Global Navigation Satellite Systems and Applications
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Lecture - 19
GNSS: Current Trends and Future

Hello everyone and welcome to 19th lecture of this Global Navigation Satellite Systems and Applications. And in this discussion, we are going to discuss about GNSS Current Trends and Future. So, what are current trends and what is coming in future that we will be bringing one by one. As you know that lot of things are related with the electronics here and you know that development in electronic in recent years have been very fast. And therefore, whatever we are discussing today is going to change tomorrow definitely. Things are from very large GNSS receivers, they are becoming now very-2 small.

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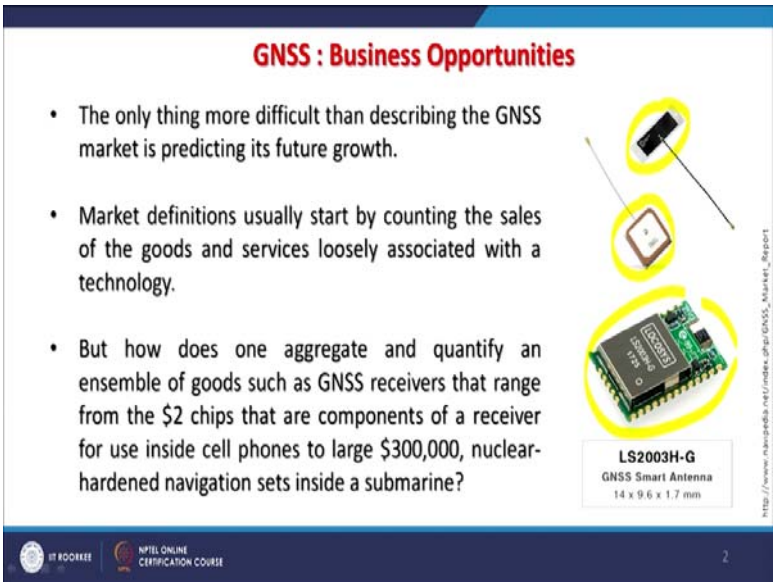

And as you can see that some of these receivers which are embedded in your smart mobiles or in independent GNSS receivers, they are getting smaller and smaller and of course, the signal quality is also improving. And therefore, it is very difficult to predict basically that what is going to happen, what are the opportunities and other things.

But let us see that what opportunities today we are having and as mention here that it is very difficult for that describing the market is predicting its future because things in this domain are changing at very rapid rate. Similarly like in other electronics or like in

mobile industry, the same in GNSS industry because many big powerful countries or whoever require their own navigation system. They are developing their own navigation systems and not exactly following but the first one that is GPS was developed by US but they are doing their own innovations in not only in constellations but in receivers as well. And similarly India has also done which we have discussed when we discussed IRNSS or NAVIC system and receivers are also initially in the beginning, they were single frequency receivers. Now we are having dual frequency receivers; more powerful, more accurate and quick to get the positioning.

So, if we look from this point of view that market definitions usually start by counting the sales of the goods but services loosely associated with the technology. So this trend basically continues, even in future it is going to continue and nowadays a small chip which is having GPS or GNSS receiver is costing say about 2 dollars maybe 100 rupees or 150 rupees. And then there are more sophisticated for very accurate or scientific studies or for maybe aerial navigations or for missile technology or for nuclear hard and navigation which may cost even 300,000 dollars. So, the range of these receivers is very huge, very big because there are different types of users from all walks of life and accordingly the products are available.

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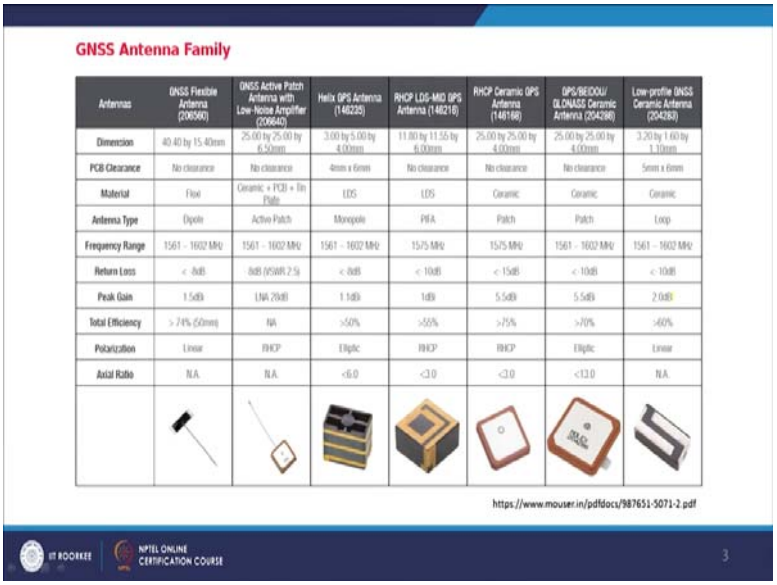

As you can see here in this table that the dimensions are changing, their signal noise ratio is changing, the capabilities are changing. As you can see here that with very small one

which is just 40 millimetres by 15.4 millimetres, we are having something like other smaller one also and which can go inside a smartphone very easily. So, different types of GNSS receivers with different capabilities are available and as you can also see that some are just GNSS flexible antenna and some are the active page antennas. And some are having capabilities of receiving signals not only from GPS but BeiDuo, GLONASS and other constellations.

So, multi-constellation receivers are becoming much more popular nowadays and this is what these multi-constellation receivers we are getting nowadays in our mobiles also.

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As you know that European Space Agency which is ESA which is focusing on the GNSS so they call as a GSA; European GNSS Agency. They have been publishing some regularity about the GNSS market report on future trends for the GNSS market in Europe or world over. And what GSA has already reported that the key references for companies and organizations to build their market strategies is in relation to GNSS. And what underlying market model utilizes advanced forecasting techniques which they applied to the comprehensive range of input data assumptions and scenarios to forecast the size of GNSS market. It is growing like anything.

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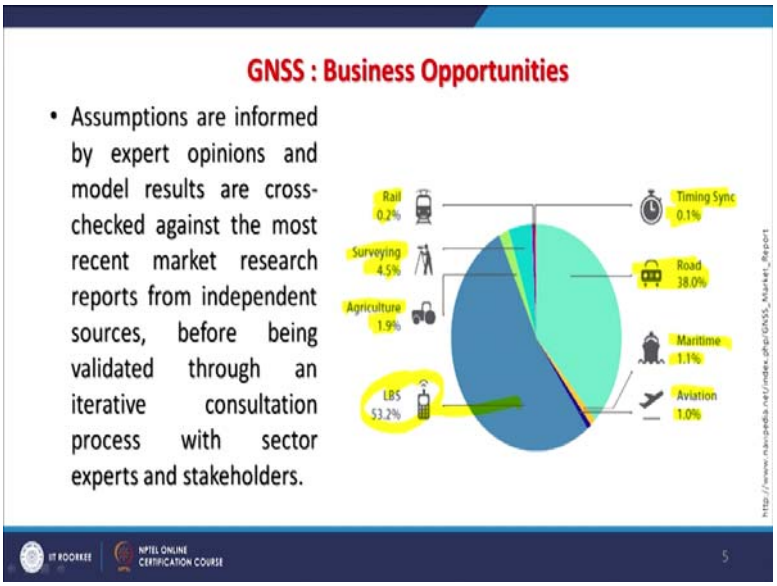

And as you can see that through our own experience, we know that most of the users of these GNSS receivers, they are using for navigation. So, they are either location based services which is 53.2 percent or for road navigation. But there are other users also, some are very-2 small one, for example time syncing to get a very accurate timing through the atomic clocks which are installed on the GNSS satellites or constellation that number of that share in the market you can say, is just 0.1 percent.

And of course like railways, they have started using extensively even Indian railway and in civil engineering survey or in some other surveys also, it is being used. Similarly in agriculture, it is being used 1.9 percent currently but maybe in different countries if we look the data then it might be different because only in those agriculture areas where farms are very big, they are employing these GNSS services and then maritime. So, the large users are of course, the Location Base Services that is LBS about 53 percent and then road users are also there of 38 percent.

So, these are the main users of GNSS services and current business opportunities are also in these two major domains apart from some other domain as well but they play very small roles. So, when we look this scenario of business opportunities, the assumptions are informed by expert opinions and models results are cross checked against the most recent market research reports from independent sources and before being validated through an iterative consultation process with sector experts and stakeholders.

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Further the first forecast is the actual global installed base of GNSS receivers or devices which is 3.6 billion units is predicted to grow to 7 billion by 2019 or 2020 by this year. So, you can see that it is going to be doubled in recent years that mean almost one GNSS receiver for every person on the planet. So, some people are having their GNSS receivers inside their say mobile but may not know or may not be using that extensively.

But most of these smart mobiles which are coming or all coming with some kind of GNSS receivers and people or market experts, they expect that this number will grow maybe by 2022, it may be again doubled. So, this is going to grow at a very fast rate because some people want not only the GPS facilities or GPS receiver but multi-constellation receivers and their mobile to get a better accuracy and that too very quickly.

And this growth of GNSS receivers is almost parallel to the growth of the smartphones which is also continuing to dominate that is 3.08 billion was in 2014 out of which the applications for navigation are 0.26 billion. Primary region of global market growth will be in Asia-Pacific region where many-2 users are there and which is forecasted to grow by 11 percent per year and that is 1.7 billion in 2014 to 4.2 billion devices in 2023.

So, as we can see here that as a smartphone market continues to grow, a similar way GNSS market is also growing further because new applications are being developed, new opportunities are also coming. Let me also give you that when we were discussing differential GNSS or RTK GNSS or this Satellite Based Augmentation System that

means SBAS through this course, I have also learned that through net also, you can get the differential signals quite easily and available freely. So, the only requirement is that the same receiver should have a net connection as well. And if net connections is there then through free servers which are providing the correction data this we also discussed very briefly.

But what I am trying to bring here that these servers which are providing freely correction data. So, one can configure their app to fetch the correction data from these servers and the position, for example one was getting say within 3 metre accuracy that improves very significantly and may become even 50 centimetre or 0.5 metre or even 25 centimetre. So from 3 metre, you can reach to 0.25 metre accuracy just by engaging with those servers and getting or fetching this correction data which might be available through these servers. Many of these servers are free, many of these servers are charging some money or many of these servers are from the manufacturers site.

For example if you buy a Trimble or US GPS or GNSS receiver then you can directly get the differential signals from these companies servers may be freely or may be paying some money or while purchasing these receivers, you are paying that subscription charges for few years and you get a very accurate position even using a single receiver and even without having your own base station or a stationary GNSS.

So, because of such changes in the technology, the accuracy is improving and therefore, more applications will come in future which will exploit this available accuracy for different applications. So, the opportunities are really very large as we have discussed that the maximum growth is happening in Asia-Pacific. Middle East and Africa, they will also grow at very fast rate that is roughly about 19 percent per year.

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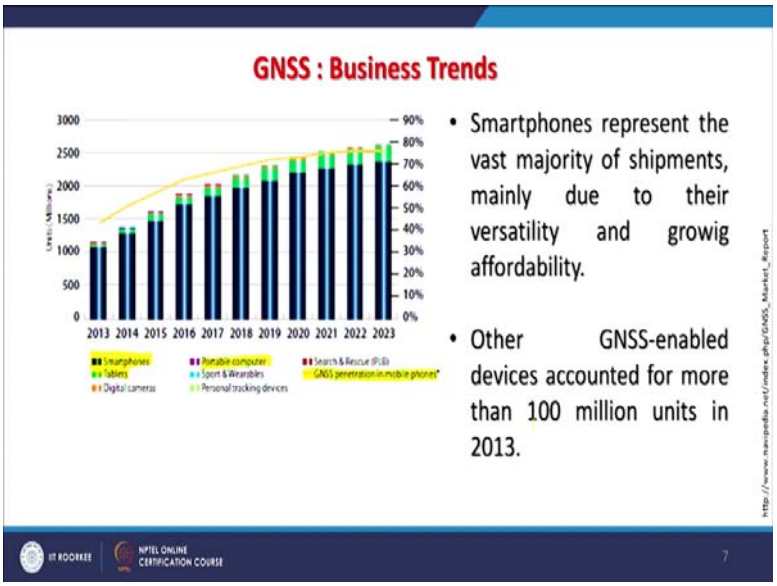

But currently it is not at that fast relative to our Asia-Pacific region. And what here we see in this bar chart that smartphones growth relatively is a very huge and then there are some other electronics which are being used and GNSS penetration in mobile phones is almost same as the growth of your mobile. This smartphone's is there and there are some other you know, like tablets and portable computers and other things, they too are growing almost in the same pace. Whether we will achieve a plateau soon, I do not think so because at the technology is developing, more applications will come.

So, a smartphones basically represents the vast majority of shipments mainly due to their versatility and growing affordability. The best part in using these GNSS receivers in a smartphones is that smartphones anyway, it is multipurpose because it is having camera and recording and voice recording and of course, telephone and other things net but same time GNSS.

So, through these apps which are available or can be bought, can be installed on your smart phones and they can use these multi-constellation data and not only that but end trip also that is through network, you get the correction data. So, even a single smartphone can give you accuracy of few centimetres. So, that is why that growth is basically attached or linked directly with the smart phones and because smart phones are becoming affordable and their versatility is also there. So that is why, the growth is also there.

Other GNSS-enabled devices accounted for more than 100 million units in 2013 that not inside the smartphone may be independent receivers. And there might be some other devices like tablets might be having GNSS receivers or Bluetooth based receivers or USB based receivers. Some people use such GNSS receivers for their car navigation because you know that road sector is using large GNSS receivers. So in cars also, they might be using the USB one. So their shipment increased by 640 percent between 2010-2013.

See the growth, it is a huge growth and those major markets are of course, in Europe, North America and Asia also.

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And finally that wearable band market because in the watches also, the GNSS receivers are coming because once the receiver itself becomes smaller, then it gets installed in many-2 small devices. So, the bands which people wear like a wristwatch and which has also exploded in the first half of 2014 and which is a growth of 700 percent. So, it is a huge growth in GNSS market. And high end devices also which are using multi-constellation GNSS capabilities coupled with 3G or 4G and better connectivity. They too are sharing some market of GNSS.

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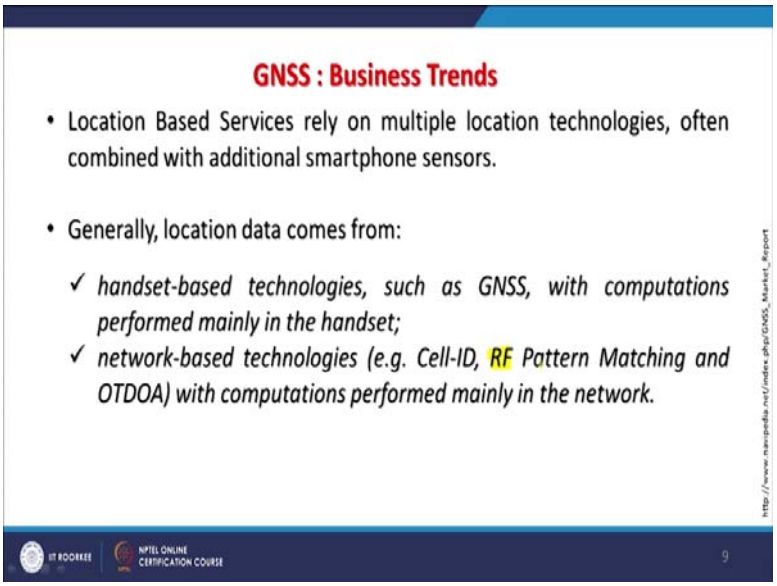

Location Based LBS services rely on multiple locations technologies often combined with additional smartphone sensors and generally location data comes from like handset based the technologies such as GNSS, with computation performed mainly in the handset; your own mobile or a handheld device. Maybe network-based technologies which we have just discussed network-based, from caller ID based or a Radio Frequency Pattern Matching or this OTDOA, the computation performed mainly in the network.

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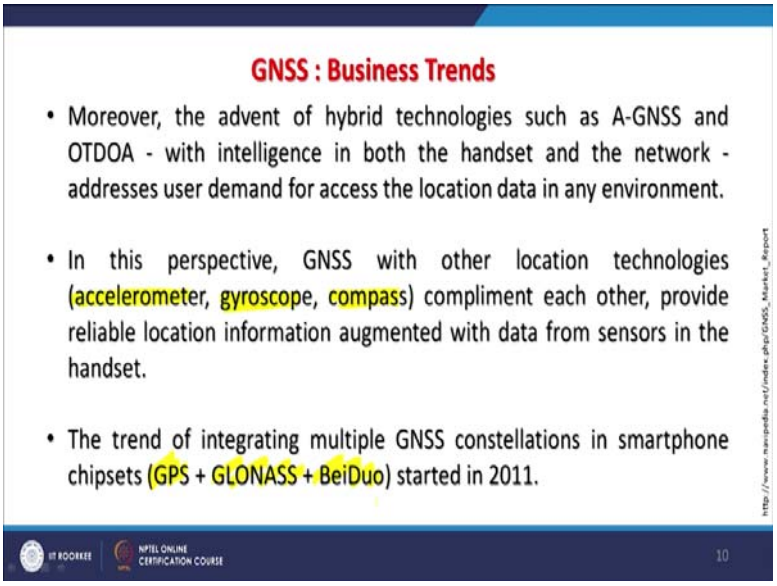

And moreover the advent of this hybrid technology such as A-GNSS; Assisted GNSS and OTDOA with intelligence in both the handset and the network addresses user demand for access the location data in every environment.

So, people want that location data should be available in almost every condition; day and night not only but in all weather conditions and inside buildings also because there are large buildings, large market and other places where people want location itself. So that is also becoming possible. There are not simple GNSS receivers will work but some other technologies have to be involved as just discussed, may be hybrid technologies and which will help users to get the location. So, this market is again very much up.

And in this perspective, the GNSS with other location technologies like accelerometer which is also in some of the mobiles, gyroscope which is also inbuilt in many mobiles and compass. These location technologies complement each other; provide reliable information not only about the location but this say augmented data from the sensors in the handset. So, the same device that means maybe smartphone can be used for multipurpose

And trend of integrating multiple GNSS constellation in smartphone chipsets. And there are smartphones which are coming with this GPS, GLONASS, BeiDuo and QZSS and we are still waiting that the chips will integrate our IRNSS as well. But currently, the smartphones receivers are capable of receiving signals from GPS, GLONASS, BeiDuo, QZSS and also SBAS. So, they are coming with that.

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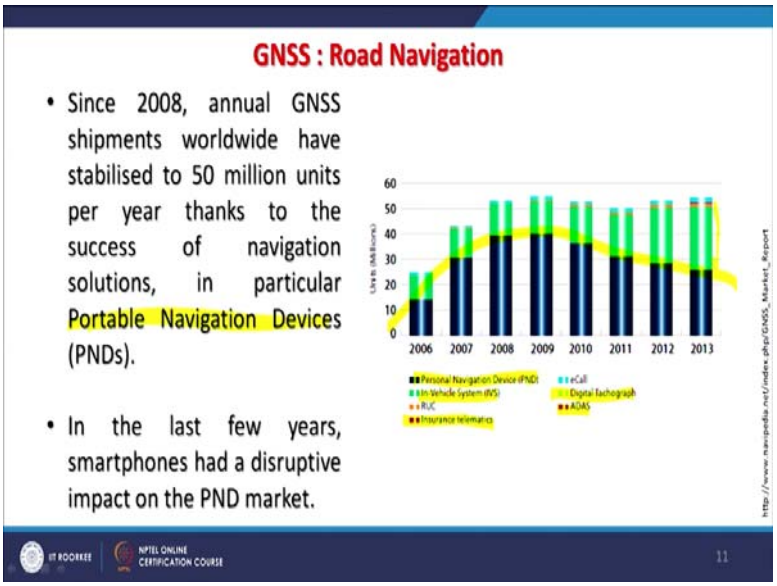

So, if anybody is going to buy a new smart mobile and he is enthusiast or user of a GNSS services then he must look that what are the capabilities which that mobile will have and if it supports the multi-constellation that would be very helpful. And of course, it will provide very accurate positioning.

What we are seeing here that the different sectors, we will go through one by one. So, the first sector is the road which is one of the major users apart from this location based services which we have just discussed. Road navigation that the Personal Navigation Devices that is PND which occupies the maximum market. And then you are having the in-vehicle systems also inbuilt inside that is also there and there are then digital techno-graph and other users are there. But the major two users are the Personal Navigation Device that is PND and in-vehicle systems IVS which is nowadays coming in many-2 of modern cars. So, these two are basically for road navigation.

So since 2008, the annual GNSS shipments worldwide have stabilized to 50 million units per year. Thanks to success of navigation solutions and especially in particular the Portable Navigation Devices. Because these devices where being used separately but because of mobiles, the uses of this portable devices is also getting stabilized. And that is why you are seeing that in recent years the growth in this PND has reduced but the same time in vehicle systems have taken place. So, the growth in this IVS has increased and overall growth of road navigation systems is almost remains same.

So in the last few years, smartphones had disrupted impact on PND market because smartphone not only for calling or sending SMS but they are becoming basically multipurpose devices. For many-2 purposes or things which one can do with mobiles, that is why they are becoming popular and that is why they are consuming the other possibilities or other market like PND or IVS system and other things.

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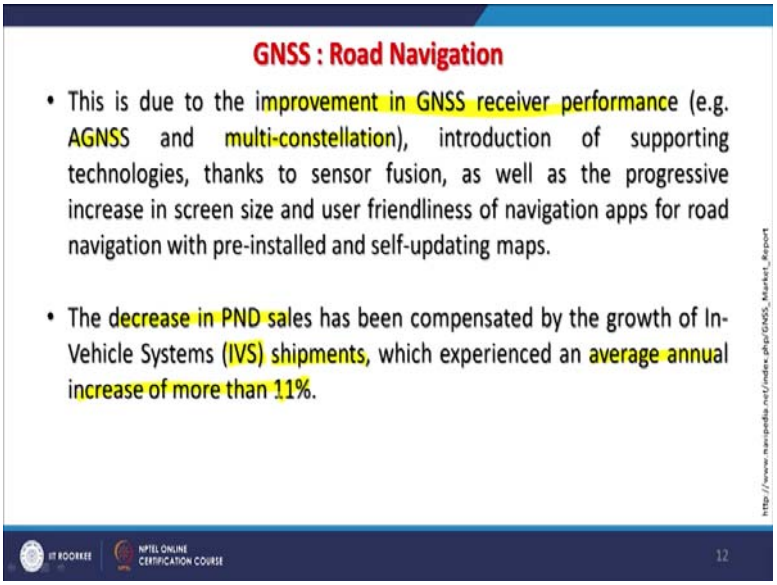

And all this is happening because as mentioned in the beginning of today's discussion that improvement in the GNSS receivers and their performance that is Assisted GNSS and multi-constellation. These two things have improved the location and that is why the market is growing and it will grow because new applications will come. We might not be thinking today but tomorrow some people as per their requirements will develop new applications because some new applications which have not yet been developed because of accuracy issues. Once we reach of centimetre accuracies in the smartphones, GNSS receivers very easily without much efforts then new applications will definitely developed.

So, they said we have seen that decrease in PND Portable Navigation Devices sale has reduced but it has been compensated by IVS. So, annual average increases nearly 11 percent in the road sector.

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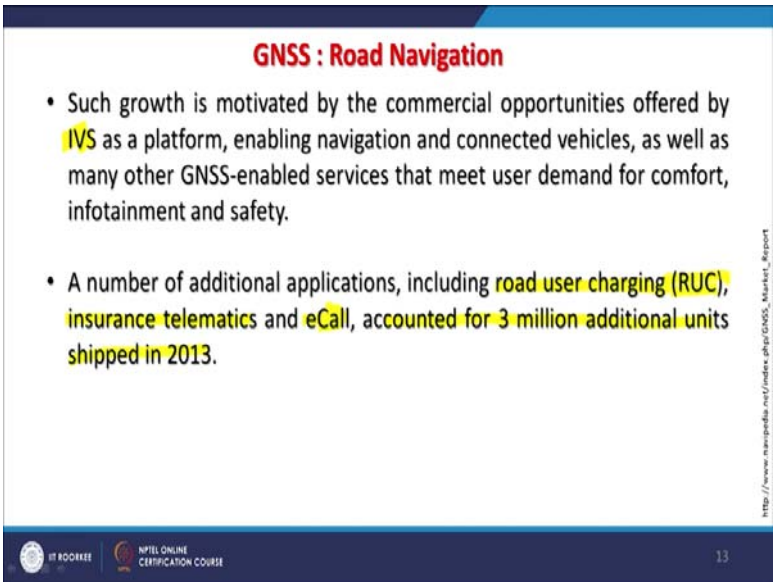

Such growth is motivated basically by the commercial opportunity offered by IVS as a platform, enabling navigation and connected vehicles, as well as many other GNSS enabled services which are meeting the user demands and comforts, infotainment and safety.

So, lots of vehicles are fitted with these IVS system and they are not only providing navigation but some other advantages as well. And one need not to then bother about charging and other things because if you use mobile as a navigation in your car then you have to think about that how to fit it and so on. But in IVS system, it is all fitted and ready to use whenever you turn on your vehicle and whenever you want to use the navigation facilities in your car, just switch on and it is available.

So, there are number of additional applications including road user charging which is going to come very soon, already there in some countries where you know the location. Once you enter in say expressway, your location is recorded and when you about to exit from a expressway, your location is again recorded and the distance is calculated and accordingly one has to pay.

So, that is what Road User Charging RUC technologies is coming in a big way. That will again increase the GNSS market because then vehicles will require having such devices inside their cars or vehicles. Insurance telematics that is also will utilize these things and e-Call is there which will account for about 3 million additional unit shipped in 2013.

But this is little older data and I am sure that this RUC market is going to grow at a very fast rate including in India.

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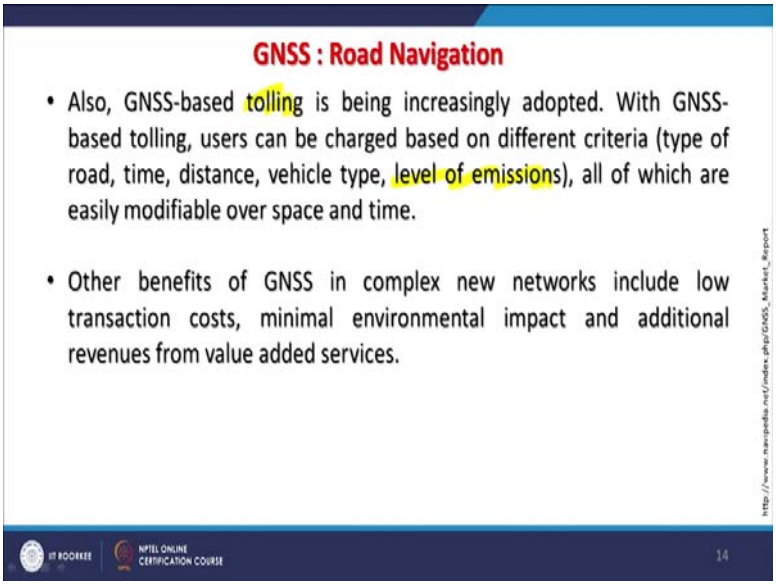

Also that GNSS based tolling which we have just discussed is being increasingly adopted. With GNSS based tolling, users can charge based on different criteria; the type of road, how much time they remain on the road, what are the distance they have traveled, what type of vehicle because for different vehicles we have to have different rates. A small car owner will pay less whereas a huge truck owner will pay more. And how much emissions it is putting in the atmosphere. So, all these things can come while tolling is there and many of such things can be estimated or calculated about the usage by using GNSS devices, indirectly at least the distance and time and that can be done quite easily with this.

And the other benefits of GNSS in complex new networks include low transaction cost, minimal environmental impact and additional revenues from value added services which is going to be there.

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Now finally in this road navigation sector, the principle of GNSS basically is the positioning and of course, with the performances of high influenced by the conditions of operational environment and the need to ensure appropriate performance throughout the equipments life. And the development of standards and certification references to positioning performance is fundamental for vehicle vendors and services providers especially when it concerns safety-critical applications. That means that when for tolling or for road uses will be there, then lot of standardization has to be done before it is implemented.

And there will be other concern especially related with the safety and critical applications that in all conditions, it should work and not only work, it should work very accurately so that in all conditions or environment it should work. It should not that in during rain or during winter, it will not work. Only in normal environmental conditions it will work then nobody will adopt and there will be problems. So, if any technology has to be adopted, it has to be standardized and the performance has to be checked before it is implemented.

And finally, that automotive industry which is related with the road agrees on future view of a sensors fusion. So, the GNSS receivers will be a core component of that sensors fusion which will be integrated into a car provide enhanced positioning capabilities to be used with a plethora of innovative applications. So, all this are either

has already been implemented in some parts of the world or are going to be implemented very soon.

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Also we know that when we look this road navigation, one of few applications which are extensively being used in large cities that are for taxis. And they are extensively using 2-3 technologies together in an integrated manner. First of all, they are using your GNSS devices for location. Second, they are using the GIS that are in the background; the map is always there and including the database which is attached with the GIS platform. And third one is the communication technology.

So, all three these technologies through a mobile and of course, a server and control centers are being used. So, like in case of road, when somebody would like to drive from one place to another or would like to hire a taxi like Ola or Uber or Grab in Malaysia and so in many other countries, such famous services are available and which are relatively cheap than conventional taxi services. Because they are maximum utilizing their resources and rather than a taxi is travelling say in a Delhi city without any passenger, to pick a passenger or dropping a passenger after that if they are travelling for just empty then it is a loss of resources.

But implying this GNSS, GIS and communication technologies, once they drop a passenger and within few metres or maybe 1 kilometres distance, again a passenger is available within a very small time and that saves not only the time but the resources. And

therefore, these taxis services are becoming convenient and cheaper as compared to the conventional one. And this technology has been used extensively in a completely integrated manner.

So, India's most popular Ola or Uber mobile apps are there for transportations which integrates the city transportation that mean road maps and other things for customers and driver partners onto a mobile technology platform. Of course, in the background there are servers which are handling the requirements of the users and giving supports to the taxi operators but main app or applications are being run on the smart mobiles quite easily. And these softwares have been designed so user friendly that anyone in just 2 minutes time can learn how to call a taxi through these services and save time and resources.

So, this is the India's fastest growing sector or companies which as we have mentioned that it is creating or ensuring convenience and the quickness in the service. So, as soon as you call, if you are not in a very isolated place, within few seconds you get a taxi available to you which is as I have already mentioned using GNSS, GIS and communication technologies to make this wholes system of transportation by taxi is hassle free for almost everyone.

So, this is the real ultimate use of these technologies which is currently, future is very difficult to predict but anyway these things may become further efficient and further more friendly for users. You know the requirements for this is that they require not only accurate GNSS receivers in their smart mobiles but also a very good street map of a city on a GIS platform that is very much required. And then of course, communication also because your smart mobile is not having that kind of detailed map available through google map or others.

So, they are maybe updating accordingly and such services are available. They have to grow; they will be growing much more. So instead of currently, these services are available in large cities. In very soon, they will be coming in you know medium size or even smaller cities such services.

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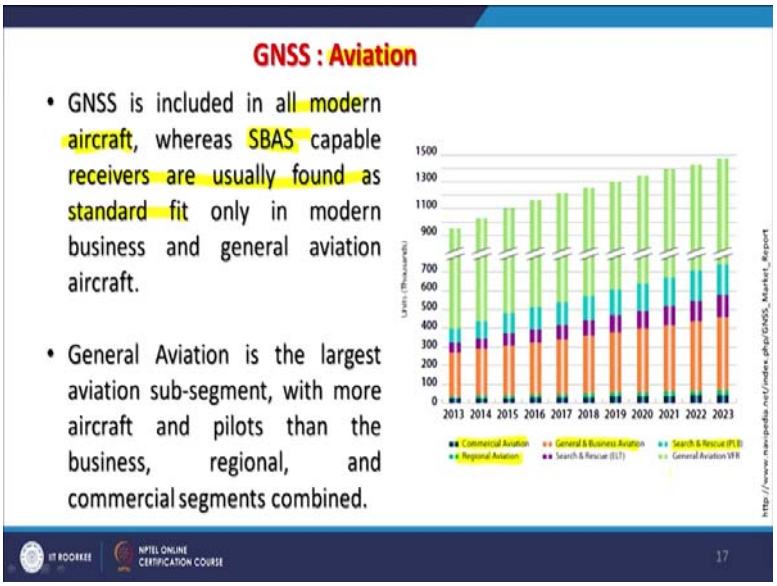

So, GNSS is included in all modern aircraft and we know when we discussed the aviation and all modern aircrafts are equipped with that. They are also having SBAS capable receivers. So, multi-constellation plus SBAS is also there whereas, this treated as is standard for not only business but general aviation aircraft as well.

And as you can see that this commercial aviation is one sector but maximum is this regional aviation; it is growing at a very fast rate who find a large market. Then you are having these general and business aviation which is also having in orange color and then you are having this in blue color; the search and rescue operations. So, they are also using a GNSS in aviation sector. In general, this aviation is the largest aviation sub segment, with more aircraft and pilots than business, regional and commercial segments are combined. So, general aviation is the largest user of the GNSS services.

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Now, sales are basically dominated by Visual Flight Rules. Because not only for the pilots but the passengers also, they would like to see where we are flying and what is speed, at what height so all that data is required. And due to cost of devices certified for Instrument Flight Rules that is IFR, most commercial regional and business aviation aircrafts are retrofitted with this enhanced avionics only once during the aircrafts lifetime. So, there are also new requirements are changing, new regulations are changing because this sector; the paramount requirement is the safety. And whatever is required for safety, it has to be done. And that is why retrofitting of a new systems, new requirements have been fulfilled there.

Another sector which is growing in a big way which is part of aviation is these UAVs or these Unmanned Aerial Vehicles are there and which is again emerging and promising market for GNSS aviation. It is already has become a quite big market for many-2 purposes, not only from a security point of view but in rescue operations or for infotainment, many-2 things people are using these Unmanned Aerial Vehicles and which requires a very precise positioning. So, these all shorty's if somebody would trying for a scientific application or maybe in agriculture or maybe in some other fields, the main requirement is precise positioning and of course, the orientation.

So, precise positioning can come nowadays through net as we have discussed or SBAS maybe RTK or maybe DGNSS. So, these UAVs are also is a big opportunity in that

sense. And wide range of civil applications will further drive market growth in aviation sector also.

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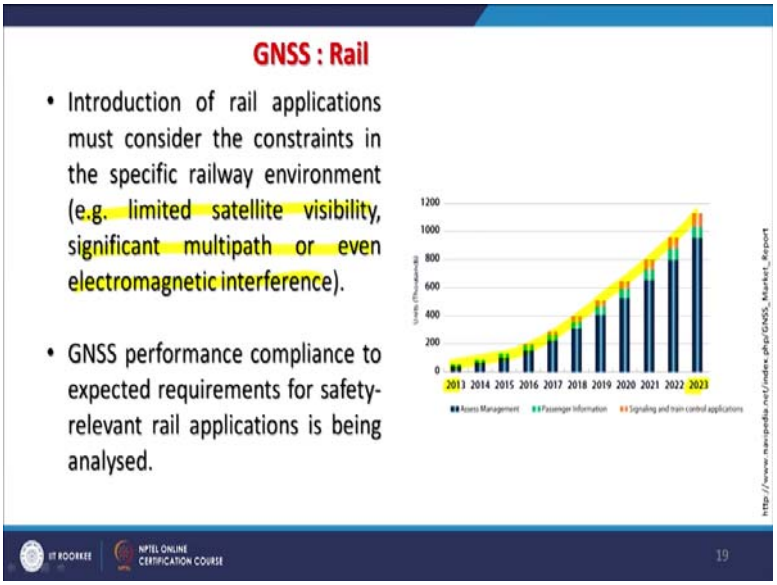

Now rail sector is also as you can see that the growth is very significant in rail sector not only in India but in all over the world. As you can see that what was the scenario in 2013 and this is predicted for after 10 years that is 2023 and this is how it is going to grow.

So, in rail applications like in India; Indian railways are putting GNSS multi-constellation receivers on all their engines plus there transmitter so, they can transmit the location to a central station so that the control room would know which engine or which train is going where, standing where since how long and so on so forth. So, because of such requirements, railway is also bringing all this.

Sometimes there you know, some limitations might be there because of visibility maybe; when it is going through forests or going through a tunnel, for those minutes that visibility problem will be there but in most of the time, it might not be there. There might be some problem of multipath and even electromagnetic interferences are also there but nonetheless, this is a big market which is growing.

Now GNSS performance compliance to expected requirements for safety relevant rail applications is being analysed.

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Whenever it is employed in especially in aviation and rail and of course in the road, the safety is paramount. So, anything which is implemented in this, the safety has to be very much there. And as you can see that 220,000 trains in the world dedicated to freight, these goods trains are wagons and they are equipped with all these receivers.

So, millions of receivers are there in these trains earlier like in India, it was very difficult to look it. Now because of this GNSS services plus communication, now we can track y at least any passenger train by civilian but railways can track any train including goods train also. And this market is going to grow in coming years, safety relevant applications will come, might be in signaling and train controlled based on the GNSS will increasely develop.

For example like maybe autonomous trains for long distances, there is a possibility. Once this technology becomes accurate and reliable then this is the future in the rail sector about GNSS.

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And despite this trend to include GNSS in safety relevant applications, GNSS is currently used in non-safety relevant ones such as passengers' information and assess management where technology innovation plays an important role. So, they are also being used.

And due to upcoming market opportunities in real sector, the manufactures are preparing to enter railway signalling domain, which belongs within the realm of safety relevant applications because signalling is from safety related thing or operations of trains. So, there also applications are being developed so that one day, we will have that services as well.

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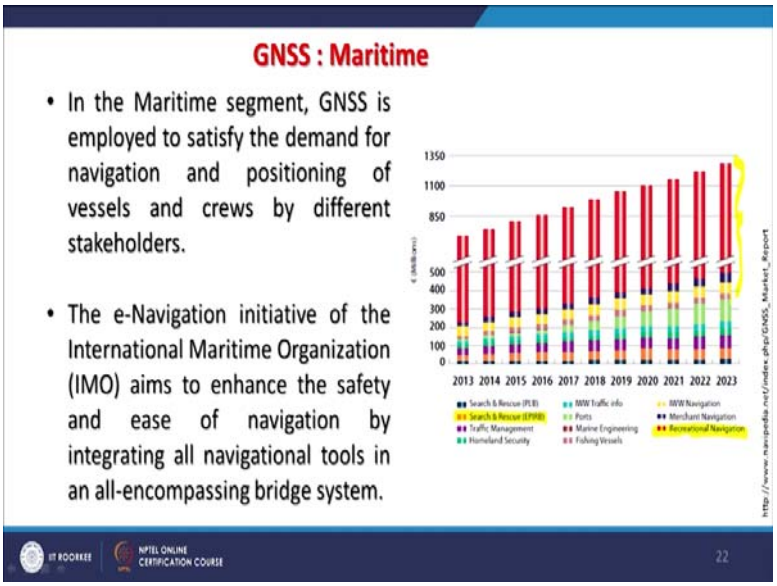

Of course the maritime for the sea or for the ships, this has been there and this market is also growing as you can see here that large users are recreational and for the search and rescues. And there are different types of maritime uses of GNSS which you can see mainly for positioning because you do not have references like in cities or on land parts, sometimes you are having references.

So in the beginning of this course, we discuss about this back bearing concept but that is applicable mainly for the land part. In the sea part when you do not have any landmarks, how you will locate. So, for that purpose of course, GNSS devices have always been very useful and they are being used. But for more accurate positioning now these multi-constellation GNSS devices as you can see for the recreational services, they are the largest users here.

e-Navigation initiatives of this International Maritime Organization, IMO aims to enhance the safety and ease of navigation by integrating all navigation tools in all-encompassing bridge system. So, as I have been mentioning throughout this course that as accuracy will improve as the efficiency and the availability of such devices becomes a real possibility then more applications will come in all domains.

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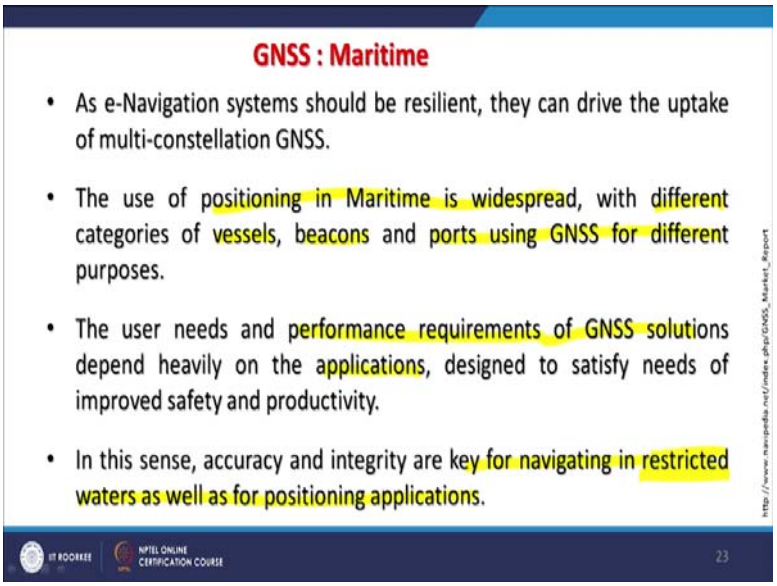

As you know that the positioning requirements in maritime domain is widespread and not only for different types of vehicles vessels. Earlier we used to have beacons or these lighthouses towers for navigation but no more required. So like in aviation sector, most of the modern aircrafts are fitted like in car sector, most of new cars are fitted with navigation systems. Similarly all these ships or small recreational vehicle you know, ships or boats are also fitted with these navigation devices so that they can utilize and life becomes much easier for locating in a water body.

And of course, the performance requirements will be there for GNSS solution basically which will depend on the applications; how these are being applied and there will be other issues also related with improved safety and productivity. Accuracy is key part and integrity of this service or these devices will be there and which is a key for navigating restricted waters as well as for positioning applications. This is very important for restricted waters because each country is having their own boundaries within the sea part or in the water bodies.

And because you do not have the landmarks so, sometimes these boats which are going for fishing, they might cross to other countries and it happens many times we hear like in India, it happens between India and Pakistan. And instead of catching fishes, they catch the humans and these are just because of poor navigation in your devices or systems which they are having.

But in future I am sure with some alarming techniques inbuilt in their systems; they will never cross restricted waters. So in that way, lots of problems can be solved, not only problems but maybe lives can be also saved because of sometimes crossing each other's water creates confusion and some other disputes as well. So, those disputes in future hopefully will be avoided with better navigation systems fitted in those boats or ships.

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As you know that around 29 million recreational vessels are in use. That is why the maximum users of GNSS in maritime is in recreational which used and whereas other crafts fishing vessels are estimated to be about 3.3 million. And this explains the relevance of GNSS shipments for recreational navigation and despite the fact that GNSS penetrating is high in the merchant vessels then in recreational or fishing vessels.

So, this is again a big market like in the road, also in the maritime. And apart from this recreational navigation, Search and Rescue that is also a very big sector not only in maritime but also on the road as well as in the air also. And the reliability is very much required. Search and rescue services based on GNSS or other technologies are also very much required in case of natural disasters like in earthquakes, flooding and other things.

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So, lots of these are using this one in coming years. Recreational vessels will be responsible for further growth of GNSS yearly shipments because this sector is growing in a very fast rate. And these GNSS shipments for merchant navigation are respected to almost double in next 10 years including some 50,000 units so, big-2 development there.

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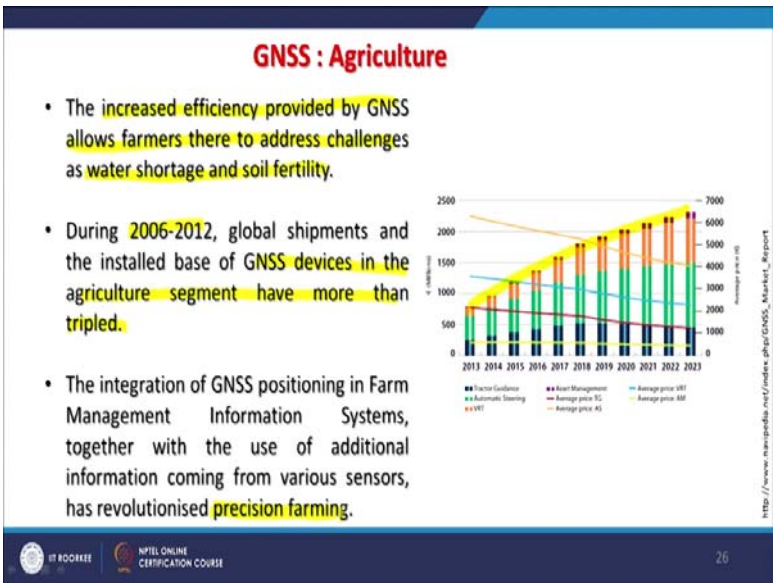

Now very briefly, we will touch about the agriculture sector. Application of GNSS in agriculture sector as you are seeing, there is also a quite steady growth in this sector and nice future is predicted in agriculture sector. But in agriculture as I have already

mentioned in those countries, it is possible where they are having large farms but countries like in India, we do not have much large farms and the individual farmer cannot really afford for such kind of you know harvesters or putting fertilizers or seeding in agriculture sector.

But nonetheless there is a growth and that will penetrate once this becomes much cheaper. So, even a small farmer holding a very small land can may imply in future about this, along with some other technologies like UABS and GNSS for you know putting fertilizers or seeds or whatever harvesting or assessing the production. So, increase efficiency in GNSS will allow farmers to have their own address challenges of water shortage and soil fertility. So, as it becomes efficient that includes accuracy as well as easiness; once this becomes very easy this technology which has already become but only for mobiles but for other equipments may not be as that good. So, once it becomes as reliable and easy, definitely more uses will come in agriculture sector also.

Like for example, in during 2006-12, global shipments of the installed base of GNSS devices in agriculture segment have more than tripled. So, it is growing at a very fast rate. Integration of GNSS with Farm Management Information System, together with the use of additional information coming from various sensors has revolutionized the precise farming. So, this precision farming is current trend. In agriculture sector, it will become much more as more efficient GNSS devices are available and are integrated with other equipments as well.

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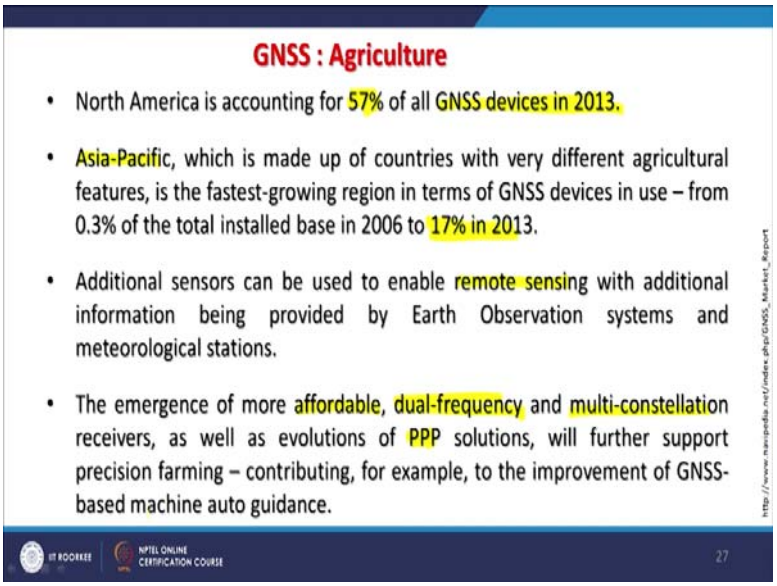

Like for example, in North America, which is accounting 57 percent of all GNSS devices because we know that they are having large farms and a single farm of few 100 acres and therefore, it is possible to imply all this. In Asia-Pacific region, which includes India is made of countries with very different agriculture features especially small farms relatively but still this market of GNSS devices is growing about which was 17 percent in 2013.

Additional sensors can be used to enable remote sensing with additional information being provided by Earth Observation Systems and meteorological stations. Especially farmers are interested to know about not only that soil but also moisture conditions and that can come through the remote sensing technologies. And of course, the location has to be there so that you know a selective treatment can be provided.

There is more affordable dual frequency; we have been mentioning about dual frequency GNSS multi-constellation receivers which will emerge with Precise Positioning solutions, will further support precision farming contributing for example, improvement in GNSS base machine auto guidance. So, automation in agriculture sector based on the GNSS and other technologies is future in that.

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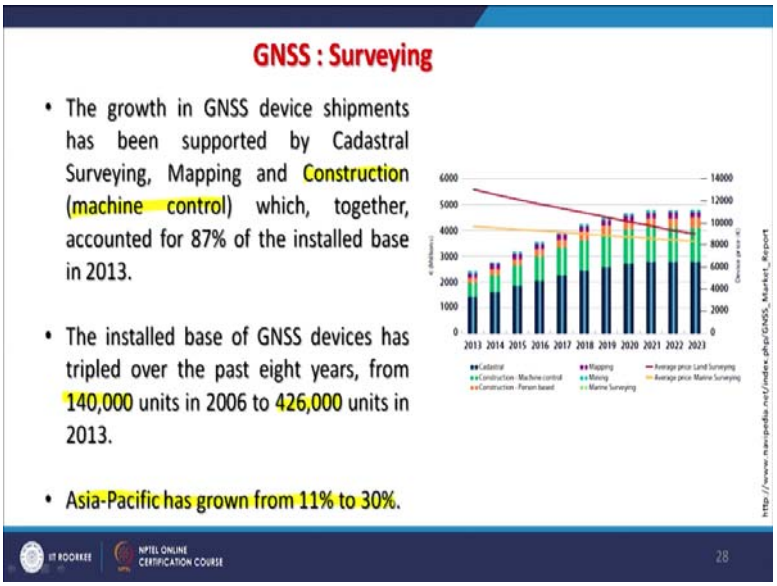

Now also briefly, we will see the surveying sector. It is already there extensively. Civil engineers for topographic survey or other surveys, they are using these differential GNSS or RTK services for surveying, mapping and construction machine control that is you know, large machines in the construction industries are also employing GNSS. This sector is also having good future that we will be having like you know, computer aided designs. So, we will be having computer aided constructions also might be in future.

And the installed base of these devices has tripled over the past 8 years from 140,000 units in 2006 to 426,000 units in 2013. And in Asia-Pacific also, the growth is quite significant from 11 percent during the same time period to 30 percent.

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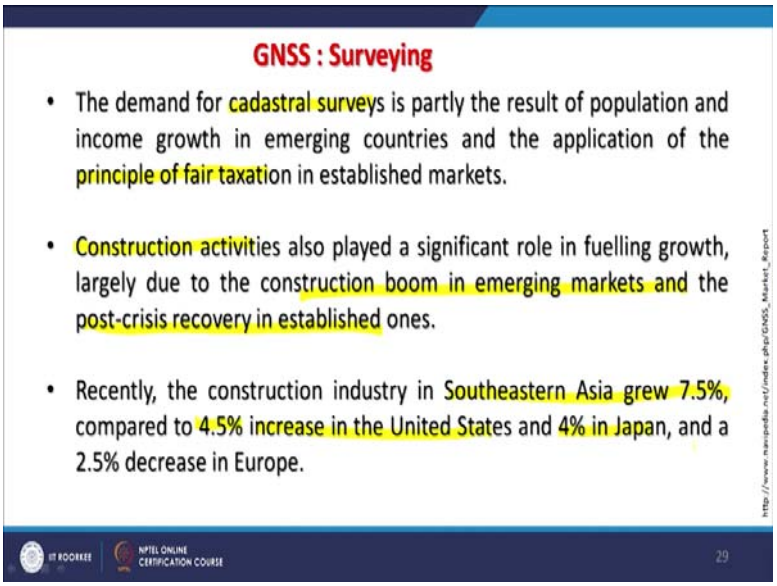

And these cadastral surveys like in this country, most of these cadastral maps which are called in North India, in other states they call as other but as we know, we called as a revenue records or cadastral maps. And these cadastral maps were in analog form without any geographic location that means latitude, longitude or other information or without any database basically, these maps had just numbers.

So, now they are being digitized and they are being brought onto the GIS platform and of course, then these are being attached with coordinate. So in this sector also, there is utilization. Many states have already digitized their land records or cadastral maps. And fully they are utilizing for the principles of fair taxation and maybe for other like in agriculture, they would like to assess that before a crop comes in the market that how much wheat has been shown in a particular area or in a state, to estimate the crop production. So, accordingly the country can think about storage and prices and other things so that all coming also through these technologies including GIS and remote sensing as well.

We have been mentioning that construction activities also played a significant role in fueling growth, largely due to the construction boom in emerging markets and post-crisis recovery in established ones also. And in Southeastern Asia, the growth is 7.5 compared to 4.5 in United States and 4 in the japan so developed countries are having less growth as you know that more infrastructure and housing is required in developing countries.

And therefore, the growth is much more and they accordingly the applications of GNSS are there.

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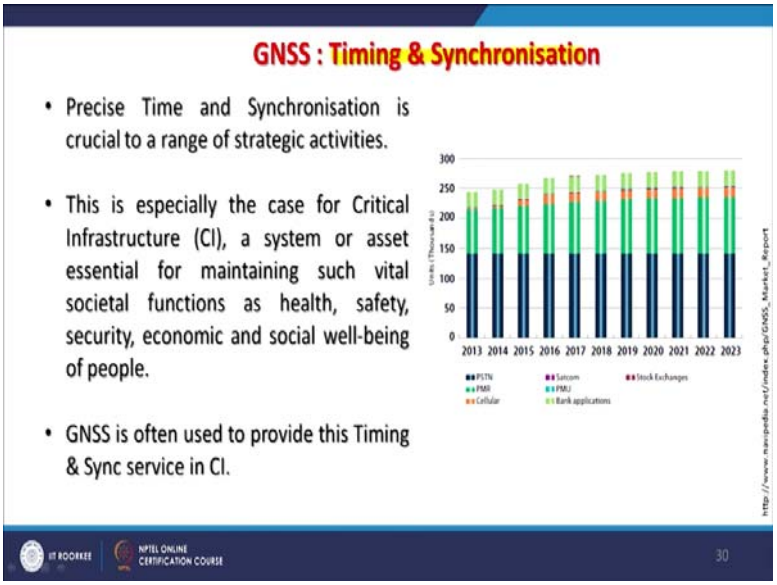

As when we saw the overall utilization of GNSS or the market share, we saw a very small market was for users are currently on timing and synchronization. But this is the sector which is also will grow that is precise timing and synchronization is crucial to range of strategic activities, not only in the aviation sector maybe in train or others but there are many other sectors where we require a very accurate timing. So, in that synchronization is also possible, apart from the frequency calibrations and other things.

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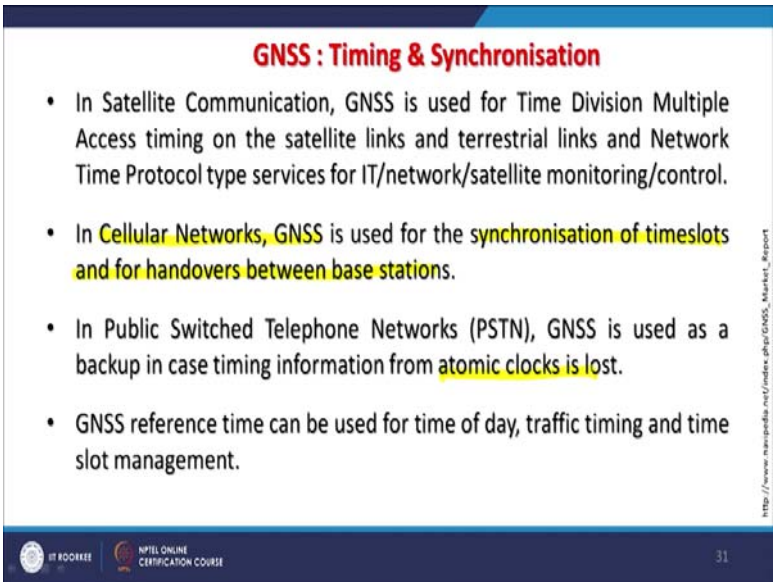

So because of satellite communications, these signals are available all the time. So, our clocks can be made very accurate, can be synchronized through this and cellular networks can also utilize this synchronization of timeslots and for handovers between base stations so that is also possible. There are some other technologies which is Public Switched Telephone Networks which requires again a very accurate timing. So, GNSS can provide timing as accurate as atomic clocks.

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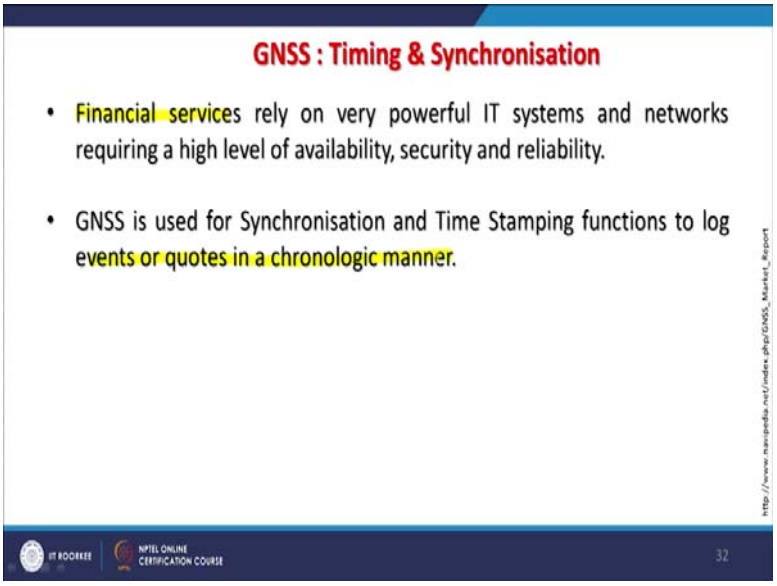

So, this is a one sector which is there, though it does not occupy a large market but there in the financial services and in share markets say you know, every second counts there and one country some like Japan is start first and then it goes to US and there the time is very-2 important. So there also, it is playing a very important role to the synchronization for time stamping functions to log events and codes for chronological manner.

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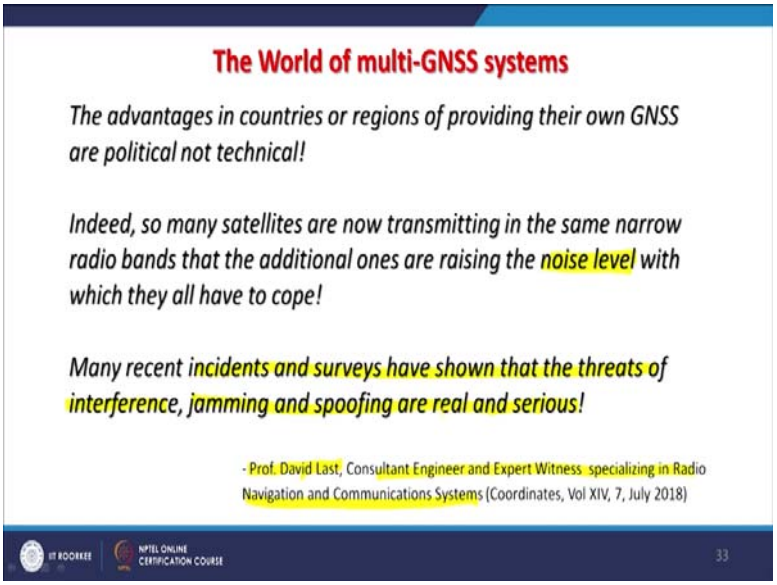

So, one of the professors David Last who is Consultant Engineer and Expert Witness specializing Radio Navigation and Communication Systems. He mentioned that the advantages in the countries or regions of providing their own GNSS are political not technical. This is what it is thought but users are going more technical in that sense. And indeed so many satellites are now transmitting that means so many constellations are there in the same narrow radio bands that are additional ones are raising the noise levels which they all have to cope.

Because the part of electromagnetic wave band which is available for communications through these GNSS constellations is very limited. So, there is of course, concern about the noise level which may create some problems. But you know like if Galileo is using certain bands so those signals because being currently regional system. So, we do not get these signals over India. So there is no interference with the signal even if they are using the same band.

So, if few countries are having their own regional systems then this issue of noise level or encroaching each others will not come, may not become big but anyway this is a concern and many recent incidents and surveys have shown that the threats of interference, jamming and spoofing are real and serious. So, spoofing this is a problem but as you know that whenever a new technology comes, some hazards also come. Some people create problems and that will be of course, all the time will be there.

So, this brings to the end of this discussion. This has been little longer but from you knows opportunities and future trends point of view, it was very much required to complete or comprehend all aspects starting from road to time synchronization. And as usual I am again leaving with a new cartoon just to enjoy and smile.

Thank you very much.