Advanced IOT Applications

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Lecture - 43
Cargo monitoring for tamper detection – Part 1

Alright so, let us take one example of a of what IOT can do in terms of logistics, support for logistics particularly if you are looking at let us say cargo monitoring of a freight monitoring essentially, it can be you know there.

Now, what has happening is most items are being delivered to your foot step foot your doorstep right. You do not have to set your foot out and items arrive at your doorstep itself, which means lot of items are coming over cargo. And cargo shipments has gone many many fold.

And therefore, airlines particularly I have to take care of what is it that is inside the package? And if there is any tamper inside this package are there explosive for instance, or their material which should not be you know exported is it part of it. So, all kinds of problems with respect to the cargo itself that is what contents of the cargo itself, that is one part. The other part indeed is the fact that, people who have submitted their cargo, customers end customers. Are submitted their cargo are interested in keeping track of where their cargo is.

Today, most often cargo monitoring is limited to you know sticking a barcode on it. And every time the cargo moves from one point to the other take a small package that you may have given for you know for sending it over let us say courier ok. Which is also to be treated more like a cargo, you the courier company keeps the track on where it is it has come to the airport or it has come to the office, in transit at the moment, as reach the destination is going to the nearest sorting station and then it is out for delivery, all those messages you keep seeing at discrete points in time.

But, you really do not know where and how if you are interested in real time monitoring of your cargo? Supposing, the content inside the cargo is something that you want to keep an eye on physically you want to keep an eye on there is no simple way.

Now, IoT can actually solve that problem for you, you can track your cargo in real time at any in at 24 bar 7 after submitting the cargo. Either, you can do or at least the cargo company which has accepted your cargo can keep a track on it. Now, what kind of algorithms would be required to keep tracking of this cargo well that is I think what we should be worried about when we talk about a advanced IoT course.

But, before we go into that detail let us look at why is this whole issue of cargo monitoring such a serious issue. I want you to see this report which was published many a several years ago this was published in 2007 ok and this report is actually called CRS Report for Congress, it was submitted it is published in the US.

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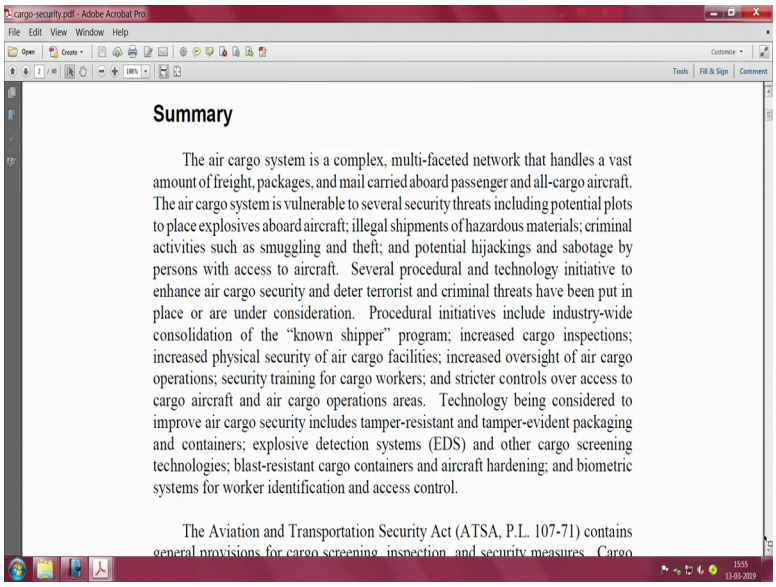

And there they talk about the air cargo system, being a very complex and multifaceted network. And it is vulnerable to several security threats right, they mention about all kinds of things that can get into the cargo, then there can be smuggling and theft hijacking of the cargo and so many related things.

However, there is something called known shipper which you see here right. So, this known shipper is interesting this part here you can see this, I am trying to mark it with this pen here. This part is the "known shipper" part ok. This known shipper procedural initiatives include industry white consolidation of the known shipper program, increase cargo inspections, increase physical security of air cargo facilities, increased over site of

air cargo operations security training for cargo workers, stricter controls over access to cargo aircraft and air cargo operations area.

So, essentially the cargo shipment becomes very simple for a end user, if we goes through what is known as this known shipper program, that is the airlines are looking for those people whom they trust. And known shippers are people whom they trust. And if they have to be known shippers, they have to follow certain procedures ok, known shippers have to take the risk of the accepting the cargo. From end users and that they do it very rigorously. They come to the customers promises and if they find something not suitable and they inspect it in detail and only then they will accept the cargo.

Once the cargo is accepted by the know shipper, then things are pretty straight forward the airlines which is carrying the cargo just does not worry too much about it. However, there are other rules I am glossing many things just to tell you that there is a full area by itself and you have to get into real detail. If, you have to understand how actually cargo moves from the warehouse up to the from the air I am just taking in airplane scenario. From where house it goes to the cargo loading zone and then goes inside the cargo, at least 3 different places where you should be able to track the cargo to it is menudo detail not just from tracking, but also monitoring the cargo package of interest.

So, if the cargo is being loaded into a cargo plane there is some procedure to be followed. And if the cargo is going along with passengers, then there is another procedure that has to be followed. All those things you have to understand in detail before you design any system.

Therefore, in IoT you might have seen all through these different modules that we did in this course, you have to get into the details of the domain before you design, any module that you want to design or you want to come up with an algorithm you have to get into those detailing, that is an absolute important thing.

That is why I am showing you corresponding literature which might help you to you know start up and have a look at that the documents like this, which might help you to design your systems.

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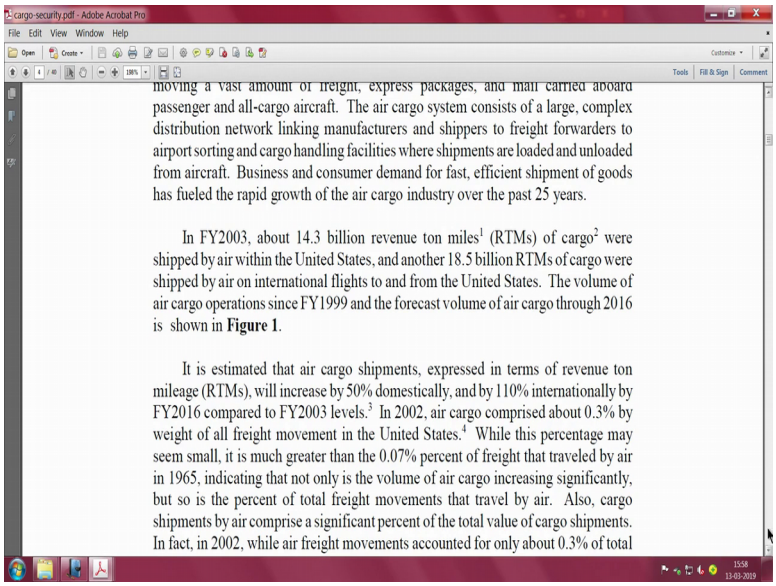

So, our focus in this module this mini module is a with respect to let us say tamper detection ok. You want to do tamper detection and you want to ensure that your cargo some how is fully protected ok. Now, if you want to do that you are at least two options at least two ways we can find more ways, but at least two ways by which you can do tamper detection. One is you put several sensors for detecting a tamper, they like for instance if someone is you can even put a microphone for instance right very sensitive microphone small embedded system.

So, that if there is a noise like a tiring kind of noise or puncturing kind of noise that comes it picks that signal and then alerts through some network, that this cargo is under attack ok. You can put a microphone there, if it is not a microphone and you are not interested in picking up sound, you may want to pick up something with respect to touch right.

So, you can have let us say a touch detection and then say someone has touch the cargo and does so, it could be typically like what these capacitive sensors are right. So, you can have a capacitive sensor and there if your touching that, then it alerts and says that somebody has touched the cargo.

So, tarring of a cargo one way of doing it the other ways to detect touch an touch sensitivity is of these systems that is another way of doing it. So, I can think of to maybe you have other ways third one could be that you wait until the cargo is torn, the cargo is

touched, but a flap is opened. Once, you open a flap maybe some proximity switch goes off and then quickly you are able to alert people, but that is already too risky right.

Even without opening the lid people may put a slip and then push whatever they want to and close it. So, that maybe a little bit risky. So, maybe microphone based sensing or touch based sensing may be applicable. But, of course, all these are subject to let us say the scenario of interest, it is if it is item that you want to push inside or take out from that, is pretty large you may making a slit is not going to help you have to open the flap and you have to replace things.

So, that, obviously, means that, you could use a different type of sensor. So, all this brings us to a important thing is how do I design this whole IoT system, which will allow us to sort of you know keep track of monitor the cargo in real time and look at tamper of this type of cargo. So, you can see that this is the motivation really this paper, this little survey that report which was submitted is indeed the motivation. And, there are numbers which tell you how cargo shipments are going to go up. And how they are going to on revenue for predictions and what kind of revenue you are likely to see.

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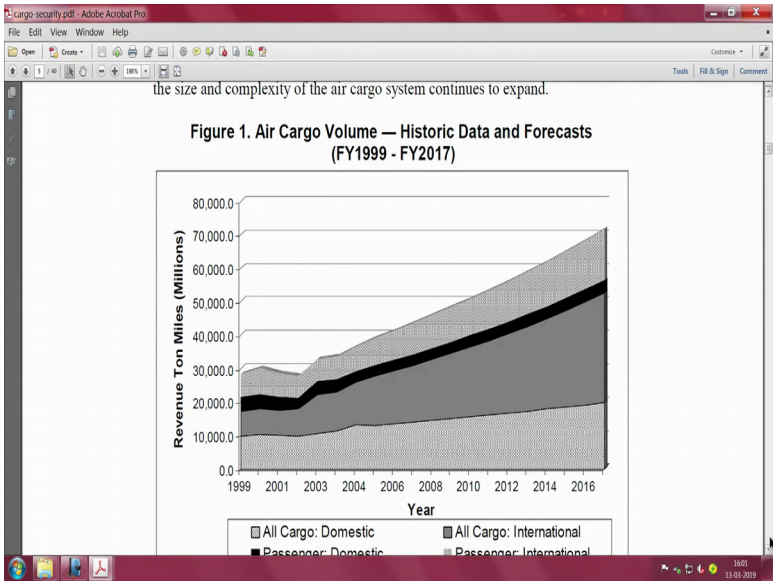

You can see that revenue per revenue ton miles over the year x axis is the year and y axis is this revenue ton miles and you can see that 2016 17 forecasts or pretty paddy it just going up.

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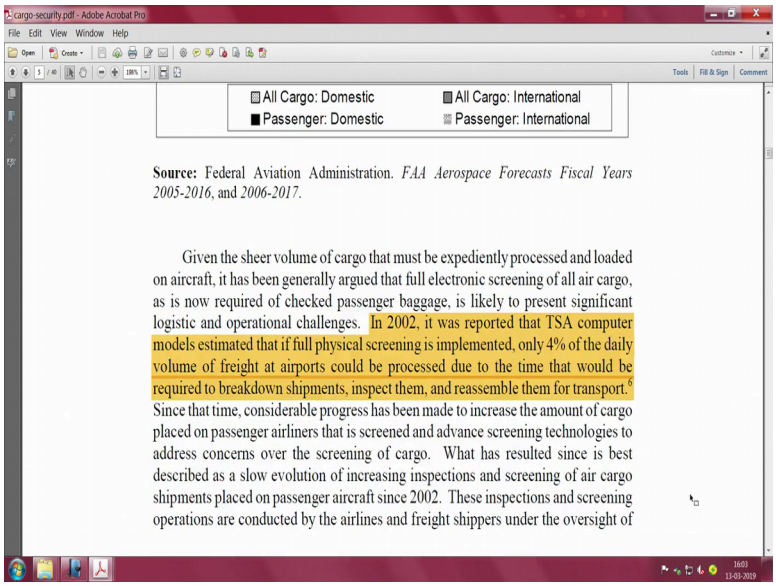

All the time from to from 99 to 2016 has been going up. All cargo, all cargo domestic, passenger cargo and passenger cargo international everything seem to be rising right. Passenger cargo has gone up and so, does all other cargo which seems to be going up.

So, this is an interesting statement which I thought ill bring it to your notice, that in 2002 it was reported that TSA computer models estimated, that if full physical screening is implemented only 4 percent of daily volume of rate at airports could be processed. Due to that time that would be required to break down shipments inspect them and reassemble them for transports. So, if you really go into great nitty gritty details of each and every piece of cargo it is not going to worth, you can only push 4 percent of the overall cargo. Say, abysmally small number somewhere you need to put the trusts these known shipper as I was telling is important right.

So, the known shipper has to take care of several things only then this numbers can scale up. If, you really want to do it from the TSA com computer systems models perspective, then it is only going to be just 4 percent of the volume of a freight. So, you can see that you need solutions right. So, otherwise it is not going to work. So, I would strongly recommend you to download this document and really motivate yourself on why this is an important problem.

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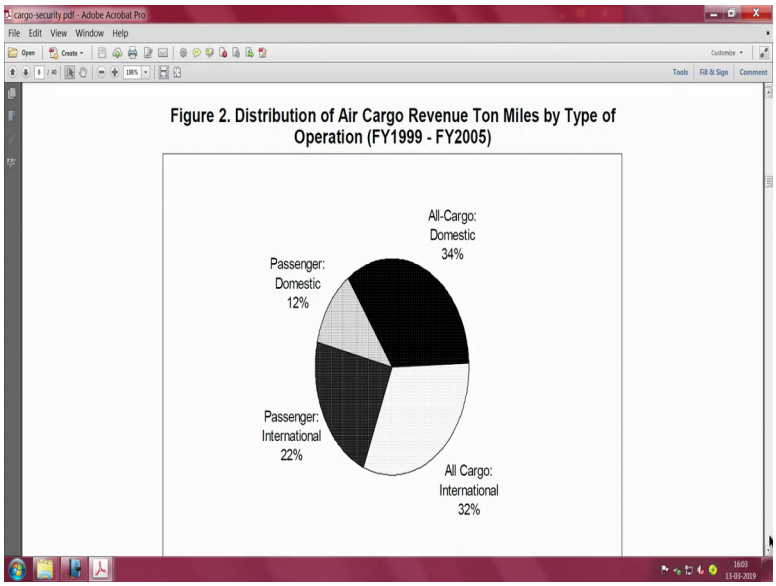

Distribution of air cargo revenue ton miles by type of operation is also here. All cargo 32 percent passenger international 22 percent, passenger domestic 12 percent and all cargo domestic is 34 percent, that is from the year 99 to year 2005 how it has gone up, how what is the distribution of the complete cargo movement right in during this period.

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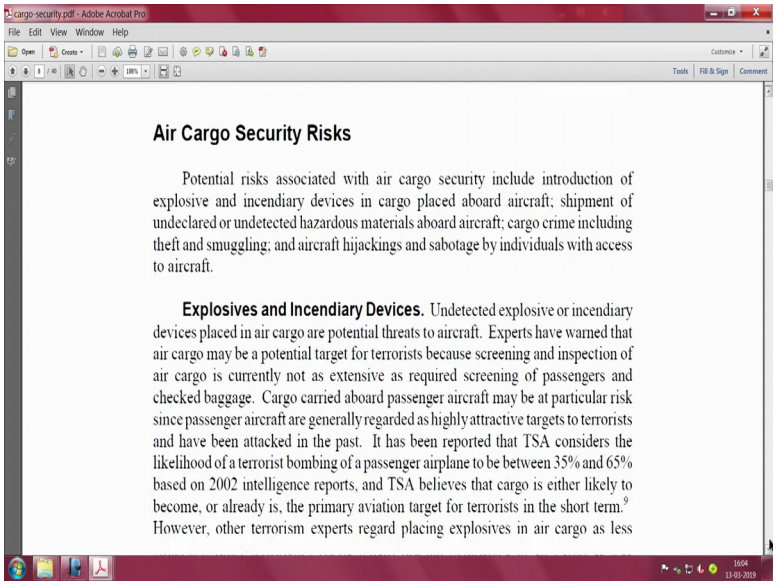

So, you can see air cargo security risks are there explosives and other kind of devices, then, there are hazardous materials which can be an issue.

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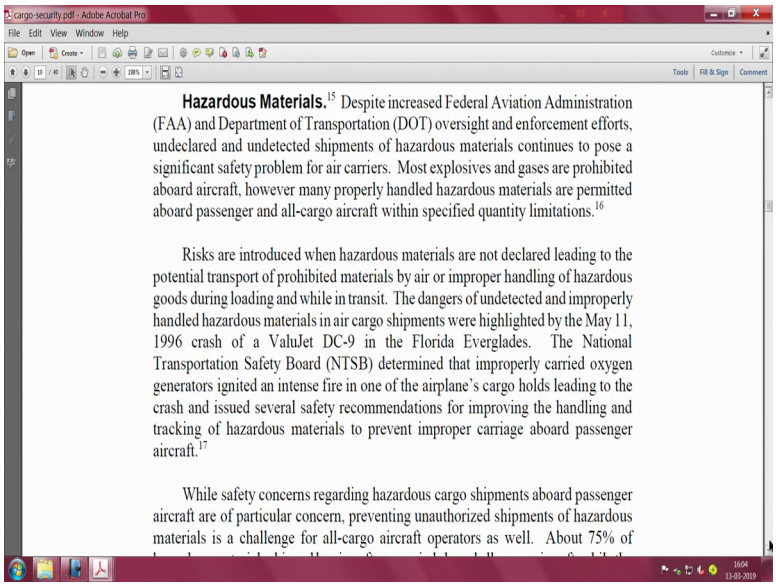

Hazardous Materials.[15] Despite increased Federal Aviation Administration (FAA) and Department of Transportation (DOT) oversight and enforcement efforts, undeclared and undetected shipments of hazardous materials continues to pose a significant safety problem for air carriers. Most explosives and gases are prohibited aboard aircraft, however many properly handled hazardous materials are permitted aboard passenger and all-cargo aircraft within specified quantity limitations.[16]

Risks are introduced when hazardous materials are not declared leading to the potential transport of prohibited materials by air or improper handling of hazardous goods during loading and while in transit. The dangers of undetected and improperly handled hazardous materials in air cargo shipments were highlighted by the May 11, 1996 crash of a ValuJet DC-9 in the Florida Everglades. The National Transportation Safety Board (NTSB) determined that improperly carried oxygen generators ignited an intense fire in one of the airplane's cargo holds leading to the crash and issued several safety recommendations for improving the handling and tracking of hazardous materials to prevent improper carriage aboard passenger aircraft.[17]

While safety concerns regarding hazardous cargo shipments aboard passenger aircraft are of particular concern, preventing unauthorized shipments of hazardous materials is a challenge for all-cargo aircraft operators as well. About 75% of

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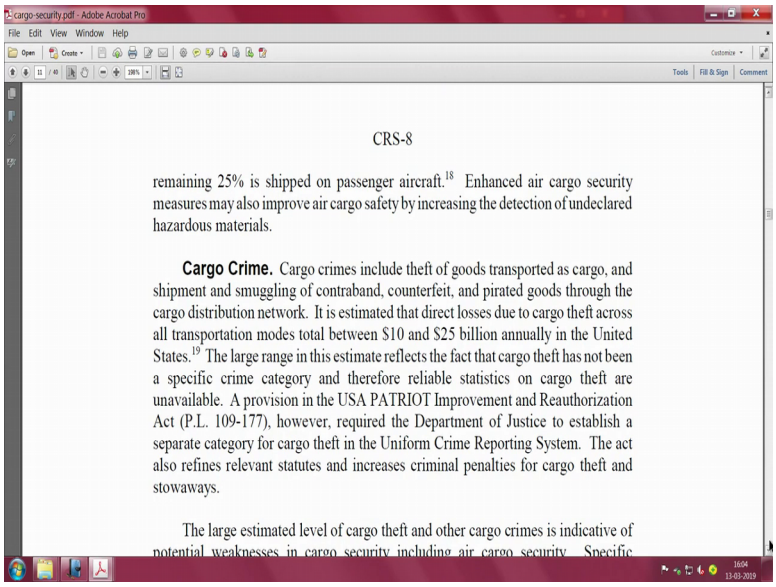

remaining 25% is shipped on passenger aircraft.[18] Enhanced air cargo security measures may also improve air cargo safety by increasing the detection of undeclared hazardous materials.

Cargo Crime. Cargo crimes include theft of goods transported as cargo, and shipment and smuggling of contraband, counterfeit, and pirated goods through the cargo distribution network. It is estimated that direct losses due to cargo theft across all transportation modes total between $10 and $25 billion annually in the United States.[19] The large range in this estimate reflects the fact that cargo theft has not been a specific crime category and therefore reliable statistics on cargo theft are unavailable. A provision in the USA PATRIOT Improvement and Reauthorization Act (P.L. 109-177), however, required the Department of Justice to establish a separate category for cargo theft in the Uniform Crime Reporting System. The act also refines relevant statutes and increases criminal penalties for cargo theft and stowaways.

The large estimated level of cargo theft and other cargo crimes is indicative of potential weaknesses in cargo security including air cargo security. Specific

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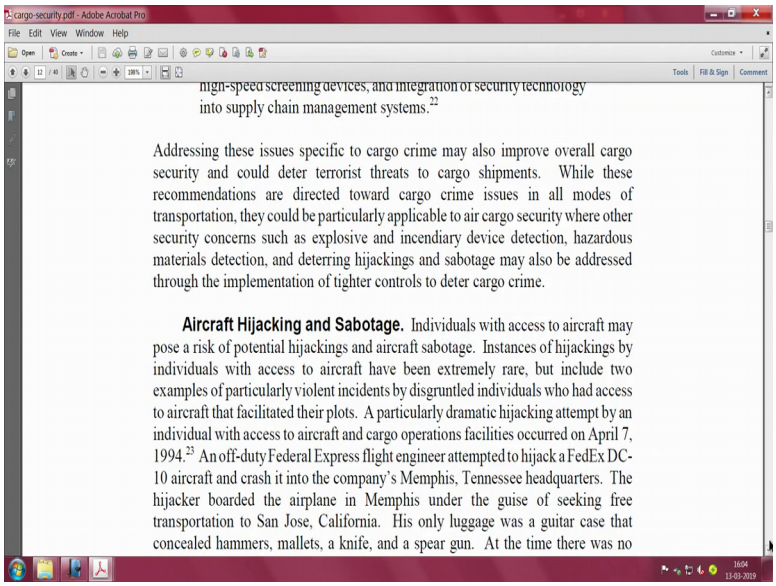

Cargo crime is a problem, then, you have aircraft Hijacking and Sabotage, which is also a very important thing.

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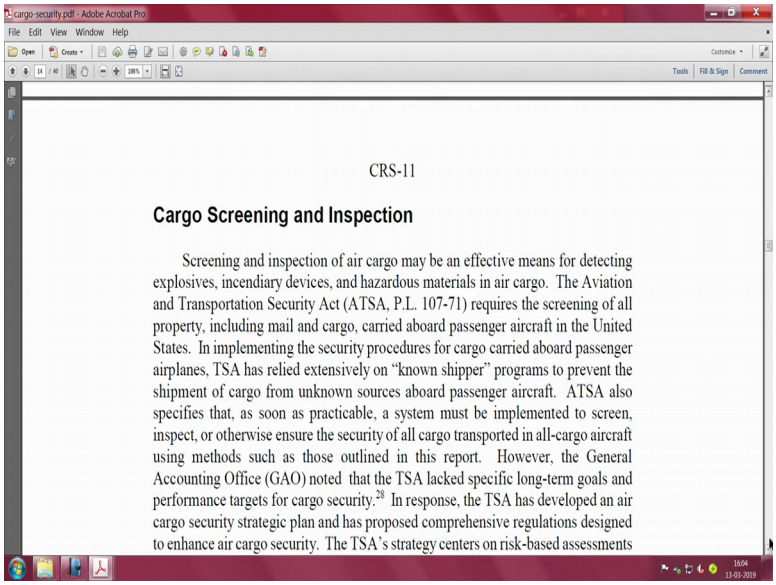

So, you have to do proper cargo space screening and inspection only then you can actually let the cargo on to the flight. So, this is the most critical part ok.

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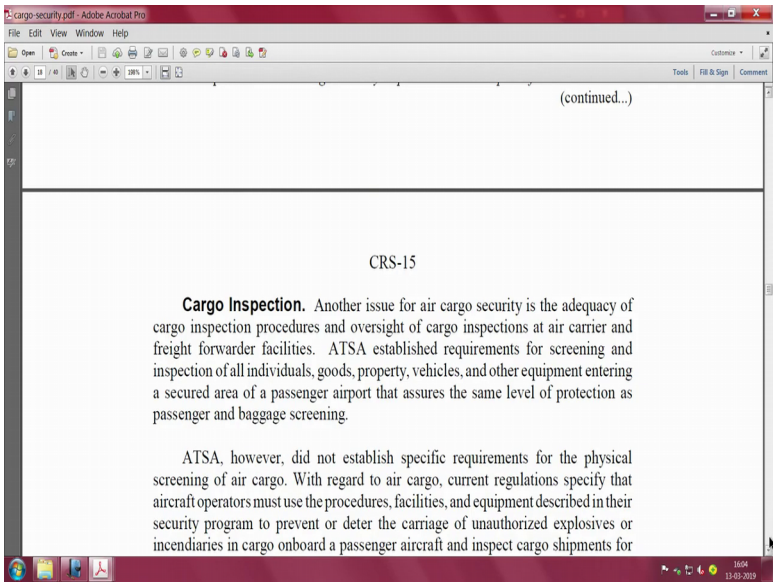

So, what is the system, that we have in mind and how do we design this system is the question really. So, I would want you to go and read this documents I would not going to the detail. But of course, you it is available for download you can simply download this and read this document and get you a very good feel of what is the problem on hand and what is it that we want to solve and what are the new issues that have come up. Because, this is published was published more than 10 years ago. What are the new issues and how does one look at this huge market segment of logistics right and how can IoT help in this logistics area ok.

So, essentially this is the module on logistics essentially ok. Then, I have taken cargo particularly air cargo as a application case for us to understand in detail alright. So, that so, I leave it that and leave you with thoughts that there has very strong motivation, why you want to monitor cargo right. So, at least to that extend the need establishment is in place.

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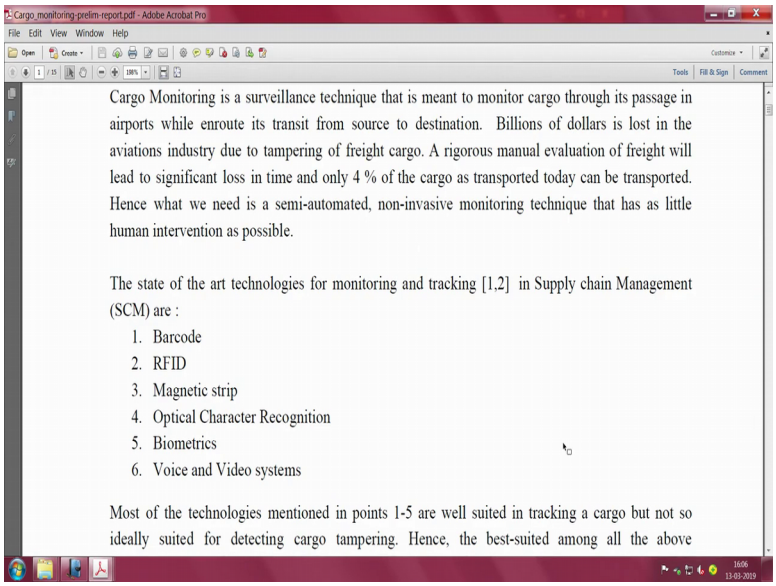

Now, so, let us go back to this document and look at quickly what are all the possible art of you know this technologies for monitoring and tacking in any supply chain management. Barcodes I mentioned to you RFID is another possibility, magnetic strip, then optical character recognition, biometric, voice and video systems are also something that can be used for many of these you know monitoring and tracking applications including cargo systems.

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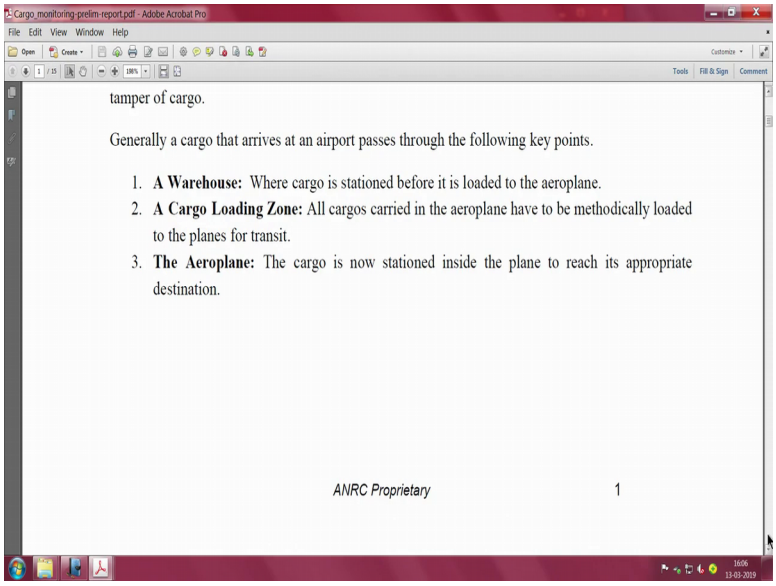

So, whenever cargo comes at the airport at I mentioned to you three parts right a warehouse cargo loading zone and an aeroplane. So, cargo is stationed here before it is loaded into the plane and then cargo loading zone. Essentially is all cargo carried in the airplane have to be, methodically loaded to the plains for transit and then inside the aeroplane you push it you pushed it inside the aeroplane.

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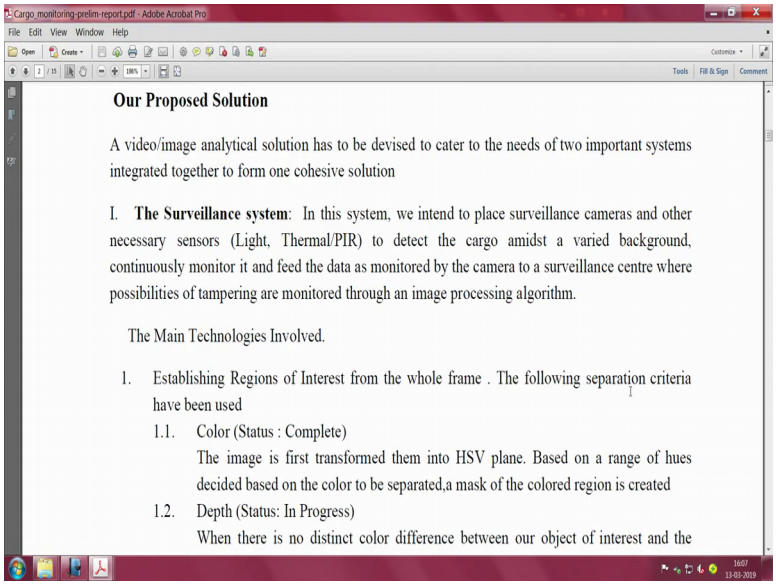

So, our proper solution that thing that I am looking up is that we need to build a surveillance IoT based surveillance system, which sort of monitors this cargo. Means, that you need a surveillance camera and this surveillance camera is both day and night camera. And then you will meet the necessary sensors like light sensors to just a see, what is the ambient light at the moment.

Then, you need movement right if you want to protect your cargo you have to ensure that nobody comes close to the cargo. So, you need movement detection, thermal sensors, a human thermal radiations which I did in the previous design for IoT course, you can look up some modules there, where thermal sensors can be used very cheap once. You can use 8 cross 8 thermal sensors or you can use even 4 cross 4 thermal sensors and these can actually detect human being said some close distance.

So, you are interest in protecting your cargo monitoring your cargo and ensuring that nobody comes close to the cargo. So, you can you PIR as a possible detection, then you

can use thermal sensors and you need to detect light. What is the current lighting condition that is there around the cargo?

So, that if you have to do I R and you have to move from black and white to colour and all that you will need to enable based on the light conditions right. Because, in most cameras in the night when the lucks falls down 0.001 lucks and all that you would not be able to get colour images right, you will only get black and white images. So, the cameras are intelligent to switch over to get you night pictures by making it black and white. So, all these things have to be incorporated into your solution most often high end cameras actually have these facilities.

But, if you are doing it during the day then you are interested in colour images and then you have to do the you want to get a you want to look at the separation criteria.

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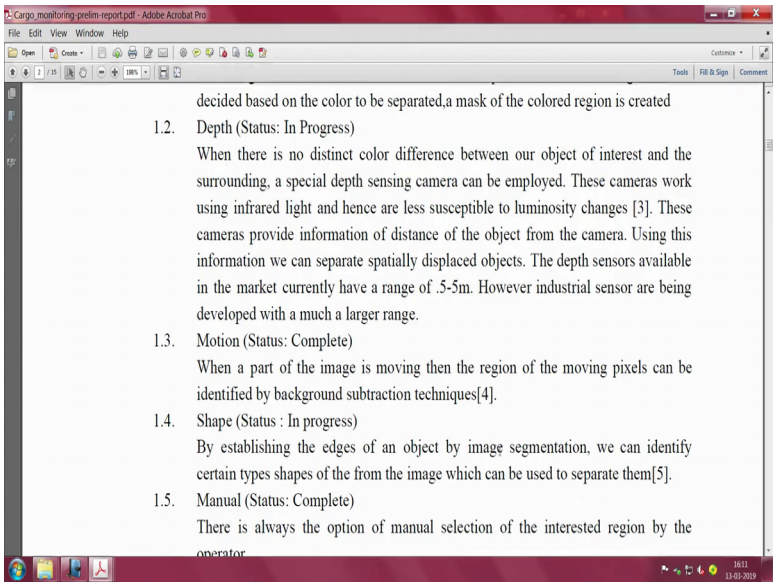

That you want to use for establishing the region of interest, when you take a camera picture and then you have a full picture of the system cargo is only perhaps occupying not all pixels, it is just occupying one part of the image. And therefore, you are interested in just the region of interest and therefore, you could look at colour for instance use colour as an important signature. The image is first transformed into some sort of HSV plane. So, you are already building your system.

To use colour and based on the range of use we decide decided based on the colour to be separated a mask of the coloured region is created. So, you can do colour as something that so, this pro you see status complete is something that is internal to us, we have been working on it. So, we have completed this colour based you know using different technologies like colour as one of them, depth we are still working on it, but we have made some good progress on it.

And where there is depth essentially means when there is no distinct colour difference between our object of interest and the surrounding, a special depth sensing camera can be implied. These cameras work using IR light and hence are less susceptible to luminosity changes. These cameras provide information of distance of the object from the camera. And therefore, you can use these depth sensors and they will tell you how far these objects are right. So, the problem is if colour merges, if colour cannot be used as a nice feature for separating out the region of interest then, you may want to use depth as well alright.

So, then motion when a part of the image is moving, then the region of the moving pixels can be identified by background subtraction techniques, something that is quite well known in the image processing world. Shape is another thing you can establish shape of an object by image segmentation

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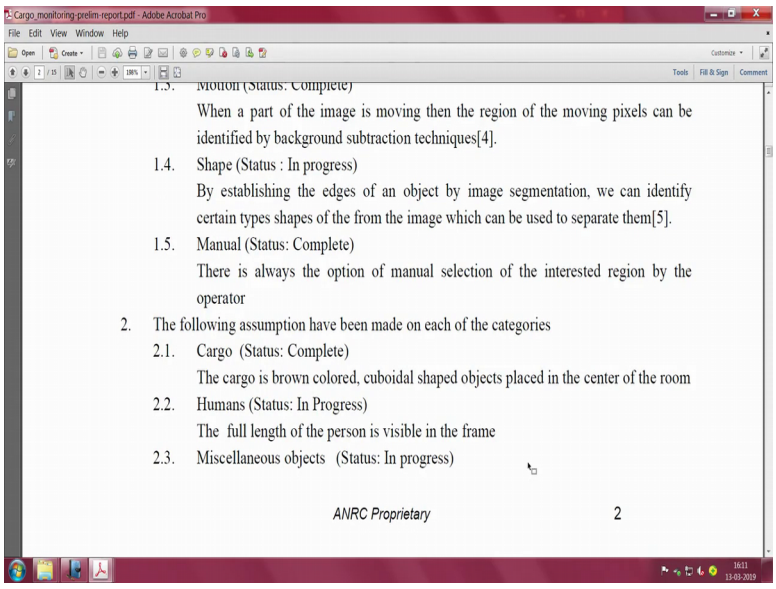

And then so, many things are possible. So, you have to look at what are all the possible signatures, that you want extract for if you are cargo, I will show you some pictures maybe that will help you. So, then what is very important is after the so, you make some assumptions about the following if you want to design your system you need those assumptions to be stated upfront correctly.

So, one of the things is that cargo colour is something that we want to fix ok. The cargo is brown coloured cuboidal shaped objects placed in the centre of a room or somewhere some place where you know you want to start tracking monitoring from that point. And then the full length of the person is visible in the frame if there is a human you are not just looking at part of the human, the camera is far enough to look at the object of interest which is our cargo, which is brown in colour and humans around can be detected in full not just a portion of it.

And then there are other objects which can be around the cargo that is not a problem. Then the cargo region of frame is monitored using several techniques. So, these are the 2 most important techniques that you may want to concentrate on. I want to emphasize this because you should try ok. I can only tell you what to look for and what kind of techniques you can apply.

Here there are two techniques and I have pointed you to both of them, which we completed we are tried out a little bit and we are quite confident that they are good. One is half transform please recall half transform, you did it in the nod module related to the automotive world. Now, it is back again half transform first strap detection, you take a piece of cargo and there are two straps which are used for tying the cargo. Look at angle deviation of the strap for that you have to do half line and then identify the angle deviation of the strap. So, the original angle and how much as the angle of the strapped deviated, that also you should be able to detect. So, these are so, you will need half line.

Then you need surf, this is very important it is called speeded up robust features detection technique with some sort of some probabilistic analysis these are interest point essentially of the cargo. So, you have to extract the interest points, which an from an image of the region of interest from the region of interest which is our cargo. You get the points of interest please look up open CV description for surf, I cannot get into the detail, but you can use this technique of surf detection technique for the purposes of cargo

monitoring very very important. Then, you need a network once you detect that there is a tamper, you need a network and you need certain bandwidth from the network, and then you have to transmitted and all that.

So, that is not at all very important, but we will just focus on essentially leaving it at the fact that you do tamper detection right. Communication of a tamper is a another story, that say something that has been, that is being touched or that has been tone or you put as I said several sensors you can imagine also in that scenario. So, look at warehouse this is where all the cargo has been brought and stored. And they are other all stored within a room you have to do the region of interest exactly there.

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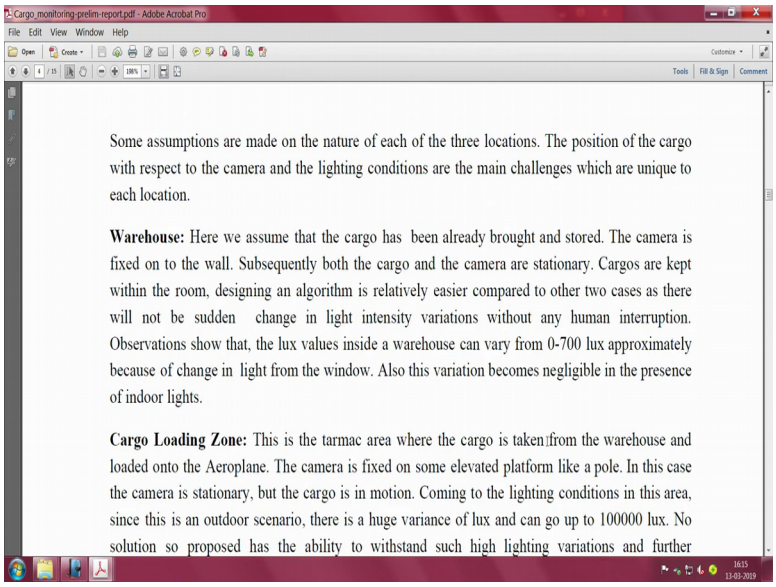

And you will have to look at cargos which are kept within the room designing and algorithm is relatively easier compared to other k other cases as there will not be any sudden changes in light intensity variations, without any human interruption. The reason is a warehouse is well lit it is uniform it is indoor therefore; light intensity variations are not going to bother you so much. And it is going to be quite a been in environment for you to do any kind of testing. Typically, you will get 0 to 700, if you are looking at the indoor environment.

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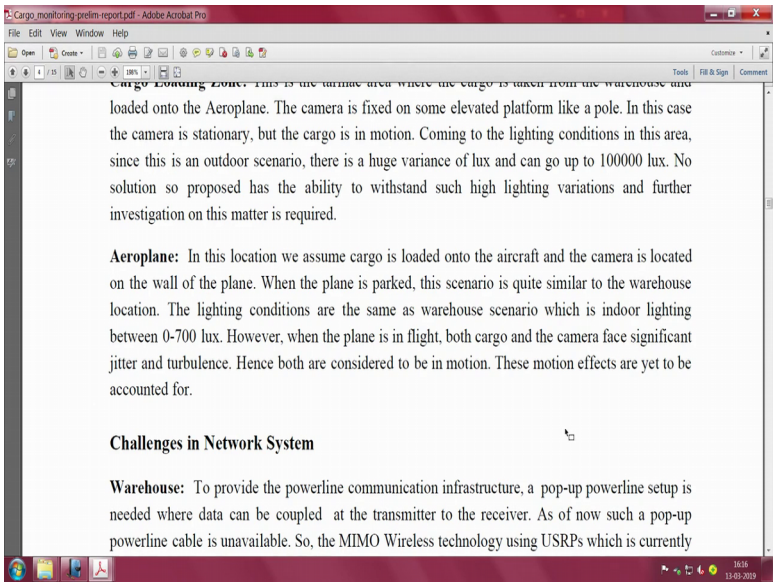

But, look at cargo loading zone this is where it is an outdoor and the camera is stationary, but cargo can be in motion and coming to lighting conditions this is outdoor there can be huge variation variance right of lux. If, it is outdoor during peak summer I mean sun at noon, during summer it can also be 200000 lux, 100000, 200000 lux and all that. Down to if there is a small cloud cover it can be down to 25,000 lux ok.

So, it can really very within seconds it can go from 200000s to 25,000 and it can 10,000 and so on and so forth. So, really the variance under lighting conditions is the variance of these lighting conditions so, quite large. So, it is hard for you have to keep detecting it carefully, you cannot build systems solutions for this, but indeed that is the hard problem right. Aeroplane, it is inside the assume though the cargo is loaded inside the plane and the there is a camera kept very close to the airplane and the plane is parked at the gate. And the lighting conditions are the same as that of similar to that of a warehouse.

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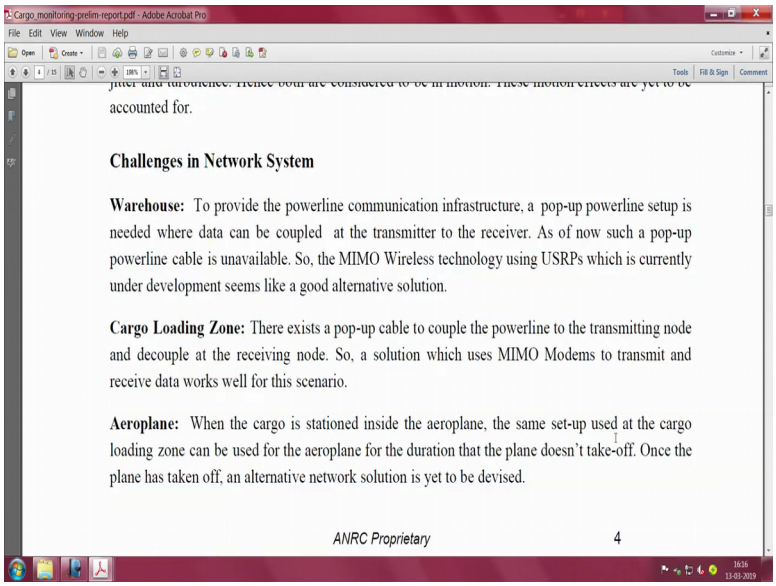

Like inside the plane they would not be much variance in the lucks. So, that should be no problem at all for you alright. So, there are other things which may not be of interest in this document.

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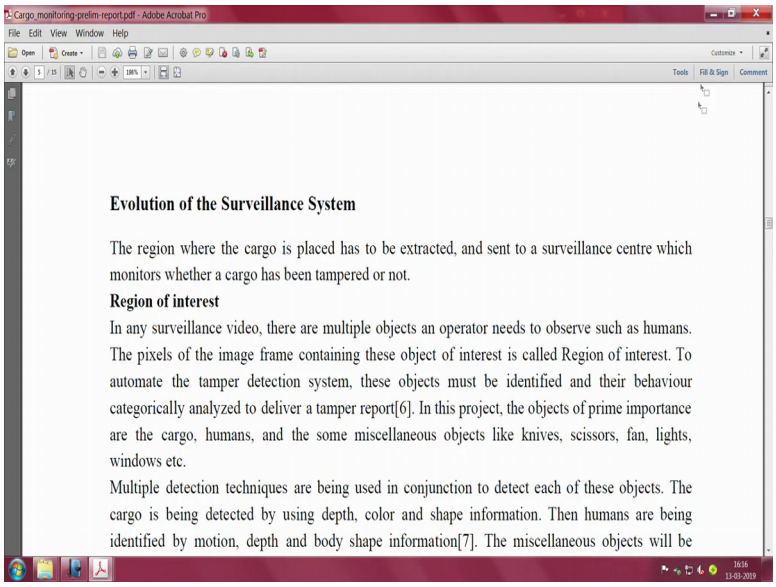

Now, I will show you a set of slides by which one can actually do this air cargo monitoring detection ok.

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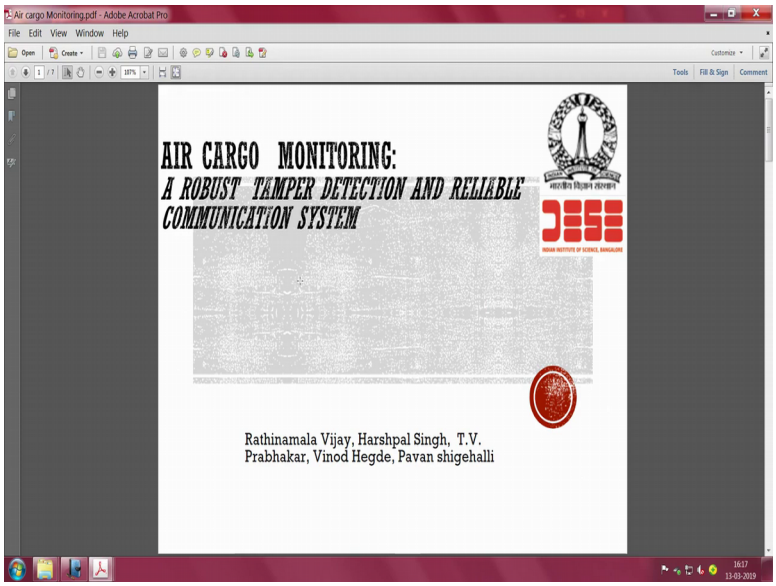

So, let me show you that this is work done by a few of our colleagues and the students in the lab. As you can see their names here Ratnamala Vijay, then Harshpal Sing, Vinod Hegde, Pawan and so, many others have worked on this project.

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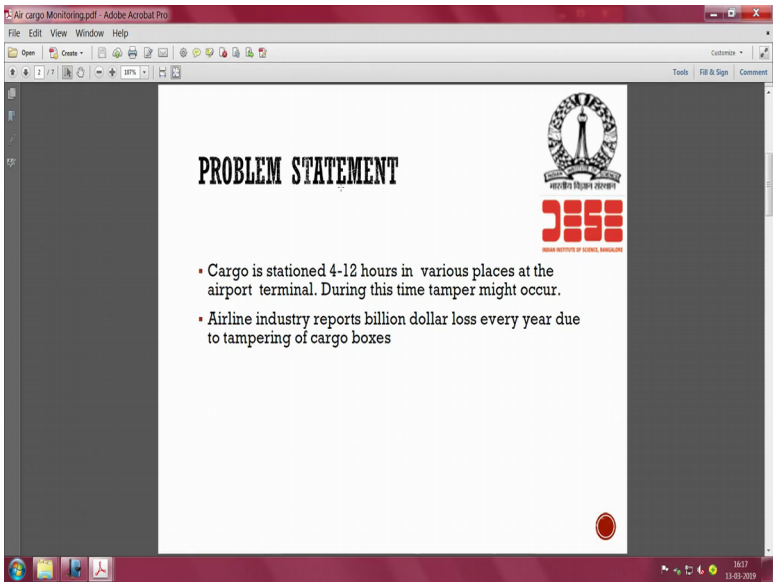

Basically a tamper detection system, here is a problem statement you have to post similar problems, problem statement to yourself if you really want to provide the some sort of solution. As a cargo is stationed 4 to 12 hours in various places at the airport terminal and the airline industry reports loss we know this very well.

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See this picture ok. You have the storage area and sorry you have the storage area, you have the pallet built up area, then you have the cargo loading zone and you have inside the aircraft. Pallet built up is you not take one cargo, but you take a set of cargo boxes and make it into a pallet. And then you maybe now monitoring just your part of the cargo, which is part of the pallet or you may be monitoring the full pallet, that is also possible right. Both you have to again look at what that scenario is?

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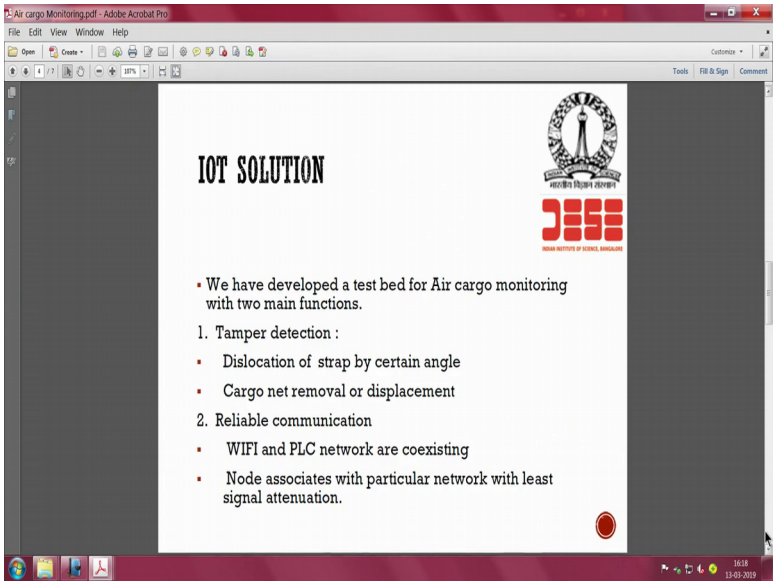

Now, what is the IOT solution? The IOT solution is to detect dislocation of strap by a certain angle. And if there is a net round the cargo, you should be able to easily identify the cargo net removal or displacement ok. And communication has to be very good it has to be reliable, you can use power line communication if there is sufficient you know power points plug points for you, you can combined with WIFI. And then use the WIFI, PLC hybrid network to carry this data alright.

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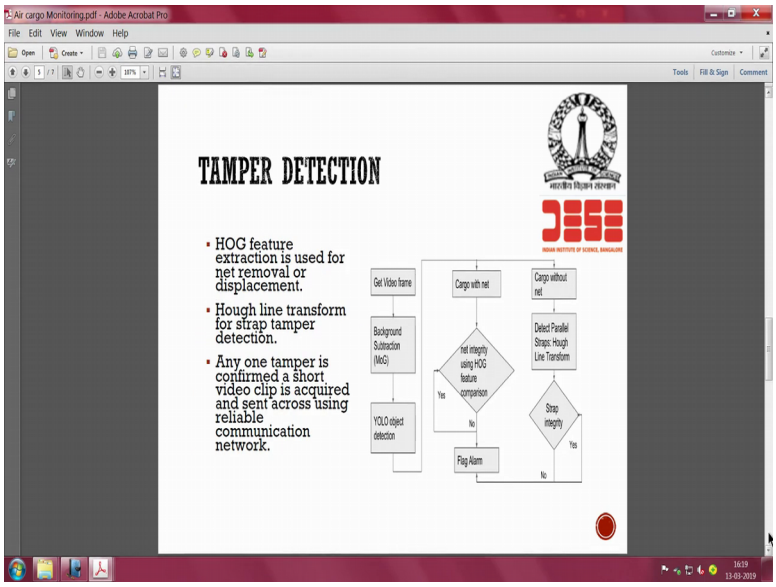

How do you do it? That is an next question, you see here that what they normally do is they so, we have to do in this way. You get the first video frame do background subtraction essentially use this mixture of Gaussians, based subtraction, then use this YOLO framework object detection in real time right, we discuss this last time.

So, use this YOLO object detection, if it is cargo with net you do it in one way, if it is cargo without net you do it in another way. So, you can see it with the right is cargo without net, if it is without net detect parallel straps simply do half line transform and look for strap integrity. And if there is it is the strap integrity is disturbed, then you will have to flag an alarm and then move on from there right.

Look at that with cargo with net this is that is this part here, you look at net integrity , but now you do not half trans half line transform, because it is not a cargo without a net it is with net. So, you now do what are known as HOG. This is called Histogram of Gradients feature comparison and then you flag an alarm, if the answer is no then there is no

problem at all, if the net integrity feature comparison is you know if it is if it gives you beyond the threshold, then you have to flag the alarm otherwise, you simply go on checking in a loop.

So, this essentially means that there is feature comparison is going fine you keep going back in this loop, but if it is in the feature comparison says that there is a difference then you are a flag an alarm right. Same thing this alarm would again come back from strap integrity, if there is a no then you come back here, integrity is gone; that means, essentially if it is yes there is no problem, but if it is no again it come back to this alarm flag. And this alarm flag is the one that will actually take and then we have to communicate soon as there is a tamper.

Thank you.