about ok. When you talk about safe how do we make a traffic system safe.

So, usually you talk about reducing speeds right that is how you talk make it is more safe, but then if you want to make it more efficient what should you do. You have to make them move as fast as possible right. So, we are seeing some conflicting objectives in the whole process. That is the that is the difficulty. So, we always look for the optimum way of handling these

problems. How do we make them move fast enough and safe enough, but it is again you cannot say that average is good enough. We want the minimum accident.

So, we cannot say 50 percent is good enough for you. So, that is one of the major challenges you will face in your trying to do this. And what are all the components that we are talking about. There are mainly 3 components one is what we already discussed the infrastructure, the roadway, the railway, the air airport and all those things. The second is the moving objects there the vehicles, the train, air plane. So, that is where I am going to concentrate maximum in this discussion because the infrastructure is something which you already have listened to into 2 different talks. And the third component which is the most complex one is the human component in it. There is always a driver there is always a pedestrian who is involved in the system and that component is not under your control. In the sense it is not easy to model it into your you know equations or anything because human behavior is very complex right.

So, the challenge in terms of modeling this traffic movement once the infrastructure is there the most complex part is how do we characterize the driver behavior. For example, different people will be behave differently for the same situations right. So, how many of you have driving license. You have not is that 2 wheeler at least 2 wheeler at least you have right.

So, you and your friend drives you do not behave the same way when you have the same situation in front of you. You yourself may not behave the same way for the same situation at different time periods. So, if you have to kind of capture this behavior into your models it becomes highly complex right. So, these 3 components each of those how do we handle.

For the other part of a vehicles if you take even if you restrict to the road roadway movement there are bullock carts, there are 2 wheelers, there are auto rickshaws up to trucks. How do we kind of incorporate all those different types of vehicles into the design right for management how will we do that. So, and what you need is finally a system which is as uniform as possible right.

You do not want different either you do not see different roadway for 2 wheelers and different roadways for trucks right that is correct. So, the one another challenge which you are going to

see is you have varied components in the sense you have different types of vehicles, different types of users and you want to provide roadways and the system which is very uniform.

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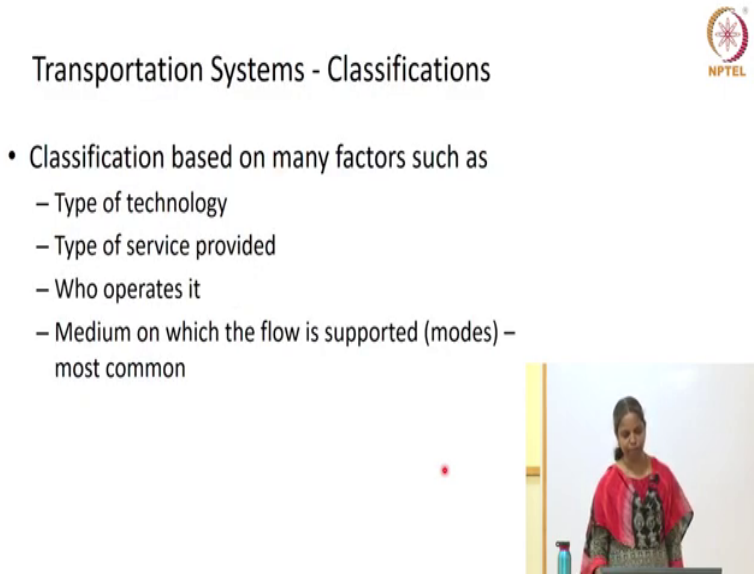

So, how do we handle these challenging problem is one of the problems we will talk about. So, before getting into how do we do that what are all the classifications of these systems? So, you classify this system based on what technology you use, what service you provide, who operates it, what are all the medium. So, each of this do you understand when I say what mode for example, if its rail versus air versus roadway for example, it is one of them.

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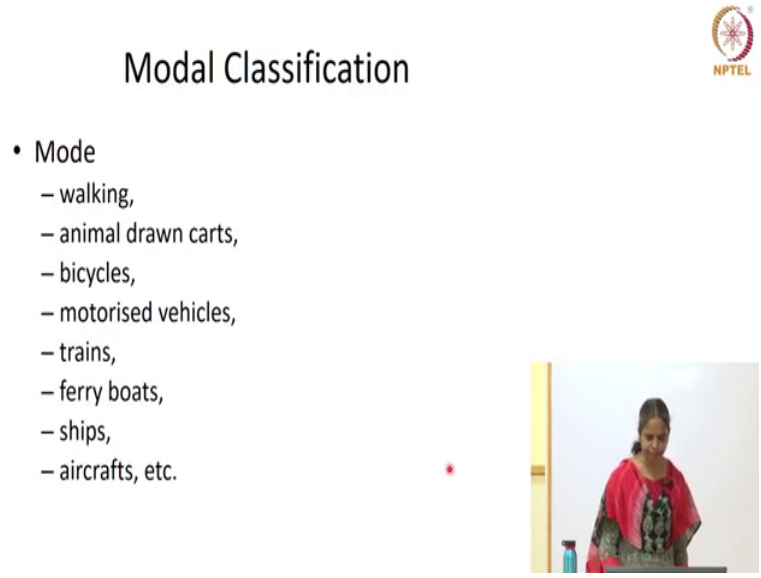

So, by mode you can see these are all the different ways in which one can commute from one place to the other simplest being walking running whatever you want to. Then there are different types of vehicles you can roadway vehicles then there are boat ships aircrafts all those the.

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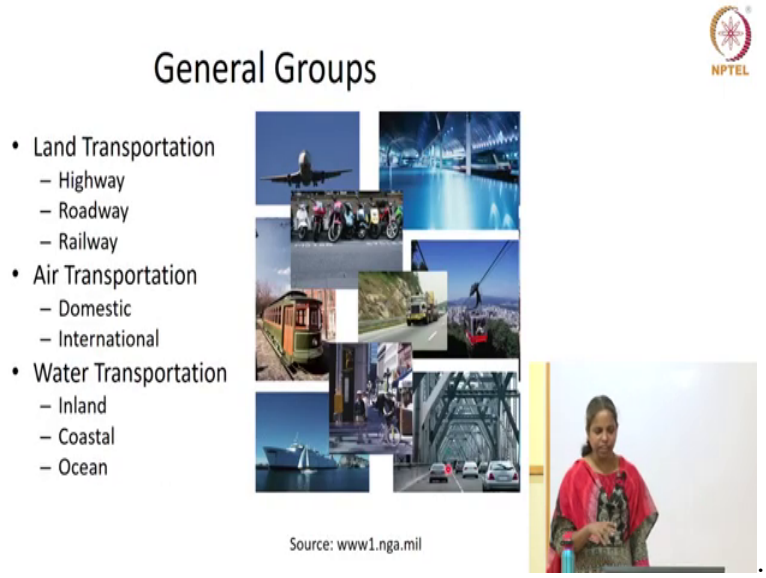

In some way if you group this you can say there are land transportation, air transportation and water transportation each of those have a bunch of different types of vehicles.

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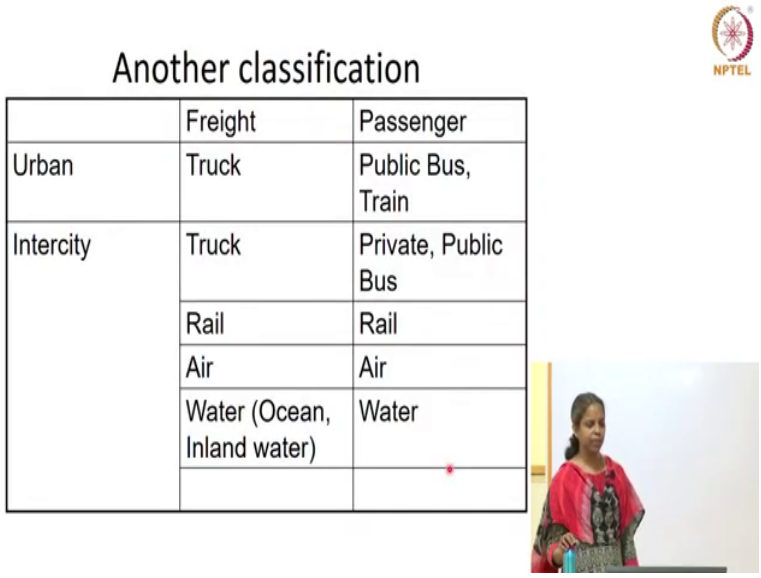

A different way of looking at the classification is urban versus you know inter city travel freight versus passenger movement. How so each of these have uniquely different ways of handling.

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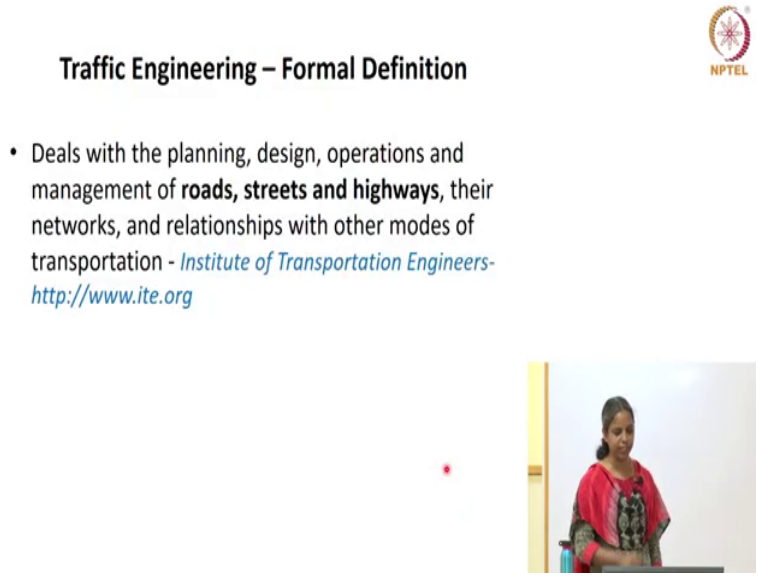

So, these are all different ways of classifying the system. Now coming to the formal definition of traffic engineering. What we saw was a very simple proved way of starting saying that you know move people and goods now one place to another.

Here is the definition you will see in any textbook or example and this is restricting it to the road roadways alone. It says it is planning design operation and management. What he repeated the is what that formal definition is. So, these are the stages you will go through when you have to do a complete design or complete system development for transportation.

And each of this terms planning design operations management I even explain in one slide each of this is a separate course eventually. You have two undergrad level transportation courses

which will cover all these in a very brief way then there are separate courses for each of this which we will cover the complete details.

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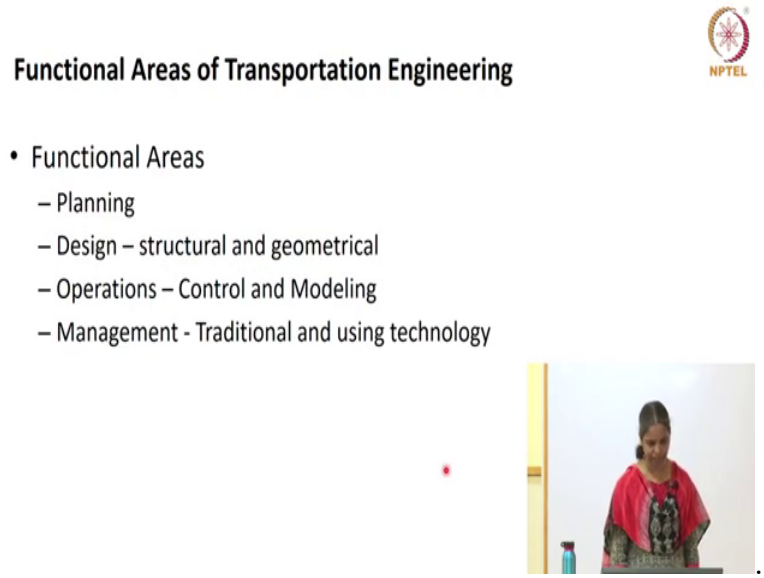

So, what is planning, what is design, what is operations and what is management. Design is what you heard little bit already from the other lectures I will believe, it is talked about how do you design the payment. For example, if there is a traffic law how do you design the road way, but even before designing you have to plan the system.

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So, why is it important? One characteristics of this transportation is you do not usually you do not make a trip just for the sake of it. You do not go for a drive whether I early moving one person you will be just for the thrill of riding a bike or something you enjoy, but most of the time you are traveling for some other purpose. Either you are going to your class or you are going to a movie, you are going to visit someone.

So, there is an end reason for you to make the trip. So, that is what is meant by the derived there is a term called its a derived demand. So, the trip you make is related to some other activities most of the time it will be socio economic a related things. So, the land use plays a major role in what trips happen correct. If its a recreational area the trips are mostly to visit the place. If its a residential area the trips are usually people who want to go to their

workplace or they want go to their collages. If its a shopping area people go for shopping obvious right.

So, each of this trip is related to the land use of that area. So, the planning part kind of link the land use to the trips that you make. So, when you say you want to plan something or when you want to plan a transportation system you start with the land use of the area. So, if let us say a somebody says that they want to move the capital from Chennai to some other city. So, you will have to design the entire transportation system there. So, you will start with looking at different zones in that area, what is the land use of each of that area, then you start planning. So, how do we do that and usually this planning and design is done for a period of around 20 years 15 to 20 years.

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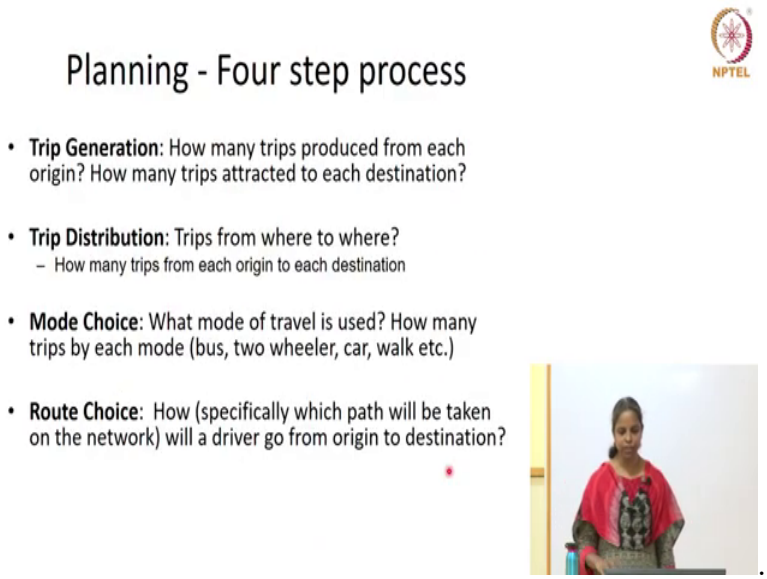

So, the planning part has 4 major steps. I am not going to get into the details, but its they are called trip generations, trip distribution, models click and route choice. So, what we are saying is first you want to find out how many trips are generated from each place or how many trips are attracted to each place in the first step first stage. In the second stage what you are doing is you are trying to say from this zone to this zone these many trips happened. That is the trip distribution step. Then you are looking at how many of those trips are done in different modes 2 wheelers, how many cars, how many public transport model and the last part is which route each of these trips happened.

So, at the end of this fourth stage you know from each zone to each zone how many trips happen by each mode through which route he understands. So, at the end of this you will know that this route this many 2 wheelers and this many cars have to go. Then you get into the design where you will use this information to design, what type of road way you need, how much thickness you should give or material you should use and all go.

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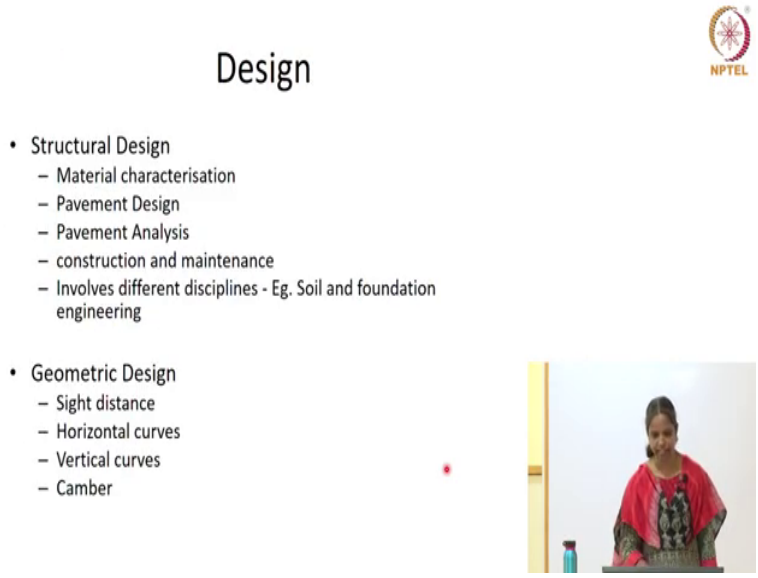

So, that is the next stage which is the design. So, there you are looking at how do I define this system or the road way. So, you will be getting into what I said as the hard side of it. Basically, you are looking at how do I do the characterization of the material, how do I design the thickness, how do I check the stress and strain. So, that is generated whether it is safe whether it will crack all those information you need.

So, this is more of the structural design of the roadway. That is one part. You would have heard some lectures on structural design of building similar to that you are talking about structural design of roadway. Once that part is done the other part is the geometric design where you are looking at how do I design the curves, how do I make sure that the vehicles are not thrown out when you are negotiating a curve or how do I make sure that a vehicle do not slip back when they are climbing an uphill. So, you have to make sure it is done correctly. So,

that is a geometric design part of it. As I said each of this is a separate course. Geometric design of highways is one separate course and is offered from the transportation.

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So, this is a second stage. So, it was planning design third is what is called as the operations. How do we control or manage the vehicular movement on a roadway. So, there is no way you can communicate with the driver. As an engineer you do not communicate with the driver by calling hey you cannot go this way. So, you need some kind of media to communicate with your drivers that is what this operations mainly is. It is mostly about sign markings and signals.

You would have seen all of these. So, markings are on the roadway, signboard sit in the roadside and then signal sits either in the roadside or across the road. So, these three kind of tell you how you should behave in a roadway. So, the operations usually is how do you design

the signals, how do you make sure the signs are correctly placed and correctly conveying the information that it should be.

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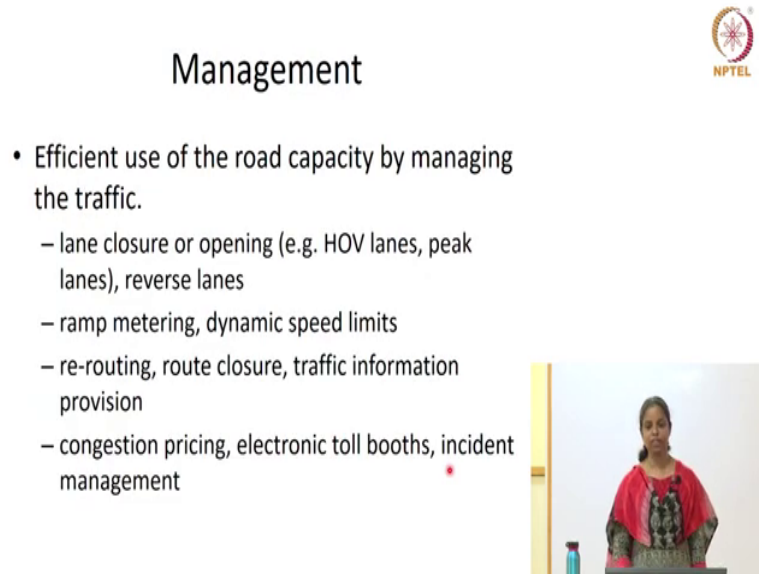

So, it is again separate course which is on signal design, signal analysis and the (Refer time: 14:40). The last part is mostly on the management. Once you have these how do we handle the traffic skill you know in terms of. Mostly you see this being done in India by the traffic police right. Suddenly the traffic police decides that this road has to be a one way because there are there is problem. Ideally it should be done by traffic engineers, but here mostly that police people do that, but these are different ways in which one can manage the traffic once you have the roadway done signals in place are done.

So, having said these 4 steps planning, design, operations and management we will mostly concentrate on the operations and management part. That is what the soft traffic side of it. So,

you have the planning done signal design sorry roadway design done and how do we make sure they are moving efficiently right.

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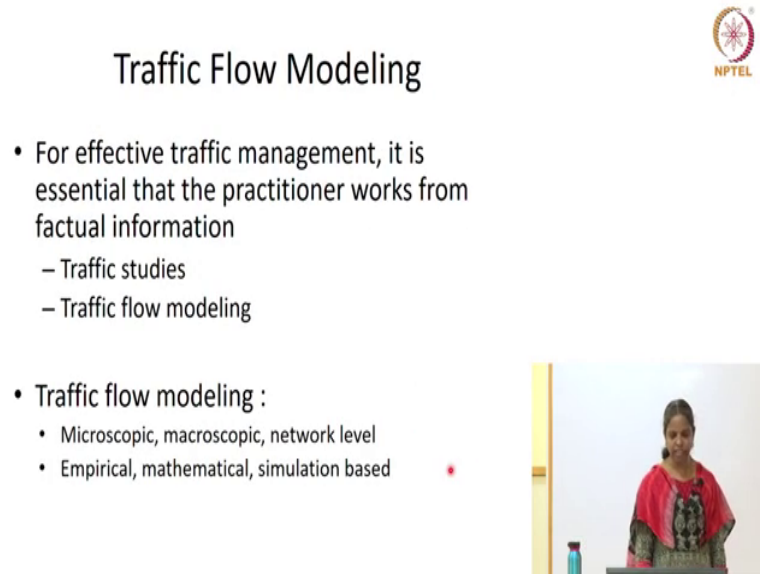

That is what this is. So, one major part is you have to model the traffic. You have to kind of you have seen you know modeling of different things. For example, rocket; if you have to design first you start with equations that will design. You will decide how it is going to move, how it is you know trajectory is going to be all those.

Similar way you have to have models which will characterize how this traffic is going it is. Its in one way to find out how this traffic is going to behave at different time and different location. That is that is what the modeling is trying to do. And for doing that you have to collect lot of information traffic studies will come up and then the modeling part which can be statistical modeling, it can be mathematical modeling, it can be just data driven models,

empirical models all those. But some way you want to model and the other question is how do we model this system. There are vehicles then there is all the vehicles moving on the roadway then there is a city level network.

So, which one you do you model. That is where these terminologies come. There are microscopic models which are individual vehicles how do they move. The macroscopic models kind of come out with the equations or ways in which you will know how the traffic as a whole is moving. Then there is network level in a city level if you want the model you do not move here at a every (Refer time: 17:04) that is how the traffic is moving. So, how do we do it at the network level. Each is challenging in it is own way because for example, if you take microscopic level how one vehicle will follow its leader. Its challenging because it heavily depends on the human behavior the driver who is sitting in the vehicle. So, how do we include all these into the modeling and have some reasonably good models is what comes under the discussion in traffic flow modeling.

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And this is something which is more recent by recent I mean in 70s it started, but still the other things are 30s. So, 1930s this is in 1970s what is called as Intelligent Transportation Systems many of you have heard this term I hope. So, what we are talking about is so far whatever we talked was done in a very traditional way. You know you collect some data by going there manually collecting, analyze it come out with something.

With the latest technologies in terms of sensors, in terms of communication, in terms of analysis there are new ways in which you can handle these problems. Whether it is operations or whether it is management. So, that is what the Intelligent Transportation System is. So, this is again a textbook definition which says that any advanced communications, control, electronics, computer related technologies being used in traffic that is what the Intelligent Transportation System is.

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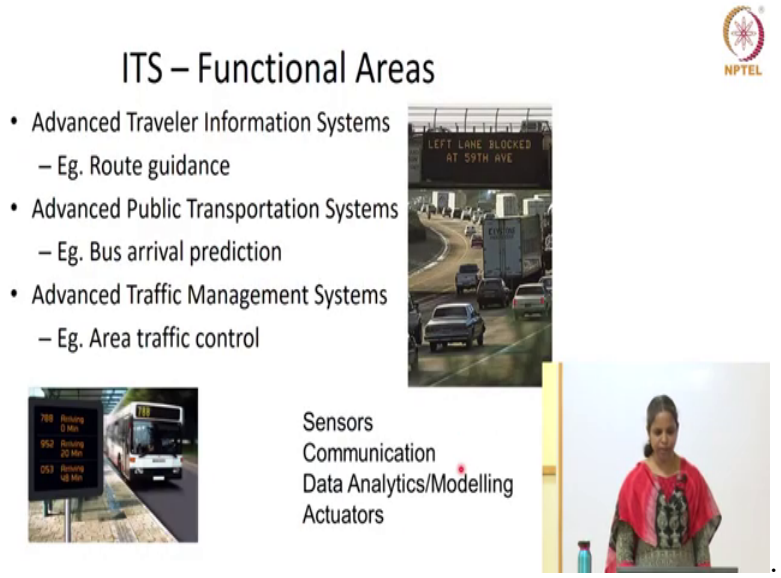

So, I will just quickly discuss a little bit on ITS because the latest trends in terms of connected vehicles, automated vehicles all those comes from this starting point of ITS. So, ITS there are many examples. Your Google driver assistance is a classic example of a ITS technology. What do you get there when you are using a Google maps. When you start your drive usually you do right whoever is driving keep the Google map ready, there this is my origin, this is my destination which route I should take or how much time it will take right. How is Google coming out with that information any thoughts? Its they are recording, but that is fine you can talk.

No thought how is Google coming out with this information that you know this much time it will take for you to reach this point satellite you. How will satellite get that information. Ok its all coming from your cell phones ok. If you use your Google map there will be some fine print somewhere there that your data will be used and many of you are using it. So, they know

roughly what is the traffic situation in that roadway at that time and they have their own analytics in the background. So, to calculate and tell you this is roughly the time it will take and this may be the best route to take at this point right. So, there are many examples that you can you have seen already.

For example, route guidance Google is one example, pictures like or message boards like this which will tell you which route to take and how much time it will take or bus arrival prediction, area traffic control signals being advanced the current signals which you see for example, how static type it always have this much time of green this much time of yellow and this much time of red. And there are times in which you go there you are in the red the other side is not having any vehicle, but they have a green right its kind of frustrating. So, how do you make it advance if you if there is a way to collect the information from each of those legs and process it and tell this leg there is no vehicles so do not give any green this legs has vehicles waiting give green.

So, if it can happen in real time that is an example of ITS. So, what it did do. It collected the real time data, processed it, found out what is the best way to handle it and then change the signal accordingly. That is a classic example of a it is application right. So, if you look at any ITS implementation the 4 major components is sensing the data, communicating the information, processing the information and then deciding what to do or you know actuators which will kind of give back this information to you.

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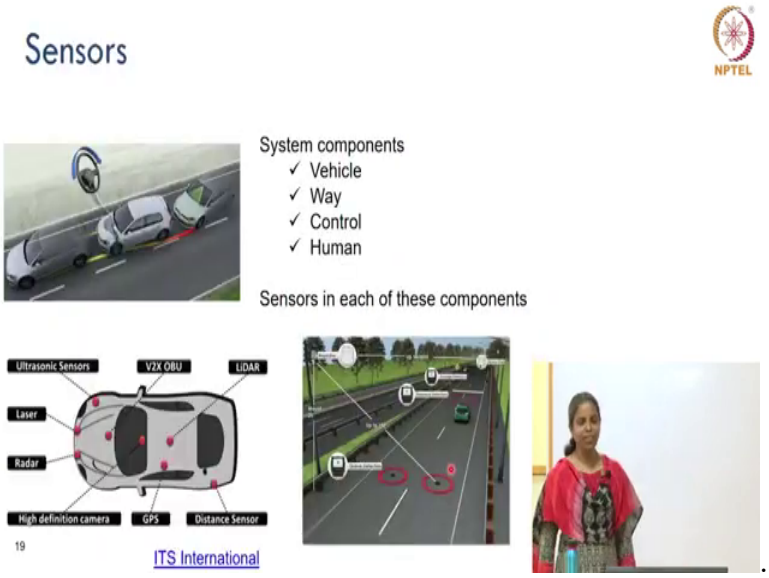

So, this need lot of sensors obviously right. The sensors can be at different places it can be in the vehicles, it can be in the roadway, it can be in the you know human beings. So, and with the advancements that is happening there are enough sensors that gets deployed into your vehicles for definitely there within you for example, your cell phone is a very good sensor it gives lot of information. Then roadside there can be enough sensor. So, slowly we are also reaching there. Many other countries already have sensors deployed everywhere and all these sensors are communicating with each other which leads to what are called out is V2X communication internet of things you must be hearing all these terms right.

So, every device or every component of this system is now giving information to each other. They can process this information and know how the traffic is moving.

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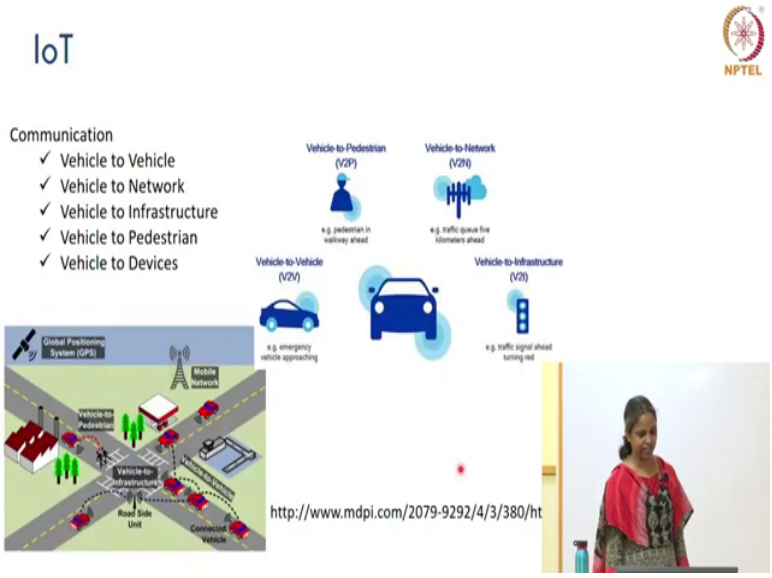

So, these are different ways in which you can have sensors in a vehicle or a road side. So, as I said this leads to what are called as internet of things. Communication can be vehicle to vehicle V to V to I V to T. So, in general V to X vehicle to anything communication can happen and this is the basic component or basic concept from which these connected vehicles. This is one of the hot topic you will hear connected vehicles. That happens because of all this information and yes once you have a lot of sensors lot of data.

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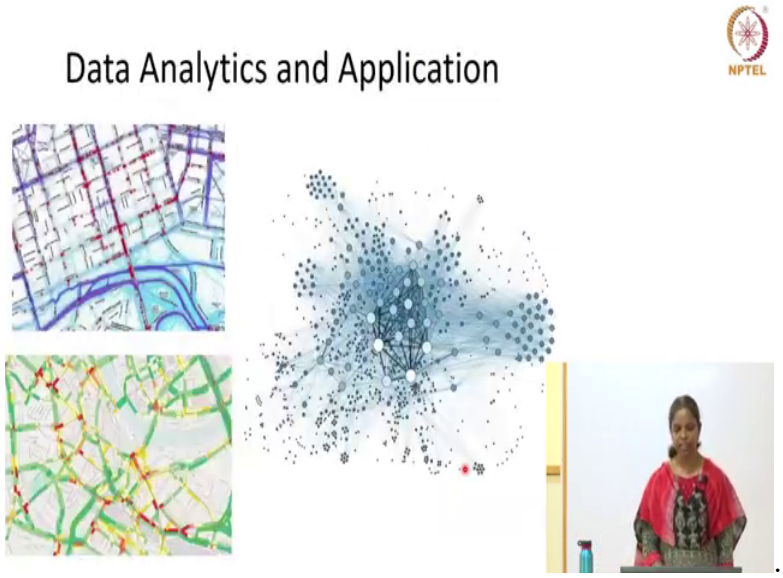

So, you have to get into data analytics. So, a lot of information can be processed. If you ask me I am still somebody who believes you know back to mathematical modeling is best, but I am getting who want to be wrong. There are places where lot of data actually gives you enough information than a mathematical equation can capture. So, there are cases where lot of data is available it can make sense. So, there are at least you know Google and all are using data analytics.

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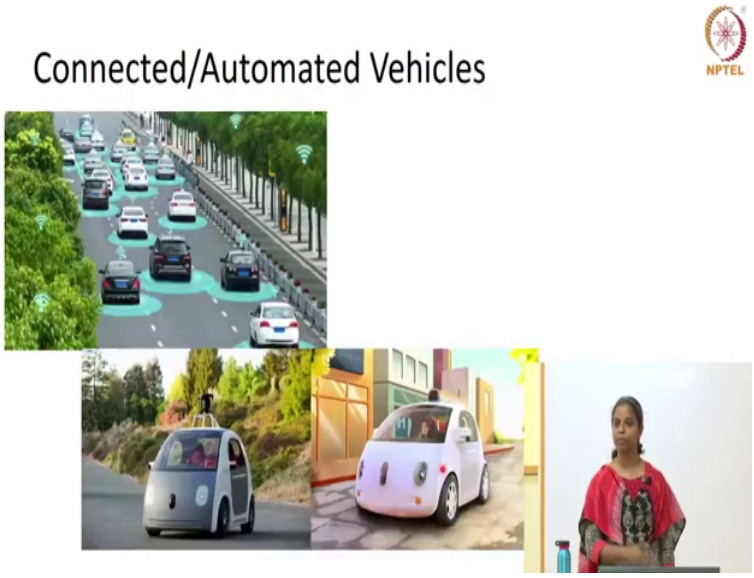

They have lot of information with them they have just process. They do not try to understand the physics of the problem. They just look at the data and the behavior and the pattern so that they will they will be able to give you information. So, as I said this leads to what are called as the connected vehicles and automated vehicles. You must have read about this Google's driverless cars and all those things. There are enough countries where they are already running in the roads. Will it come to India it needs time needs not affect because we have a very unique way of driving, but in many other countries we have these kinds of vehicles.

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So, all these the starting point is having enough sensors and enough communications happening. That was kind of quickly giving you an overview of various things that can come up in this traffic engineering and planning site. Having said that I thought I will just tell you where what is the Indian context to all these.

So, some of you may be thinking why are we talking about connected vehicles and all when we are still building infrastructure. It can happen in parallel also. So, this is one way of looking at it you. You again would have heard about the smart city initiative of the current government previous term itself. So, mobility is one of the verticals under this smart city initiatives and that is what I have highlighted. They have given some examples smart parking and intelligent traffic management, integrated multimodal, integration and things like that. But,

it is not that these are all the only things they are interested in anything where you can use technology to make the traffic move better.

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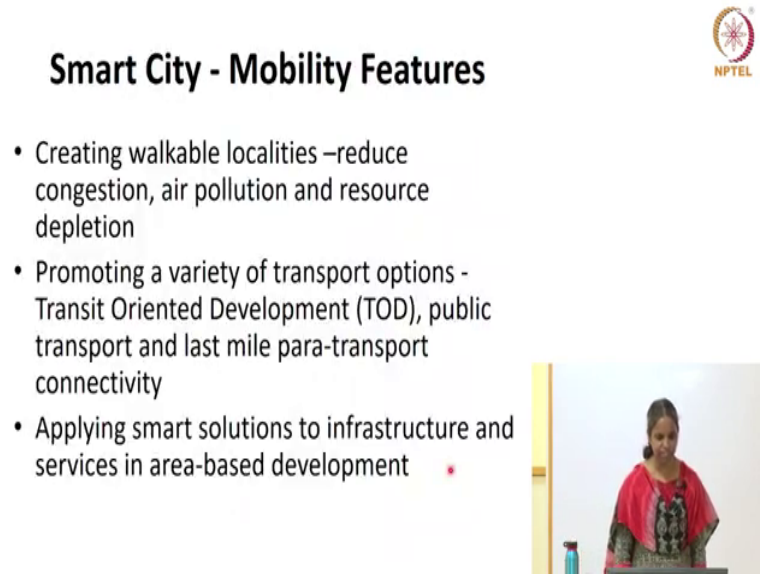

So, that is where some of these things can make sense. These are some of the details I collected from that website where they talk about what mobility features they are interested in. Let us not worry about it. But, what I am trying to say is under this marketing initiatives there is a lot of interest in terms of having such developments to be there.

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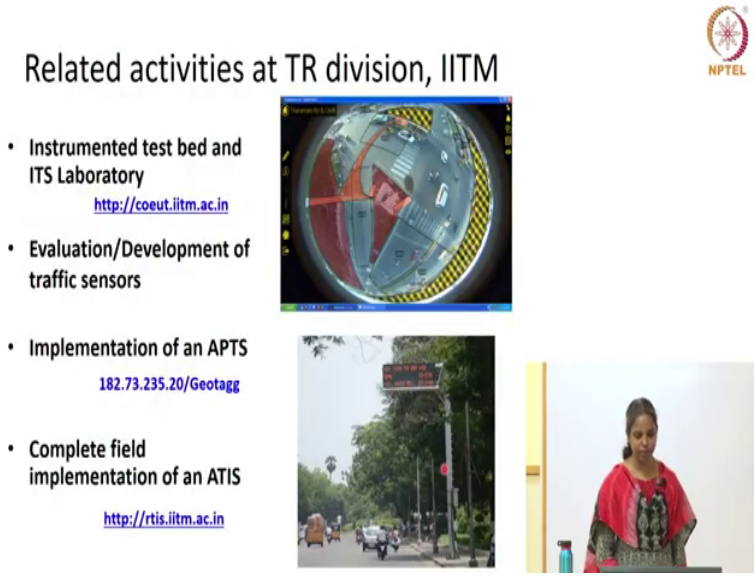

And yes I have to do some PR work out further to excite you. So, these are some of the activities that that have happening in our lab in related to this ITS or traffic operations management all those.

So, I will just briefly show you some of the examples just to show what you are seniors have done. Many of the work which I am showing are done by undergrad students. Either as part of the curriculum mostly they were interested. So, this they start working on it. So, I have put mainly the activities are we have developed a laboratory which is I will kind show you some pictures and we have a test bed live test bed from where we are getting data, then we have developed lot of sensors which work for our traffic conditions, then some of the solutions we have developed and implemented.

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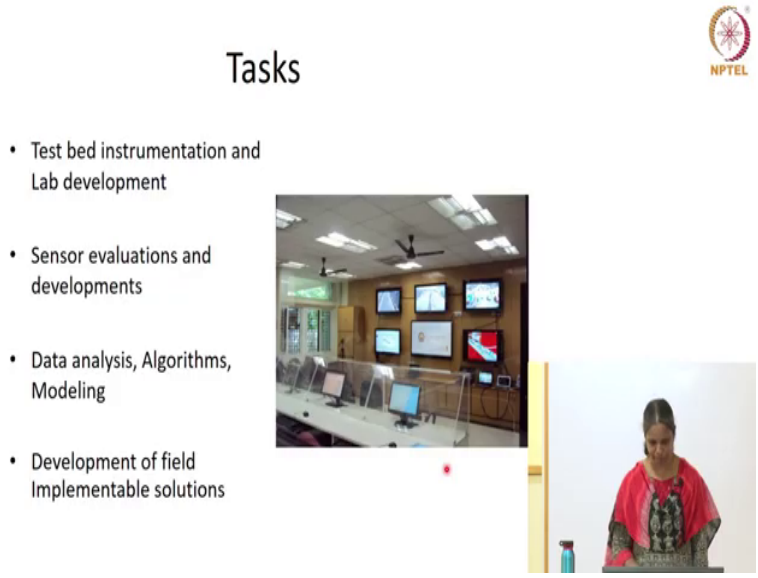

So, as I said one of the task I have divided into 4 headings one is the lab development and the test bed sensors, then data analysis and the solutions that we develop. This is the picture of our lab. Any of you can come and see the lab when if you are interested we will make sure.

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So, before I get into the details why do we have to do this right? I do not think I have to explain much you know that our traffic is completely different from what you have seen elsewhere. And all the models all the solutions that are developed are actually for the traffic which is lane based and homogeneous. By lane based I mean in one lane you expect only one vehicle. They move one after the other. They do not move parallelly within the lane which we happily do.

We do not believe in this you know follow the leader in behavior. We will occupy any space available. So, it its in one way interesting we are using the whole available space we do not want to waste anything, but the problem is modeling it becomes extremely difficult because you do not know how the vehicle is going to behave right. Any gap you see a 2 wheeler fellow can move in whatever way. So, how do we handle that?

So, any solution that is already available we cannot use. We have to kind of redo the whole thing to meet this requirement of lane less movement. The other is heterogeneity. We have all types of vehicles there are some 16 different types of vehicles that can be running on our roadways. So, the typical US road if you look you have cars, you have truck that is all. Very small percentage of truck maximum number of cars.

So, its again very simple way of handling. So, as I listed heterogeneity is one challenge. Plain discipline is another these two together gives you enough uncertainty, randomness to any model which you develop should actually be handling the randomness than the actual behavior. So, your things should be able to take into account this (Refer time: 28:41) demo. So, this you do not need you know what plane discipline is.

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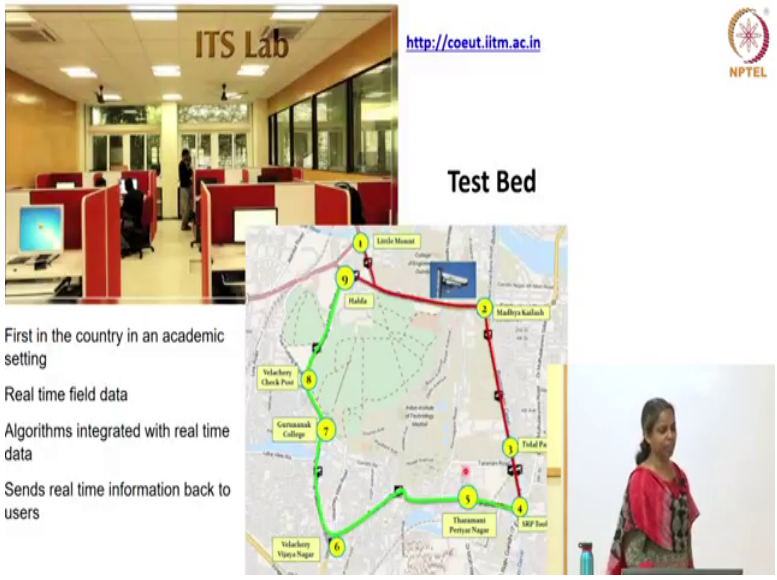

So, why I said that is many of you otherwise may wonder why should you do this. This is already done in other countries right. Most of these solutions or most of these things already is happening why do we have to? Because we have a unique way of handling. So, as I said we have a lab and the test bed. Lab is just a place where we are receiving all the data. The test bed is the interesting part.

So, we have a 15 kilometer corridor around IIT SP road IT corridor. You may not be knowing at least some of this Chennai's will know. So, the its all the roads outside which are surrounding the IIT campus the IIT is actually. So, and we have kept enough sensors in those roadways. There are some I have the details. So, this is the first time an academic institution did that actually even non-academic institution places where they do not have it. So, we have real time data coming from field, we are processing it, we are having algorithms running solutions being given back to the users.

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So, the complete cycle we have implemented in a this small corridor. What are all the sensors, we have around 300 MTC buses with GPS sitting and sending the data to our lab every 5 seconds or 10 seconds. We have around 32 video cameras relaying their feed to our lab. So, then we have message boards which we have installed in the field which gives information back to the users and there are other several sensors which I have enlisted.

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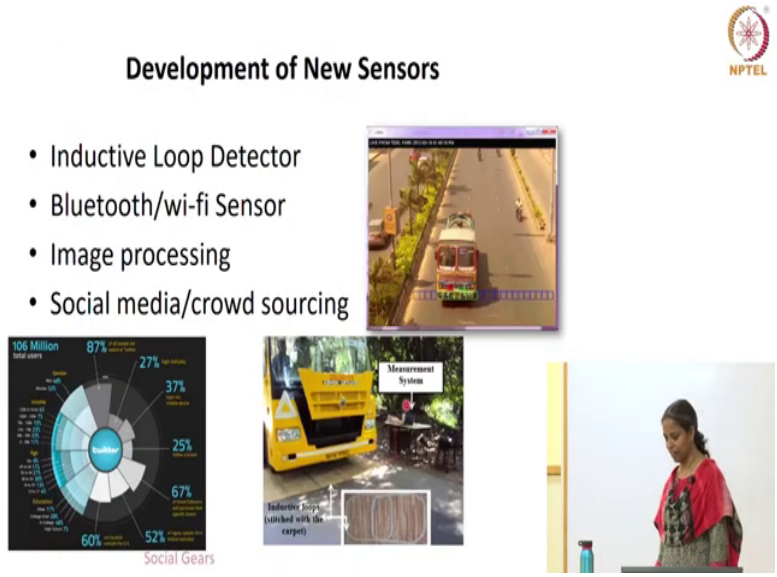

All of them are sitting in the field and sending us data. And many of the students were involved in developing sensors. So, this is not purely a civil engineers work alone. We collaborate with electrical engineers, mechanical engineers, engineering design and I have a slide showing all the collaborator. So, we work.

So, I usually joke about this if you some of you may be you know feeling very bad that you wanted to be an electrical engineer or computer science engineer and you ended up in civil these are ways in which there is no fixed territories these days. Its all inter disciplinary. Nobody stops you from working in any of the topics you want.

So, this is one of the areas in which a lot of my students work with electrical engineering faculty. Developing sensors we have developed these four different sensors which are working

and giving information in a much better way than any of the available sensors. Details I do not have time.

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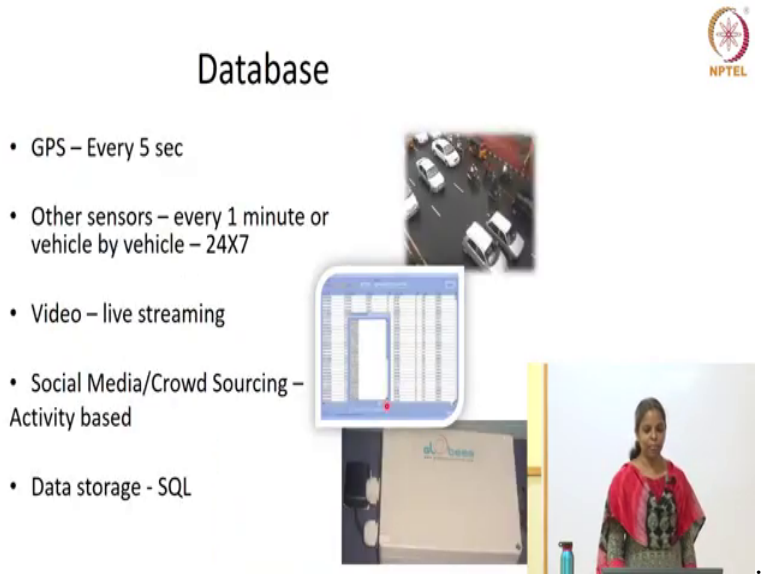

So, I am not getting into. So, obviously we have a good database lot of in a data that is coming from all these sensors.

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And communication we are using various technology GPRS, wireless data transmission, regular wired connection, 2G 3G modems etcetera.

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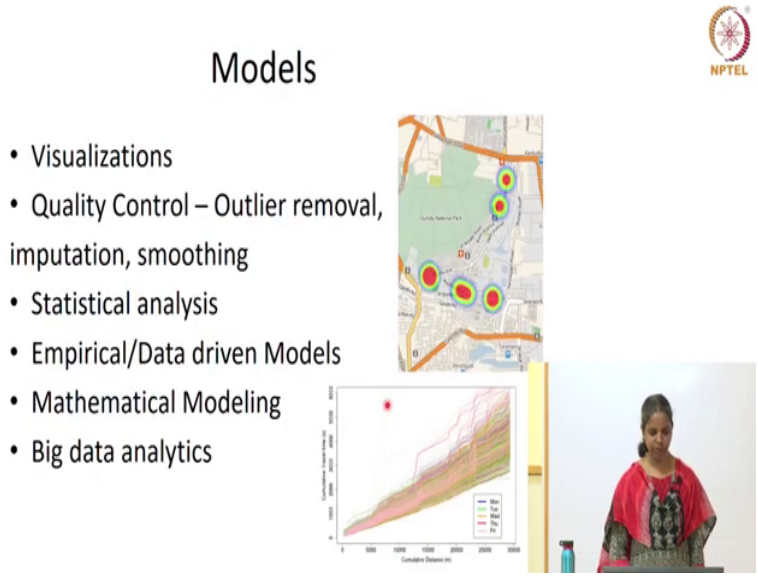

Lot of modeling that happens which again I cannot get into the details, but starting from very simple empirical models to you know mathematical models to data analytics all are happening. So, depending on your interest you can pick what you want to try out and then you will give.

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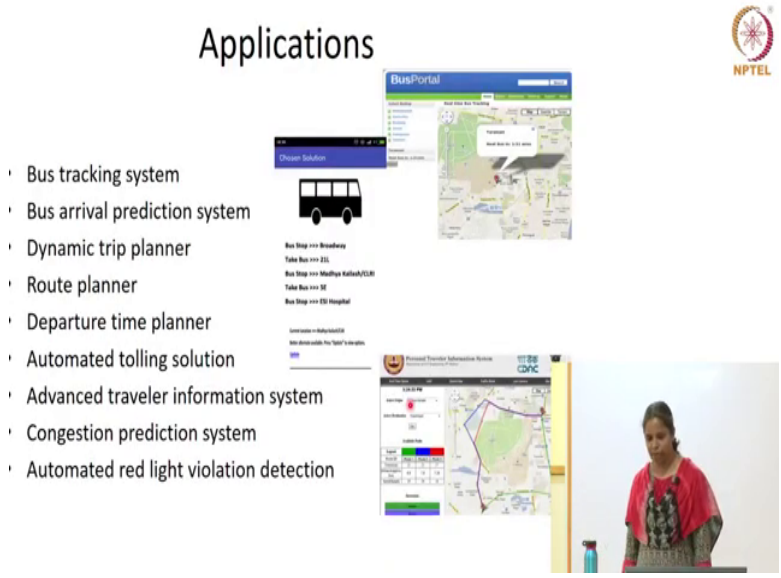

Some of the applications which we have developed include the bus arrival prediction system. What you see the picture there is actually a live system where you can go click on the route number it will show the bus stop you can click on the bus stop it will show when the bus will come.

So, if there are multiple bus route it will show these are all the route numbers which one you want we can click and it will show. So, there are many solutions that were developed of sensors. Most of them are undergrad students work.

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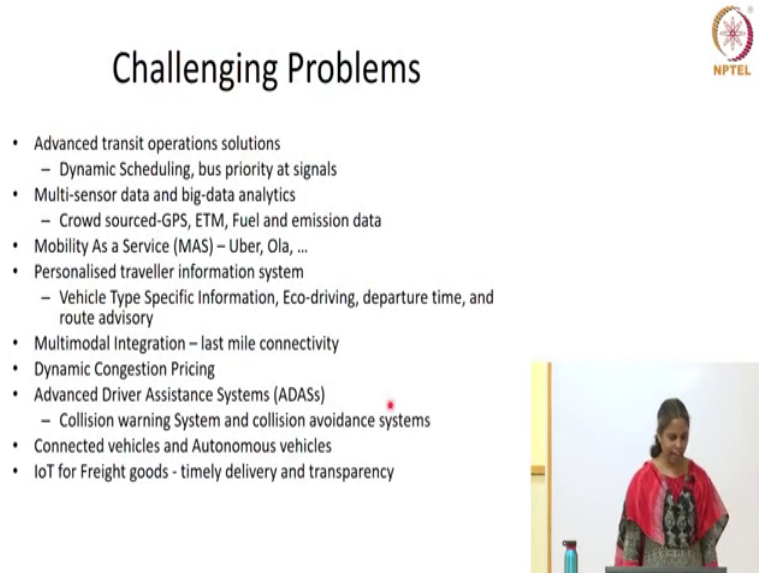

And I will stop with what are some of the challenging problems which are often which if you get into the civil one you can work on. For example, dynamic scheduling no city is doing that. They all have this fixed schedule. Saying every 20 minutes one bus have to leave or every 30 minutes one bus has to this will sense. Peak hour you may need more off peak hours you do not need.

So, how do you handle this on a dynamic way depending on the actual traffic situation how will you schedule? Each of this problem as I have a listed is a interesting often problem which can be worked on. Mobility as a service for example, this Uber, Ola kind of system. It works completely different from a bus completely different from a traditional taxi service. So, how do we handle their scheduling? The routing thing how do we do that all those are as I said interesting problems.

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I do not know whether. I will skip this as an undergrad student may not be of interest you. It basically I was trying to tell what are all the challenges if you want to do this. One main challenge as I said is it is not traditional civil engineers topics any more you have to work with multiple domains. So, it is very interdisciplinary in nature and it is very difficult to transition and that needs (Refer time: 34:01) ok.

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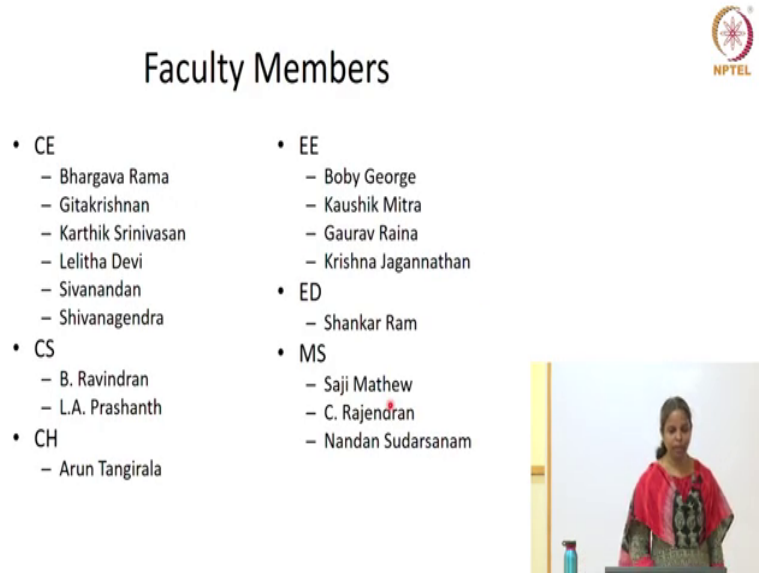

So, that is the last slide. As I said we collaborate a lot in terms of bringing all these solutions. We can feel civil engineering, computer science, chemical, electrical engineering design management studies. So, various faculty members we work with. So, as I said it is it is something which if you wanted to be in a different department because there here is a way you can still manage that.