**Logistics & Supply Chain Management**

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**Lecture 04 : Storage and Warehousing**

Hello dear friends, once again welcome to NPTEL online course on logistics and supply chain management. So, today lecture 4 will be on storage and warehousing. So, I am Dr. Vikas Thakur, Department of Humanities and Social Sciences, IIT, Kharagpur. So, under this session we will try to address the various concepts of storage and warehousing and then we will see the cross docking as one of very big opportunity and how we can utilize this opportunity, but yes there are some challenges and then we will discuss small case studies on storage and warehousing. So, let us start with the very basic function in any logistics distribution network that when we are talking about inventory, when we are talking about transportation.

So, in between where we will keep this inventory. So, we need to have some storage centers. Either you can store your raw material or you can store your sub-assemblies or you can store your finished goods. Even once it is dispatched from your manufacturing unit, down the supply chain also you can store those goods just before distributing the product to the final customer.

So, storage in logistics and supply chain management refers to the process of storing goods, material and products at various points along the supply chain from the raw material procurement to finished goods distribution. Effective storage management is crucial for ensuring the smooth flow of material optimizing inventory levels and meeting the customer demand. So, just before proceeding further we will discuss what are the different aspects, but yes we will go through this video link and then we will see how this wonder is happening when we are saying that 10 minutes delivery. and how we are dealing with those perishable items and we are getting these out of nowhere kind of thing and the term used is your ghost stores or dark store. So here I have included some video links.

You guys can just quickly go through these videos and then we will continue our discussion on the topic. Yes, so Blinkit, Zepto, these are some of the few players which are promising you 10 minutes delivery and you have seen one dark store in Delhi, then Mumbai and then Bengaluru. So, the Delhi store deals with all the routine items you are

using in your household, but especially talking about Bengaluru and Mumbai, which is a small store dealing with perishable items, such as fruits or vegetables. Now, the basic feature of this dark store is that you need not to brand this store. You can take this facility may be somewhere little bit outside of the city where you can get probably the more strategic location in terms of if you are talking about the price of that facility.

that way we can move little bit away from the main city and then you are recording orders through different channels omni channel approach can be there and once orders are recorded may be in the morning orders whatever you are recording by evening you can deliver or whatever evening you are recording in the night your the second shift you can process those orders and in early morning you can go for delivering the products right so in that way this is a kind of another concept where you are not inviting customers to your store rather you want to save that time interacting with the customer you want to save that all those facilities which you will provide when customer are visiting to your store all those you can minimize the cost as well in addressing those things that cooling AC facility not required, that much lighting is not required in that way you can be efficient. Then because you are keeping enough space in between in that warehouse that customers can easily move with their trolleys and all the stuff in their hands right so that way when your specialized trained workers are moving so obviously you can optimally you can use that space limited space right so these are some of the advantages when you are working in dark stores right let's go further and we'll discuss about the storage and what are when we are talking about storage what are the key basic elements we are addressing first is your We talked about in probably in the first or second lecture that 7 Rs that through this logistics services we are targeting the right customer, right quantity, right place, right time, right price and quality, variety all those things are there. So, obviously here also in storage we will try to address the customer requirements. So, to know the requirement first we will interact with the customer, we will analyze their behavior pattern and then we will manage the customer in that way with the right offerings. so with right offering means you need to find out the taste of the local people community where you are operating what quantity they are buying what type of flavors they are going so all those things right or maybe shape or size different size products are there in your basket right usually up to what size or shape or maybe the weight they are buying that product right and how frequently they are buying right so that will help you to manage your category of products and then you need to manage the suppliers also so storage part is They are also because it is not one piece kind of flow in the supply chain or in the manufacturing unit or we are talking about just in time.

So, your suppliers are also part of that, they are also storing the goods, the raw materials. For whatever the raw material we are taking from the supplier, may be it is raw material for us, but that will be the finished product for the supplier. For supplier, raw material

may be coming from some other supplier. So, in between we are providing those storage houses. So, right place then we need to place to the customer using your logistics and warehouse management.

There also we will try to you know in distribution centers or we talked about the fulfillment center. where you are recording the order and then in the end you are processing those orders by delivering the orders and again you are going for replenishment of the inventory. So, when again you will go for the replenishment, again you need the storage houses to replenish the inventory. so how you will plan the replenishment cycle that will be based on your forecasting how you are forecasting the demand the behavior patterns right the buying patterns rather right so accordingly you will place the this is how will manage the total store Within the store, how we are channelizing the inventory, how we are keeping the products on the shelves, how we are ensuring that product should not go obsolete, which product we should move first, depending upon and once it is may be outdated, so expiry after expiry, how we are again returning or channelizing the product. So, this is very important if you quickly talk about a small maybe milk supplier who is maybe having the milk related products or milk itself let us say.

So, let us say he is daily he is predicting that he can consume around 1000 liter of milk. So, those many packets of 1 liter or packaging may be 2 liter packaging or may be half liter packaging he is storing in his storage house in his refrigerator. But let us say on one end he is able to consume the full inventory and may be to some customers he said no. So, next day he will increase the inventory right. So, the again very fundamental concept of this is we should never say our customer no because then that person or customer will carry that perception that sometimes I am not getting the products.

So, product availability is the major focus of any distribution network. So, let us say the other day he could consume only 900 liters. What he will do with the 100 liters? 100 liters of milk again he will return back through the reverse supply chain and may be it will be processed, again it will be processed and will be delivered in the very next day. So, this is again very important function of storage. so what are the components of storage first component is warehousing as we talked about warehousing function as storage hubs where goods are housed prior to distribution to the customers right so these facilities may be owned by your manufacturers manufacturer may have their own facilities but usually in large distribution network or even in small distribution network as well we are outsourcing this to third party logistics who is taking care of this logistics transportation warehousing and these distribution activities right so we are usually outsourcing that but then they are also having their warehouses and in that way they are

managing so their warehousing is important component of storage so usually warehouses are equipped with some very common equipments you can say shelving are there racks pallet auto pallets are all also there right so that depends upon the infrastructure of that warehouse whether it is automated or not so usually to cut down the cost minimizing the handling cost and breakage cost you are not damaging the products so what we are doing now we are replacing the manpower with the robots where we can more efficiently handle the products and warehouse will be totally automated and we will ensure this through robot process that So, anything in our inventory should not go outdated.

So, we will move that inventory first. So, automatically information will be shared, stored digitally and electronic records will be shared throughout the supply chain. Second thing is the important component is inventory management as we discussed about. So, usually if we are talking about warehouses, so we are keeping the finished goods, but yes raw materials or sub-assemblies also sometime we are keeping. So, I told you that that raw material may be raw material for me, but for my supplier may be it is the end product.

So, we as inventory manager we need to ensure the sufficient stock availability while minimizing the holding cost. On this promise that always you are available with the product should not go with very high storage cost and then if you are storing too much inventory then chances are there that it may go obsolete. So, that also you need to maintain. So, accordingly you will design your replenishment cycle and then your inventory valuation will keep in the limits. The third important element is storage facilities.

So, storage facility, different types of storage facilities can be there that depends upon again the size of the product you are storing, the shape of the product, the nature, liquid, gas or any hard product you are storing. So, sometimes you are storing perishable items then you need cold storage kind of facility. Sometimes you are storing those items which may should be protected from the common man or may be dangerous items, hazardous item in terms of that we can say. So, then you should ensure that should be leak proof. So, means depending upon whatever your requirements are then storage facilities we have to design accordingly.

So, specification will be tailored around your requirements. The another important component of this storage is storage equipment. As we talked about these warehouses are equipped with pallet racks, shelving units, mezzanine floors and forklifts, automatic forklifts are there, conveyors are there, tugs are there, automated storage and retrieval system. So, these are some of the hard equipment we will talk about. We are using

softwares also like transportation management system software is there, warehouse management system.

We will talk about these softwares also, how these softwares are playing very important role when we are talking about the storage part. The next thing is safety and security. So, when we are talking about like I told you about the hazardous material, if anything hazardous you are storing in your warehouse. So, you should ensure that it should not be you know carry away by any unknown person. So, the access should be limited to that.

Again, if you are storing the damage and load should not happen. What type of product? Very fragile kind of items you are storing. So, then in that way you need to ensure the safety. So, then you can ensure the surveillance cameras. You need to access the control systems, alarms or physical barriers whatever you need to deploy that so that you can ensure the safety and security of the inventory.

Again that depends upon what type of inventory you are keeping, if you are kind of military organization. So, you are related to defense system their warehouses should be you know what type of you know that infrastructure is required and how they need to ensure the safety and security of those kind of stuff they are storing inside. Another important component is material handling. So, material handling is the movement of the material or goods from one location to other location. And if I will talk about material handling is usually this term is used within on organization within one manufacturing unit.

So, if I am talking about one manufacturing unit. So, let us say these are the assembly lines and these are the substation or workstation or all those assembly lines. So, may be one product may be moving like this, like this, other product may be moving after this stage it is coming directly to this stage then it is going to this stage, this stage may be some stages are not required then it is going to this stage. So, this way material handling is required on the production lines as well. So, even before the production line if material is coming you are storing it in your stores then your production planning and control PPC is issuing the kit production kit to the shop floor to the production floor.

So, accordingly what are the items required for today's production you will be issuing the material to shop floor. So, during that storage also material handling is required. When your material is reaching at your factory gate, even after that the first stage is you need to ensure the quality of the incoming material. So, IQC will be handling the material. Based on some samples, they will check whatever their sampling plan is.

then they will declare that lot is rejected or accepted if it is rejected again material handling is it will be returned back to the vendor but if it is ok then it will be moved to store this is again material handling in store you will store it for may be 5 days 10 days or whatever safety stock that for those many days you want to maintain. So, then comes the role of your material handling, but during this the major portion is accidents and damage. So, we need to minimize that so that if we are saying that in one car 5 tyres are required. So, if we have 50 tyres finally, we should come up with 10 cars. We should not say that during handling or storing we damaged 2 tyres.

So, accordingly this is not happening because tire is a kind of thing we can maintain it easily, but there are so many other things if you are having glass. So, may be for 50 units you are storing the glass, but in the end you end up with the 45 units only because 5 you damaged in the material handling. So, that way it is very important. So, then this is what I talked about whether you are handling it through your robots or you are handling physically. When it is physically done, so then there are chances we can damage that product.

So, that is why now big houses are moving towards automating their storage centers. Robots are being deployed where they are handling with care and then ensuring the all the quality related parameters. So, here I have included some video links, you guys can just quickly go through these videos and then we will continue our discussion on the topic. although these tugs are being operated by manpower but now we have robots or manless these vehicles which are moving through sensors and then the inventory the pallets are moving automatically from one point you can see in the video from one point to other point and we'll go to that shelf only where you need to stack it right so that way into inventorization is now being automated and you can see how it can be helpful when you are talking about avoiding the damages. so a warehouse is a commercial facility designed for the storage of goods materials and products right function as a centralized hub so see in warehouse this is very very important like let's say this is your warehouse right now there are so many customers attached to this this is at one location let's say this is location one and this is manufacturer now there may be another location location two and you want to you know from this location you want to serve so many other customers right this is one market this is another market now this is why this is a strategic decision that you you where you should locate your centralized hub because see if you can utilize the full capacity of their this warehouse and you know that that demand is there that you can enjoy the economies of scale by being there so then you can go for individual warehouse but if you see that the demand coming from this market and this market can be met by using one facility so then you have to go for one facility only but again when you are moving near to customer that means you are in that way more efficient because quickly you can respond to the demand maybe this from this customer 1 this location 2 is

only 10 kilometers away but because our that's capacity is not utilized fully so what we are doing we are routing this customer 1 to location 1 so maybe it is 50 kilometers So, when it is 50 kilometer, obviously responsiveness will be reduced in that way.

It will take time to respond their queries, it will take time to do their repairing thing, it will take time to deliver the first product right. So, that way you need to somewhere make the trade off whether you want to be responsive enough, you want to have many facilities near to customers or you want one centralized facility because many facility, now if you are having two locations, let us say we will add more location into that location 3 location 4 instead of keeping inventory at location 1 now what you are doing you are keeping inventory at location 2 location 3 location 4 so that means inventory carrying cost will also increase and then material handling damages all those will increase right so you have to in that way make the balance between responsiveness and efficiency. So, this is very strategic decision where you should locate your warehouse. So, again we discussed about warehouses are using these kind of equipment shelving, racks and pallets to efficiently organize and manage inventory. So, furthermore warehouse frequently integrate logistics and inventory management system to monitor inventory levels, expedite order fulfillment and optimize the flow of goods in and out of the facility.

So, again storage, transportation, distribution. So, that way it should be streamlined. warehouse layout design so before laying out the design of the warehouse this we need to take care of these four factors first is flow see flow is you need to take care of the flow whether your product is flowing like this so that type of layout is required that from here it is inward journey here it is outward journey outbound logistics you can say right so and then you are storing may be many different items So, that also depends that this particular items how frequently you are shifting, how frequently you are transporting to other location. and not only frequency then what is the size of this item, what is the shape of this item, what is the weight of this item. So, if that is too heavy or size is that it is very difficult to move or may be the nature of the product is like that very fragile.

So, then you should store that product at the location which is easily accessible. but it is kind of very small components from anywhere you can easily locate you can pick you can deliver then so that means you need to maintain the flow of the product flowing through that network right second is accessibility now this is again very well connected with the automated warehouses if your manpower is included you are operating manually so then obviously you need to ensure the proper space for movement of them proper space for moving the trolleys and depending upon the size of the items you are handling inside the warehouse but if it is you know handled by robots right or automatic forklifts are there or those automated tugs are there then you need not to you know keep that much space. So, automatically they will follow the line and they will just collect the inventory

and will deliver that right. Then space obviously if we are going for automation in that way space can be very well managed right, but in case of if human beings are involved. So, obviously that efficiency will not be there when we are talking about the space utilization.

throughput rate also you need to consider how many units you are processing in interval. So, that will decide I talked about the frequency right here. So, frequency how frequently you are moving that product may be different components in different in one product also you are coming up with different models. see if you are using if you will talk about 4 wheeler car so they are coming with the petrol version with petrol version also the lowest base is there then the next up to that level is there then middle version is there then top version is there then automated version is there so in that way 4 5 So, you can see more than 4, 5 and then these 4, 5 different models are coming in all 4, 5 colors. So, let us say 5 into 5, 25 then they are having if different engine capacity sometimes.

So, then you can keep on multiplying the things and then if you have 50 models in one for petrol version only then 50 models for diesel version then 50 models for may be CNG operated. So, that what type of material you are using and the component size is imported when you are designing the layout within the warehouse. So, easily you should be able to move the products. So, defining that we have 7 steps to plan the warehouse layout right either you can go first you need to define what is the purpose of the warehouse that means shape size weight all that nature of the product you need to define then you need to define the warehouse diagram what is the space available then what are the storage requirements right so liquid phase or you solid phase you are using or maybe gaseous phase you are storing right and then material handling equipment need so whether you need big equipments or you can handle with the small robots one right then you can map it out and you can optimize that you need to test the traffic flow whether there is traffic jam on the line or not so that you need to check and finally you will come up with the particular layout that this is the particle now we i have given just three different types of layout u shape on the one end you will enter and the other end you will come out so this is most commonly used. So, only thing is that space is uniformly designed.

So, now it is up to you how you will organize that. But if it is I shape, I shape is a kind of thing where you are getting the maximum space, maybe you are getting in from here, you are coming out from here. So, high volume products you can you can suggest that i shape warehouse is better so l shape warehouse so it depends again the needs if you need something very frequently you can keep it here right from here it is entering from here it is going out say then maybe the items which you need rarely you can keep on the back side then again shape and size of that product you are storing and what are the

requirements so depending upon that you can follow either u shape and that also how much land is available where you are developing your that facility warehouse facility right that also plays important role so within warehouse these are some of the elements you can take it out you have unloading cargo you have loading cargo transportation is happening from there you are keeping the equipment here and within this warehouse cargo you are keeping on one way so that depends upon this is one kind of layout right so there depending upon your requirements there can be different types of layout options. So, utility of warehouses.

First is product consolidation. See, we have small small orders. So, in warehouse what we can do? We can make it one order and if it is going to one location, so it will go through one transportation mean only. So, in that way we can consolidate the order. So, we need not to go four different deliveries will not be done. So, instead of that we will be having one your warehouse where we will consolidate those products and because those products are to be shipped at one location only.

So, through one vehicle we can travel. So, this will reduce the transportation cost and will enhance the distribution efficiency. Cross docking is something very helpful in this case because cross docking where a kind of facility will be there, where trucks are coming from different directions and may be we need to deliver these items right so maybe from factory 1 factory 2 factory 3 we have customer 1 or maybe market 1 market 2 market 3 right so let's say from factory 1 we have demand from market 1 as well from market to market 3 right and same is the case with for your factory 2 and same is the case with your manufacturing hub 3. Now, in this cross-docking what we will do? All the shipments which are supposed to go to market 1 will combine here from all these 3 vendors or manufacturers. So, we will combine these 3 into 1 and this will go to market 1. Similarly, all the items going to market 3, we will combine here just So, small stoppage center you can say in that way where we are not storing the products, no inventory.

So, in that way we can cut down the inventory cost because it is just a temporary kind of stoppage center. where we are redistributing the products so that one location we should go with one type of transportation mode only right. Second, then another utility of warehouse is value adding services. Sometimes what we are doing many manufacturer they are coming up with the promotional kind of activities and where they are selling some may be some free products with them right so again you need to develop one kit where you will be you know attaching some free products in that packaging right so sometimes we are doing labeling also in the warehouse like if you talk about ekart amazon flipkart so in their warehouse centers they are getting the products and then they

are labeling the product with their package that is one model other model can be directly your seller whosoever is registered on your website will put your package amazon package on that packaging and then will deliver that that is also another model right so these value adding activities are also done when we will talk about warehousing seasonal storage warehouse will help you to you know fight those seasonal demands Why? Because if there is peak season, let us say next 2 months there is no season for maybe woolen clothes because it is already summer.

So, temperature is high, we never need woolen clothes. So, right now they can manufacture, they can store and then maybe in future whenever there will be demand towards September, October, November in those hilly area. So, then they can ship the product. so seasonal demand you can meet in that way right now demand is there for ac products right now cooling all those products home appliances like fan cooler or acs right so maybe in december or january because weather is that way tolerable so that way during that time this is season of time so where you can prepare your sub assemblies of finished goods and then can meet the seasonal demands so in that way you can prevent yourself of being stock outs and then you can also handle the overstocks. Inventory management.

So, already we discussed about inventory management. So, three different types of inventory we are storing whether you are storing raw material or you are storing sub assembly or you are storing the finished goods. so to ensure the smooth flow in the supply chain you need to balance the supply and demand and that you can do only through inventory management strategic location already i told you why is this warehouse location is very strategic because if you are near to the customer then you are responsive you can immediately meet the customer requirement but if you are little away from the customer then that much distance you need to cover every time whenever you are addressing the needs of the customer So, but yes when you have multiple warehouses right, so that way cost will also increase because at this you are managing now 10 different facilities instead of managing only one facility. Risk mitigation, if any disruption happens in the supply chain, you can store the buffer stock in your supply chain. If any delays is there during the transportation, any natural disaster happens, any.

kind of manmade disaster sometimes right. So, COVID-19 or may be strikes right. So, farmer agitation is going on in the northern part. So, may be then that supply chain is interrupted or delayed if they are taking the alternate route which may be very longer. So, somehow your supply is interrupted or delayed right.

So, warehouse will help you to mitigate the risk as well. This is the cross docking which

I just talked about. See, these three different manufacturers are there. Let us say I have just coded this with color and coming from these three manufacturers. Now, this is one market.

So, this one market requires all these three products. So, in cross docking center what we will do? ship all the products required in market 1 using one vehicle for market 2 will. So, now what we can do is instead of making 3 different deliveries from point 1 to point 2 now we are making we are combining it here and making only one delivery. So, cross docking is very helpful in that way to reduce the cost. Another some utilities quickly we will go through these advantages of cross docking just in time inventory whenever it is required quickly you can get it. So, optimized transportation as I told about the transportation routes and vehicle utilization will be perfect because only one vehicle is going with the outbound logistics.

then reduce inventory handling cost because in cross docking we do not have the storage houses where we are storing our product right these storage houses are not there so what we are doing we are just making the small stops there and we are just reshuffling the inventory and reordering the inventory so that all the inventory going on one route can be routed through one vehicle only then improved efficiency in that way because we are not storing inventory inventory cost is cut down we are also utilizing the maximum vehicle capacity that way also efficient right and minimum handling will be there so that way it should be efficient faster transit time because now only one delivery is done so obviously faster transit time will be there instead of waiting for three different vehicles now only one is carrying all that so easy to integrate easy to track that supply obviously there are challenges with cross docking first very basic challenge is customer supplier relationship let's say i told you customer is here and we have different distribution centers now so many customers are there let's say so many customers are there here so i need to aggregate the demand coming from all these different customers only then if i have the correct information i can combine that product those many products and ship as one shipment right so that way this relationship need to be strengthened so how we can do that if we have that digital network where we are sharing the electronic record so that there should be there should not be any gap between the customer requirement and the supplies Quality control is another challenge because now otherwise in warehouse we were storing the products. Earlier we were storing here the products, but now we are not storing. So, directly we are shipping. So, we cannot do any quality check here.

So, quality is a point we need to take care. Coordination and synchronization is important. top level it is required as i told you you need to integrate your customer into your channel as well as your first supplier into your channel so that this can be synchronized and this will only happen when you have the technological infrastructure

and you can efficiently handle the material in that way you can track the customer requirements and then you can combine those orders and can send in the minimum lead time you can send that to the final end customer combining the inventory from the different suppliers. so impact of cross docking already we talked about enhanced customer services because at one location if we are supplying to market one from different location instead of three different deliveries now we are only making one delivery because we have consolidated the order so all multiple orders are now even if you if you will take small example at your doorstep delivery if the amazon person or flipkart person is visiting twice or thrice or may be five times in a day it will be little irritating for you so why don't they combine all the orders and maybe deliver at one common time so then it will improve your customer experience right so but then to combine all the order you should have that information that these many orders we need to deliver by today on this location right this will also help your transportation cost because instead of making five different deliveries you are only making one delivery but then that consolidation is required so in that way improved efficiency will be there right so transit times will be reduced and overall supply chain performance will be there cost saving obviously when performance is there we can save the cost there is no inventory carrying cost so that also we can save and it will provide you the competitive edge anywhere you are efficient cost efficient that will help you to get extra margin and that extra margin you can share with your stakeholders you can share with your customer or you can keep as that margin as your profit for further expansion so quick case studies i have taken two three case studies so who who are you know beautifully implementing this crossdocking concept first one is amazon where they have this one centralized facility in germany and can you imagine whole europe they are covering within one day just because of the help of this cross docking they have invested massively in setting up those information channels centers connecting all the stakeholders in that and then they have designed high tech cross docking centers where they are compiling the information code wise pin code wise they are locating this and making one delivery at a time so and this is not manual right so this is robot done by robots another very small example beautiful example of roche diagnose diagnostics a switzerland uh company pharmaceutical company and it's world famous especially in vaccine industry right so when we are talking about vaccine industry so again perishable product same day delivery is required how you can ensure that same day delivery so obviously you need not to store in your storage house you need to go for only cross docking you just make small stops at particular location and then combine the inventory for one particular market and ship all that vaccine or whatever supplies you are doing. So, in that way, you can ensure the temperature.

You need to maintain those vaccine at very particular temperature. So, that also you can ensure. But if you are storing that in somewhere in the cold storage even, even then there may be fluctuation in the temperature and that may affect the quality of the vaccine. the

last example is of main freight which is a very well-known firm in New Zealand and this firm is specially offering the cross docking services they don't have any product or something like that they are offering cross docking services for you so let us you whatever you are producing whatever your demand is we will take care of everything we will segregate whatever demand you are coming from the segregated market we will consolidate that demand from wherever you are manufacturing we will be setting up our own facility for consolidating the demand and making the efficient deliveries right so this is main freight organization which is doing providing you know these services of fast deliveries through cross docking and they have separate you know product basket or services basket they are saying that they have one package for if you are dealing with the perishable items if you are dealing with the retail products routine products or if there is constant demand of the product they can manage in that efficient way so you will you can leverage more on that if it is constant demand product right so in the end we can conclude that so effective storage management is very very important and required to ensure the continuous flow of the material and obviously you need to streamline first all the functions stakeholders within that distribution network only then you can ensure this smooth supply and then the very important function of warehouse you need to store although it is temporary storage but yes it is required before distributing to the final product right to the end customer but what if your you can do some value adding activities as we discussed right packaging labeling or maybe getting you can do that. but what if the constant demand is coming from one market so you can use cross docking as one very beautiful you know tool to just minimize the cost and increasing your efficiency so these are the references so thank you very much