Carbon Accounting and Sustainable Designs in Product Lifecycle Management

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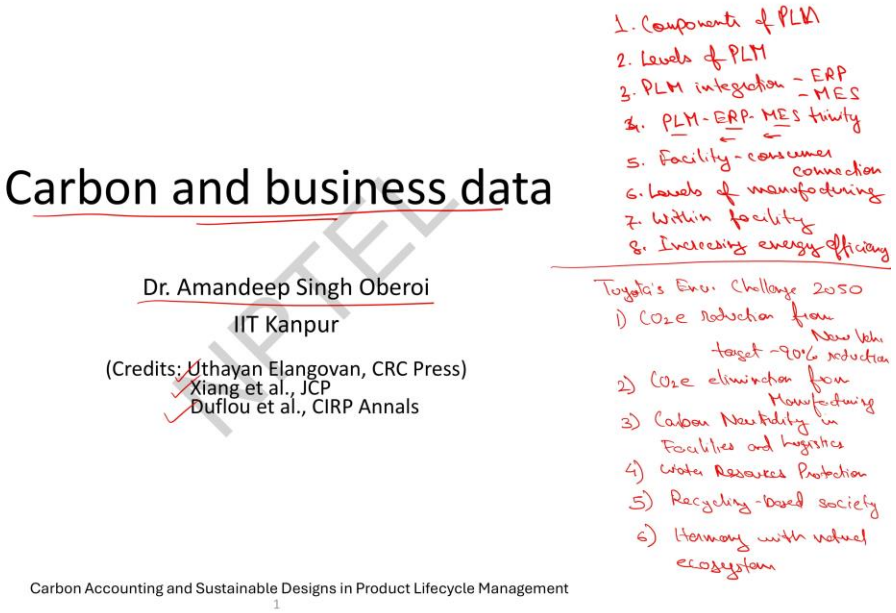
Week 07

Lecture 29

Carbon and business data (Part-1)

Welcome to the week 7 of the course Carbon Accounting and Sustainable Designs in Product Life Cycle Management. In this course, we are discussing about the about the techniques, about the overall system in carbon accounting and in designing for a sustainable future. When we are talking about the complete product life cycle. And we are trying to learn how to manage it throughout even post sales, after sales and recycling, disposal, everything is being covered.



In this week, I am going to cover Carbon and Business data. This course is co-taught by Professor Deepu Philip, Dr. Amandeep Singh Oberoi and Dr. Prabal Pratap Singh. Here are the credits of the authors from whom I have taken the studies. These are the major people and there are certain other studies which are given in the references of this course. You can definitely go to have a detailed information on what we are discussing. In the last weeks, what I have discussed is components of PLM.

In the components of PLM, I have talked about the different components such as product data management, manufacturing, process management, change management, supplier management. Which is overall taken care by project management. Then we talked about levels of PLM. In the levels starting from the planning, designing, building, support services and the service systems. Those were all discussed in the levels part.

Then we talked about the integration of the PLMs with enterprise resource planning, with manufacturing execution system. These were discussed and further I talked about the Trinity that is PLM, ERP, MES. Trinity and these three go hand in hand parallelly while collecting information about even the design of the product. The execution system is also considered and the feedback goes from MES to ERP to PLM, this is what we discussed. Then I had a discussion on facility consumer connection.

Where we try to see that the supplier organizations supplied the products or whatever the assemblies that they have to the functional modules in a system. Functional modules then work together to develop a set of the parts of the product, maybe assemblies or sub-assemblies. Which completely collate towards a final product, which goes to the user. And user also has an in-between the manufacturing system and itself is a supplier organization. This after the use the product goes to the disposal after the end of the life of the product.

Now this was what we discussed. We tried to talk about the carbon emissions in them. We tried to talk about the corresponding decisions at the levels of manufacturing. Then within facility. What are the activities?

And while try to look over these activities, we try to also understand certain strategies or certain tips to increase the energy efficiency. And also we watched a video in the last week on Toyota's environmental challenge 2050. Where there were six goals that Toyota talked about, like it was the reduction of carbon emissions from new vehicles, that is COTE, reduction from new vehicles. So, this was the first goal where they have set ambitious goal to eliminate nearly all carbon dioxide emissions from the new vehicles by the year 2050. So, they targeted 90 percent of reduction in emission.

So, target was 90 percent reduction and they use advanced technologies as mentioned in the video to achieve low carbon future within the automotive industry. Second goal that was mentioned in this video was to eliminate emissions from the manufacturing processes. To say manufacturing processes, it means the manufacturing of parts and materials used in vehicles. So this goal necessitates close collaboration with suppliers and partners. That is why we talked about the order decomposition and those were all implemented by Toyota in the goal 2 that they set.

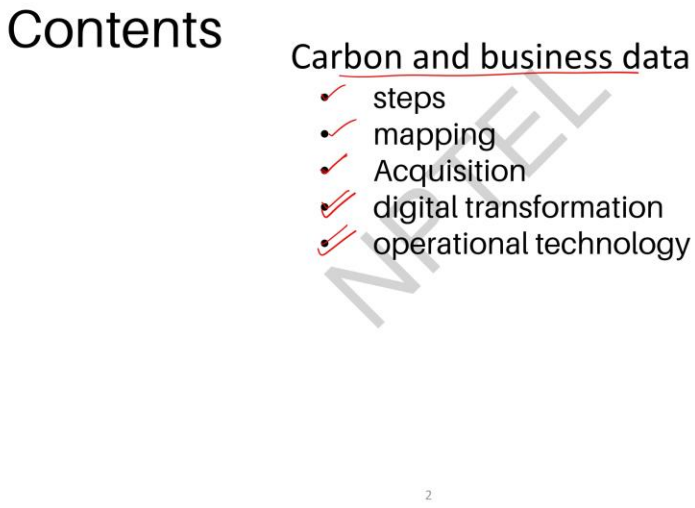
Third goal that they have set is carbon neutrality in facilities and logistics. So here they talked about elimination of carbon emission from its facilities logistics from operational processes by 2050. That is revaluation of energy sources in the North American continent that they talked about and transition. Towards increase reliance on renewable energy was also talked in this video. These were certain steps taken by the ecological conscious companies such as Toyota.

Also they talked about conservation of water resources. You call it conservation, you call it protection. Toyota said that they are committed to ensure that all its facilities and processes would actively manage, protect, conserve water resources. That is water reuse,

water recycling, particularly within the manufacturing operations is what they work upon. Also, the fifth goal they mentioned was promotion of recycling-based society.

That is, they were talking about the circular economy where the old components, old cars are also taken back and certain discounts are given on them. That is the principles of reduction, reuse, recycling, what the objectives were set. Along with it, they talked about ensuring harmony with natural ecosystems. That is along with working within the organization or with their vendors or around the organization, they talked about minimizing disruptions to natural habitats. That is safeguarding the ecological balance of the local communities where Toyota operates.

So, thereby supporting biodiversity, ecosystem health and so. So, this was all discussed in the last week.

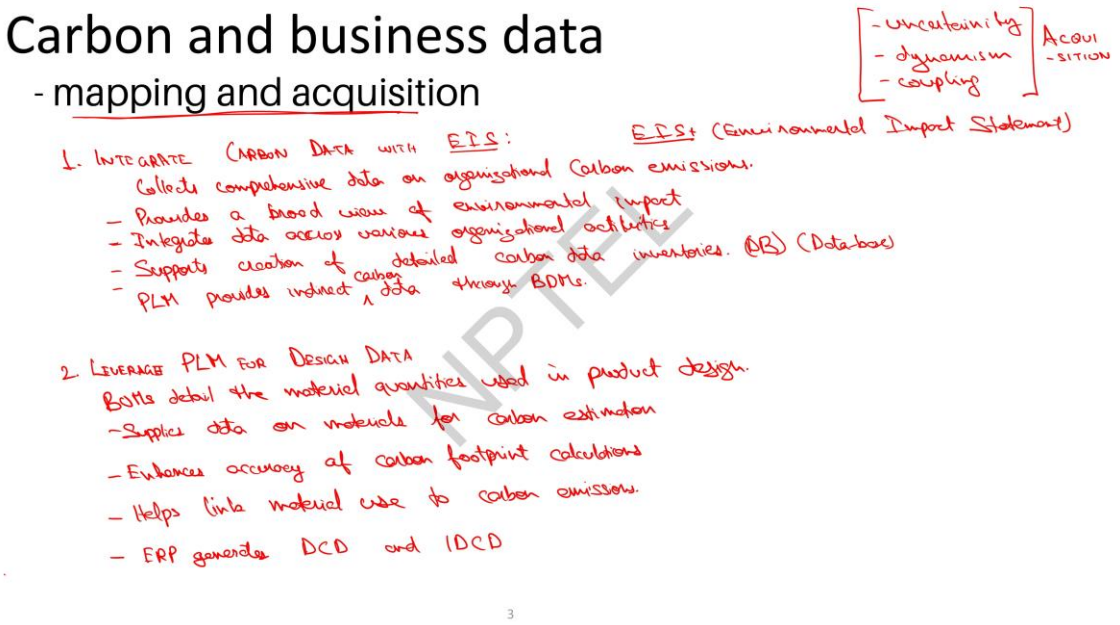


This lecture, we will try to cover carbon and business data mapping majorly. We will try to talk about certain steps when we try to map the data, when we try to acquire the data. Data acquisition is also being covered.

And we will try to see an illustration, where we will try to see all the components. All these small elements that we have discussed that is direct carbon indirect carbon. Then we will try to talk about PLM supply chain management ERP, MES then WMS is also their warehouse management system. ERS is enterprise information system, scada all

these parts would be put into a one platform or a one illustration and try to see how are they connected. Then, in the coming lecture, I will discuss about the carbon accounting model, where we will also see at a unit level.

How do we calculate the carbon emissions? How do we try to determine the carbon emissions, while dividing even the unit cells into further small elements, into at a mini level, at a micro level. So that we try to understand what is the power consumption, which when scaled up, maybe 100 times, 1000 times. Gives you an overall minimum or optimal carbon emissions that is in the favor of the sustainable designs and sustainable PLM system.



Mapping and acquisition. Let me try first try to draw down certain steps in mapping and acquisition of the data in carbon that is carbon data in business.

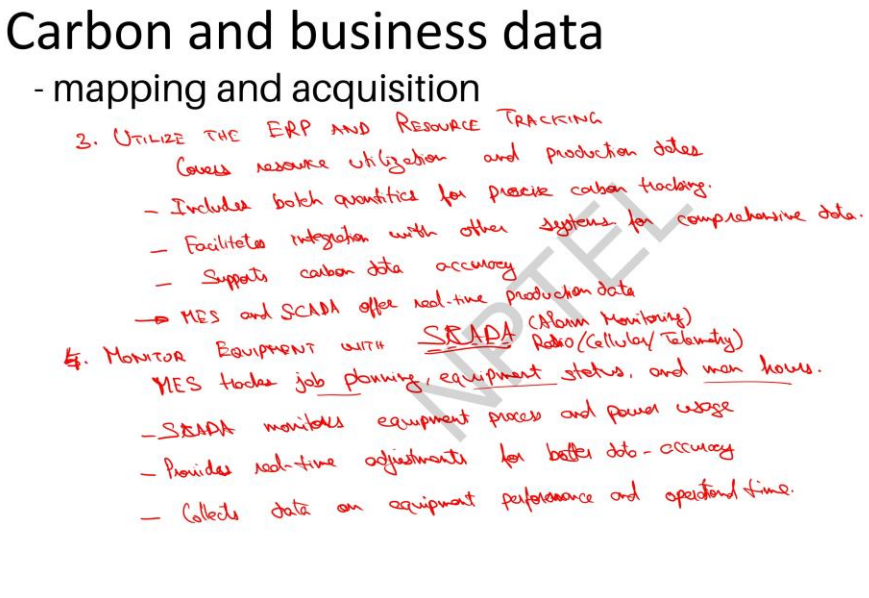
The product life cycle management. In order to enhance the traceability of carbon data sources, mitigate the uncertainties, dynamism, coupling. When I say coupling, it is coupling of the multiple inputs of the data. So here, acquisition is of utmost importance. Acquisition of the data.

The most important part or most important contribution here is played by EIS (Enterprise Information System). Enterprise Information System serves as a crucial instrument for facilitating the operations of the organization. Its primary purpose is to gather, store,

oversee, process, analyze the diverse data pertaining to company activities. So, I will put the step here as integrate carbon data with EIS. That is what does EIS do?

It collects comprehensive data on organizational carbon emissions. So, I will first draw down these steps, then I will try to talk about a little more detail about them. Next point is, once the data is integrated or once the data is definitely taken through an EIS system, then we try to leverage the PLM for design data. It is what I am trying to do here is through the bill of materials, it is engineering whatever bill of materials, I am trying to prepare. We try to have detailed material quantities used in the product.

So, bill of materials itself detail the material quantities used in product design. This is the second part that I will talk about.



Third part is or third step or third move is we utilize the ERP and resource tracking. That is once we have gotten the information through EIS, we try to now generate production plans in accordance with production management requirements. That is the primary purpose of the ERP.

The data set encompass both direct and indirect carbon information. Pertaining to the resource utilization together with supplementary data including product, manufacturing dates, batch quantities and so on. Which means this ERP system covers resource

utilization and production dates. Then to monitor the health of the equipment to monitor the actual operation of the equipment, we need to have a system. The system that is well being used in the last decade is SCADA.

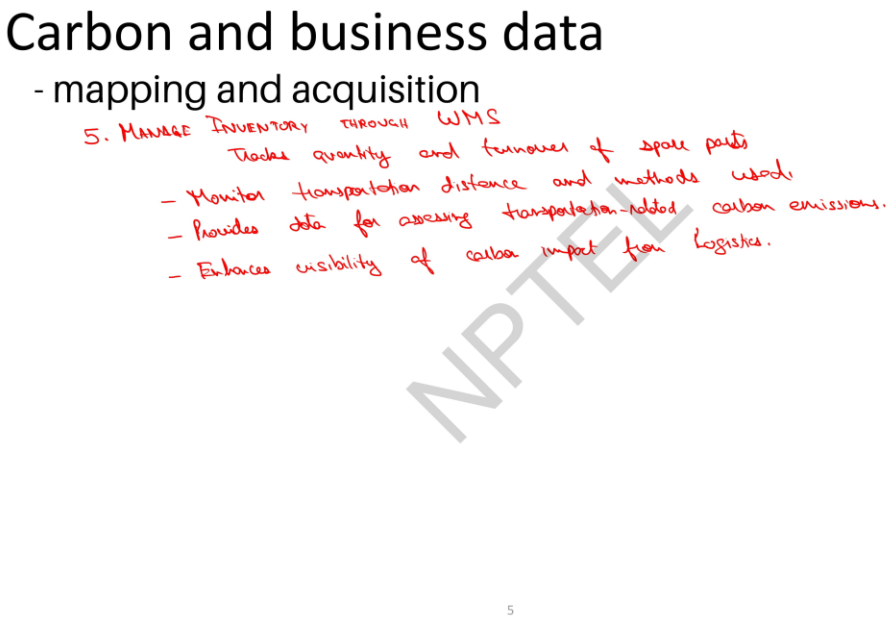
So, I will put it here. Monitor equipment with SCADA. What is SCADA? It is Supervisory Control And Data Acquisition. So, as we discussed about digital twin, whatever is happening in your machine, parallelly in your virtual mode as well, the things are happening.

If there is a heating there, overheating there in an engine, your virtual engine will also show the overheating there. In your maybmpute coational fluid dynamic systems, it can help you to mitigate there in the simulation system itself. Now, SCADA is a starting point of it. SCADA, what do we have? Whatever is there in the system, power that is being consumed or the machines which are running.

So, SCADA will give you what is the speed of the machine, what is the power being consumed. It is supervisory control and data acquisition system using Internet of Things or using certain systems such as we have alarm monitoring. We have the radio or cellular systems here radio cellular or I could even call it as telemetry. So, what does SCADA helps us to do? It helps us to monitor the equipment processes and power usage.

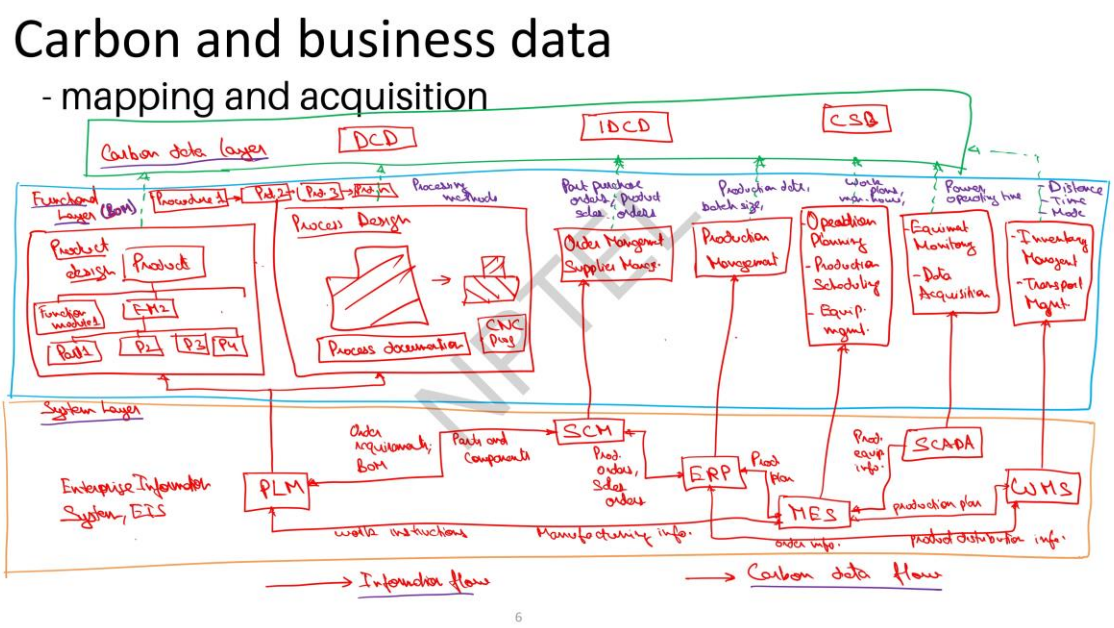
So, when I am trying to put here monitor equipment with SCADA. Here definitely I am talking about the manufacturing execution system that tracks job planning equipment status and man hours. This is number 4. Number 5 would be now once the system is being manufactured. We are talking about the production system, also we talked about the engineering bill of material with the quantity of the material per unit of the product.

When talking about the quantity, then comes the throughput overall number of components or number of products that would be produced in a week time or in a day or in 2 hours or so. This also involves inventory. Inventory of raw material, inventory of finished goods in between there are lot of inventory or buffer stocks which is known as work in progress inventory.



Here comes the inventory management system that is manage inventory is the fifth step through WMS. WMS is Warehouse Management System which tracks quantity and turnover of spare parts.

So, let me now try to draw my mapping illustration where, I will try to explain all the systems step by step and also, what are the contribution of these systems? And also, I will try to keep jotting the pointers here to the various steps that I have put here. So, when I am talking about the total layers of the data.



Let me try to see here we have at the top is carbon data layer, carbon data layer where we have Direct carbon, indirect carbon. I will put it as DCD which is my Direct Carbon Emission Data.

Then I have IDCD (Indirect Carbon emission Data. Then I have CSD. What is CSD? CSD here is Carbon Emission Calculation Support Data. So, separately about DCD, IDCD and CSD just to recall direct carbon emission data is carbon emission from fossil energy use.

So, fossil energy use such as natural gas, gasoline, diesel. So, these were the carbon emissions from the operations of gasoline and diesel vehicles. Or maybe carbon emission due to leakage of equipment or the greenhouse gases whenever fossil fuel is being burnt. Or we have to use that carbon we are talking about the direct carbon emission data. So, this is one part.

Then comes the indirect carbon emission data. Indirect carbon emission is the supporting or the carbon emission that could not be seen directly. So, we are talking about the material carbon emission. Or we are talking about the carbon emission from the use of raw materials for steel, alloy and other work pieces and auxiliary material. For example, from cutting fluids from lubricants, then waste material, that is for chip removal, then material recycling and disposal.

This is all indirect carbon emission data. Direct carbon emission data we have already talked about. Carbon emission calculation Support Data that is CSD. This is the term that is first introduced in this course which we were talking about the product process route information data. Because we need to have the data acquired, we are talking about data mapping and data acquisition both.

To acquire the data, we need to understand what is the route of the product that you are manufacturing and how are the processes being performed. What are the total times when the process is in full mode of running? So, this product and process route information, then we have a production order information. Then energy consuming production equipment information, production man hours or so. This is our direct carbon, indirect carbon and carbon emission support data.

So, here, I have put this layer once but this is carbon data layer. Carbon data layer now would interact with my system layer the other envelope in which I have my product design system. Product design here in product design. We have one product. This product has multiple functional modules.

If you could recall, I will call it as functional module 1, then FM2, FM3 and so on. Which creates or which are giving input to the certain parts. I am here part 1, P2, P3, P4 and so on. This is my product design system. Similarly, I have process design system.

In process design system, as we talked about it, Certain processes are there. There is one machine. There is another machine, right. Multiple machines are coming up here.

So here in machines, we have the documentation of the process. Process documentation and along with it, we have maybe CNC programs. You call it CNC programs, you call it a program in additive manufacturing, anything that you have, this is the process design system. So, this process design and the product design is giving input to the carbon data layer. So, I am not connecting it directly to the direct carbon data or indirect carbon data or carbon emission support data.

I am just telling here this input goes to the carbon layer, the direct carbon, indirect carbon, carbon support data from product design. Similarly, direct carbon, indirect carbon, carbon support data from process design, right. So, this is our manufacturing concern that we talked about. Let me try to move it little left so that I also put other systems here. Now, here because we are talking about product design, process design, majorly we are trying to talking about the PLM, it is product lifecycle management.

And this is the third layer. I am talking about the second layer here is the functional layer. Functional layer and third layer is my EIS layer or system layer. In functional layer if I have bill of materials here in the system layer I have enterprise information system. This PLM is giving inputs to the product design and process design in the engineering information system.

That is what is happening. I will just input envelopes over these layers. So this functional layer, I will put it in a blue envelope. And for the system layer, I will also draw an envelope in orange color. So, what we are trying to talk about here is from the product design level to process design level to the order management to equipment management and finally.

We will go to the inventory control. We are trying to talk about the data travel or data movement. Let me say it is trying to talk about here is information flow or and carbon data flow. So, what happens here. My EIS system integrates the carbon data.

It collects comprehensive data on organizational carbon emissions. So, it provides broad view of environmental impact. That is it also integrate data across various organization activities. And the EIS system here also gives us environmental impact statement. That is also EIS.

This is Environmental Impact Statement. So, what is it? So, because the carbon data exhibits a strong correlation with the reported activities. Hence the collection of the carbon data can be accomplished via the EIS that is Environmental Impact Statement. Thereby establishing a comprehensive carbon data inventory.

So, the models the carbon accounting models. Allows us the allocation of carbon data that is aligned with the business activity data of the organization and products outlined in the environmental impact statement that is the EIST. So, here other steps I will also talk about let me try to come down here once again to my processes here. So, what we are having is functional layer. Is having product design and process design and also there are certain procedures to develop this product.

From the product to process itself, there are certain procedures. I will put it as procedure 1. Then I will name it as procedure 1, procedure 2, procedure 3 and so on. This is flow of information from the product to process itself to the procedure n. Now, here what are the certain inputs, the processing methods, the speed, cutting depth tools, etc.

Those also we will talk about. Now, another component other than PLM, let us talk about Supply Chain Management. SCM, because we are talking about now supply chain, we talked about the orders decomposition in the last lectures. We have order management and supply management system here. Order supply management system.

That takes inputs from supply chain management. On the other hand supply chain management is connected to my product life cycle management and there is the information exchange in the both directions. So, order management system, product design system. We have talked about after order management definitely there comes the production management. That is when we are talking about production we are talking about something related to our ERP (Enterprise Resource Planning).

Which gives input to the production management system and there is an interaction. Two-directional between supply chain management and enterprise resource planning. Then we have the manufacturing execution system. Let me also put it down here manufacturing execution system, because as we are not talking about the execution of the manufacturing. The execution of the manufacturing implies the system is now into production now let me put it here.

Production management was taken care by ERP. Operations planning and production scheduling, everything will be taken care by manufacturing execution. That is the production plan. So, here I have operation planning, production scheduling. And whatever other parts which are there in the manufacturing execution such as maybe equipment management.

So, this is one box I will draw here that is managed by our manufacturing execution system. So, here again manufacturing execution system is Interacting with enterprise resource planning. As we know ERP is the interface between MES and PLM. I have now also put in between supply chain management. Now along with it the other systems, I talked about the SCADA.

I talked about the warehouse management system. When we are talking about operations planning, production schedule and equipment management. The SCADA would help you to monitor the systems. I will put it here SCADA. That is giving inputs to the manufacturing execution system and it is helping us to monitor the equipment and acquire the data.

Equipment monitoring and data acquisition. This is through SCADA. Then I have inventory management that is warehouse management system. This warehouse management system because it is warehouse management. It keeps the inventory that is of the finished goods.

It keeps the inventory that is of raw materials and work in progress. All the inventory systems are kept here. So I have my inventory management system. And along with it we have the transport management. Because we are talking about the warehouse, the transportation, the incoming and outgoing logistics systems are also part of it.

So, this is taking input from my warehouse management system. Having laid down the different components in the different layers, carbon data layer, functional layer, system layer. I will try to take a break here and in the next lecture, I will try to make connections between various components or various stakes which are put here.

And in the next part of the lecture, I will try to make various connections between the different layers and the components within the layers. And will try to see what is the overall system when we try to acquire the data and understanding the mapping of the data between the layers.

Thank you.