

Introduction to Industry 4.0 and Industrial Internet of Things
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Lecture – 12

Industry 4.0: Collaboration Platform And Product Lifecycle Management

For Industry 4.0, there are different technological considerations that are required. One thing that is often not looked upon seriously, but it is very important from our viewpoint for Industry 4.0 compliance is to take help of the knowledge base. Knowledge base from the same industry from a previous production processes, existing production processes in other units, or from the knowledge base that can be obtained from other industries following similar kind of production processes.

So, this knowledge base will be very helpful, that is why we need some kind of a platform that can help build a knowledge-sharing mechanism. Collaboration platforms are very important. And also in this lecture, we will talk about product lifecycle management. How you can achieve automation in PLM - products lifecycle management for trying to step forward to meet the Industry 4.0 objectives. So, let us look at some of these features, the high level understanding about each of these, in the next little while.

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What is Collaboration platform?

- Category of business software which combines organizational networking capacities to operations.
- It includes knowledge management into business operation to encourage renovation.
- Collaboration platform helps employees to share information and solve business problems.

Source: Techtargget.com: Collaboration-platform

So, what is a collaboration platform? So, basically we are talking about a platform which can be a software platform, which can be a software-hardware platform, which helps the

employees to share information and solve certain business problems. So, employees can share information between themselves using a collaboration platform. The employees of one industry can share the information with employees of another industry by virtue of use of these collaboration platforms. And this thing you can generalize and extend to different scenarios, likewise.

So, collaboration platforms essentially are talking about building platforms that will include in the sharing of knowledge, a platform for managing the knowledge, knowledge management and including it in the business operation for renovation of the business processes, and improving upon the efficiency of these business processes in the future. So, this is what a collaboration platform will help in doing.

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What is Collaboration platform? (Contd.)

- There are some perspectives to build collaboration platforms.
 - A social layer is combined with provision of business utilizations.
 - New products are implanted with collaboration tools.
- There are some common attributes in business collaboration platforms.
 - Easily accessible and easy to use.
 - They require some familiar functions which help team collaboration.
- Example: **ProWork Flow**
 - Web-based project management designed for Managers
 - Collaborate to improve project delivery

Source: Techtarget.com: Collaboration

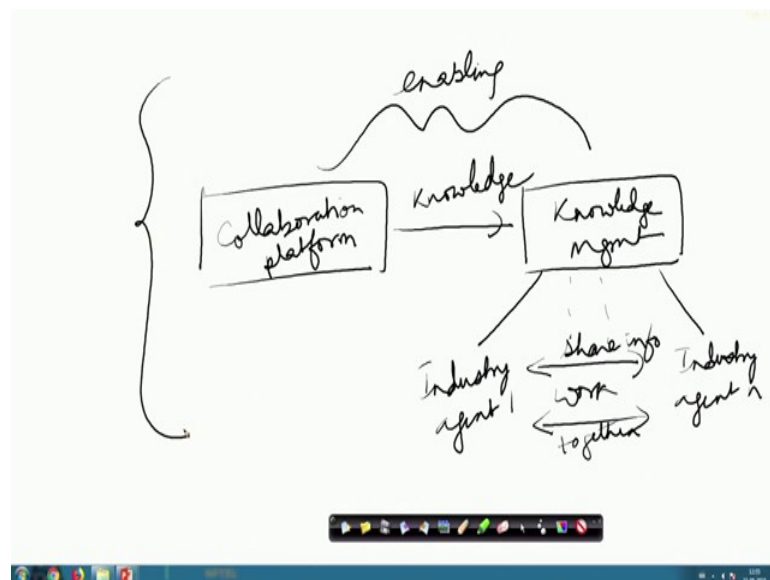
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So, what is a collaboration platform? There are some different perspectives to build collaboration platforms. There is a social layer component that is introduced in the business social layer; because we are talking about employees we are talking about users who will share their different knowledges with the help of these platforms. Social layer component is combined and integrated, with the provisioning, with the provision of business utilizations, but then you need some kind of a platform. So, you need some kind of a tool, which can be integrated with the existing products or the new products, that are being developed or, are being acquired and implanted in the industry.

So, there are some common attributes in business collaboration platforms. These collaboration platforms should be easily accessible, and this should be easy to use. And they require some familiar function, which help in the collaboration between the team members or across different teams. One such platform is named known as pro-work flow that is the name of a collaboration platform that is often used in the industries.

So, this is a web-based project management platform that is designed for managers. And then this platform basically helps employees to collaborate and improve upon the project delivery in the production process, in the project management process. So, this is an example of a collaboration platform. Let me now show you how this collaboration platform is going to work.

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So, we are talking about a collaboration platform. This collaboration platform will help in collecting knowledge, collecting knowledge. So, this knowledge will be used in knowledge management. So, basically what is happening essentially is this collaboration platform is helping or, it is enabling knowledge management.

So, this knowledge management is important for different industry agents, there could be other industry agents, likewise, and industry agent. So, these industry agents would be sharing information between themselves, and they would be working together for achieving the objectives of the business. So, this is how a collaboration platform works, and how it is linked to the knowledge management aspect of it.

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Collaboration Productivity in Industry 4.0

- Collaboration Productivity
 - There are four key parts, which enable collaboration productivity:
 - IT Proliferation
 - Single Source of Truth
 - Industrialization
 - Coordination

Source: Collaboration Mechanisms to Increase Productivity in the Context of Industries 4.0

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So, essentially, what is happening the idea is towards the objective of improving the productivity, improving the efficiency of these business manufacturing processes, and so on for fulfilling the overall objectives of Industry 4.0, we are saying that these collaboration platforms would be found to be useful. So, collaboration productivity is going to be improved, is going to be increased. So, there are four different aspects of increase in the collaboration productivity. And this will be enabled with the help of different key parts such as IT, single source of truth, industrialization, and coordination. Say let us look at each of these individually in little bit more detail in the next few minutes.

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Collaboration Productivity in Industry 4.0 (Contd.)

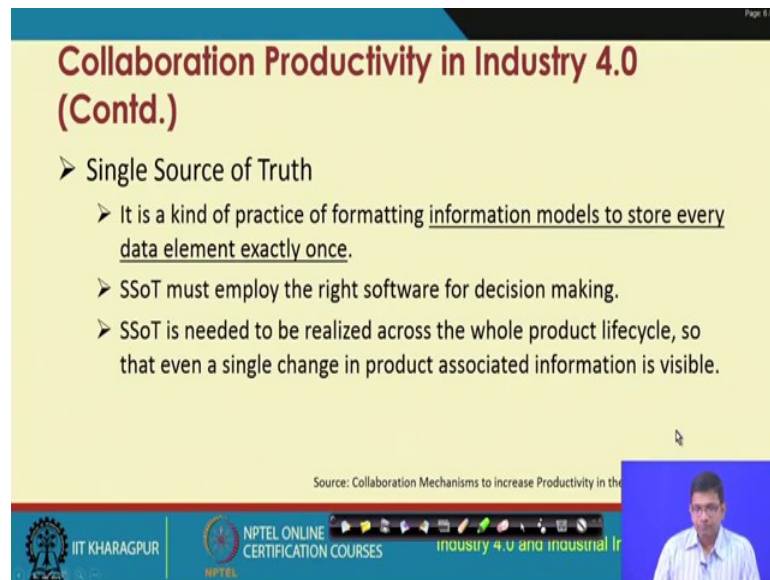
- IT Proliferation
 - It shows the huge impact of computers on economic growth and their impact on increased capital stock's shares.
 - Industries are required to consider and promote global information technology and computing power.
 - Storage capacity and high speed computing are increasing day by day.

Source: Collaboration Mechanisms to Increase Productivity in the Context of Industries 4.0

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IT for IT proliferation. So, basically what has happened is as we know that computers, computational devices has a huge impact in our economic growth in the last few decades. And there has been increase in the capital stocks and shares across different companies worldwide. So, these industries worldwide are required to consider and promote global information technology, global information systems, with the help of this computing power. So, storage capacities have increased computational high speed computational capacities have increased and they are increasing even more day by day. So, this IT proliferation has basically helped in building the computational platform that will be required for coming up with the collaboration platform.

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Collaboration Productivity in Industry 4.0 (Contd.)

- Single Source of Truth
 - It is a kind of practice of formatting information models to store every data element exactly once.
 - SSoT must employ the right software for decision making.
 - SSoT is needed to be realized across the whole product lifecycle, so that even a single change in product associated information is visible.

Source: Collaboration Mechanisms to Increase Productivity in the

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Single source of truth means we are talking about a single repository, where all the data are going to be stored. So, essentially we are talking about a data model and information model that will help in storing every data element exactly once. So, this single source of truth must employ the right software, at the right time, at the right place for right decision making. So, single source of truth is needed to be realized across the whole product life cycle, and this is very important.

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Collaboration Productivity in Industry 4.0 (Contd.)

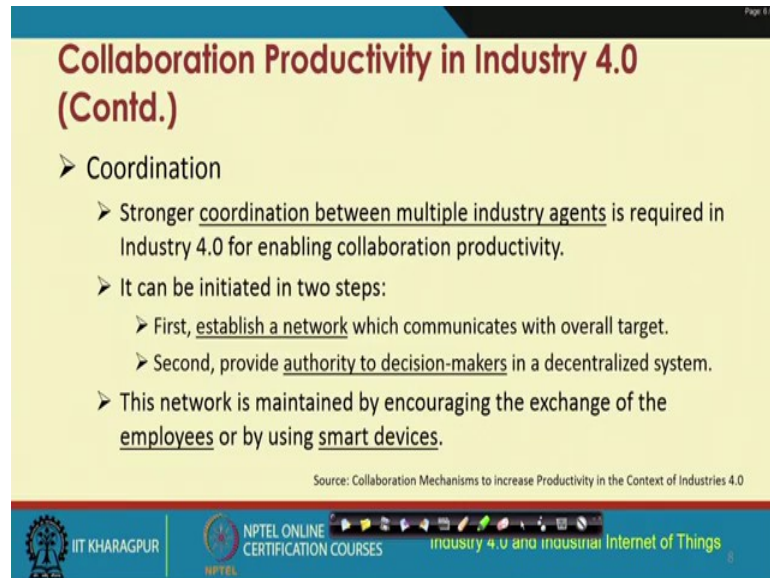
- Industrialization
 - It is the bridge between the virtual world and the physical environment.
 - Physical environment is linked with the virtual world using CPS, which fix computers and sensors into an application platform.
 - It requires intuitive and self-effective elements.
 - For dynamic objectives in technology and industrial area, it adapts the system behaviour like smart factories.

Source: Collaboration Mechanisms to Increase Productivity in the Context of Industries 4.0

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Industrialization. So, it is basically the bridging between the virtual world and the physical environment. So, the physical environment is linked with the virtual world using cyber physical systems which we talked about earlier. And these cyber physical systems are equipped with computers, sensors, actuators. So, these systems will require intuitive and self-effective elements to be adopted in them.

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The slide is titled "Collaboration Productivity in Industry 4.0 (Contd.)" and is numbered "Page 8/11" in the top right corner. It features a yellow background with a blue header and footer. The main content is a list of bullet points under the heading "Coordination". The first bullet point states that stronger coordination between multiple industry agents is required for collaboration productivity in Industry 4.0. The second bullet point indicates that this can be initiated in two steps: first, establishing a network that communicates with the overall target, and second, providing authority to decision-makers in a decentralized system. The third bullet point notes that this network is maintained by encouraging the exchange of employees or by using smart devices. At the bottom of the slide, there is a source attribution: "Source: Collaboration Mechanisms to Increase Productivity in the Context of Industries 4.0". The footer includes logos for IIT KHARAGPUR, NPTEL ONLINE CERTIFICATION COURSES, and the text "Industry 4.0 and Industrial Internet of Things".

Collaboration Productivity in Industry 4.0 (Contd.)

➤ Coordination

- Stronger coordination between multiple industry agents is required in Industry 4.0 for enabling collaboration productivity.
- It can be initiated in two steps:
 - First, establish a network which communicates with overall target.
 - Second, provide authority to decision-makers in a decentralized system.
- This network is maintained by encouraging the exchange of the employees or by using smart devices.

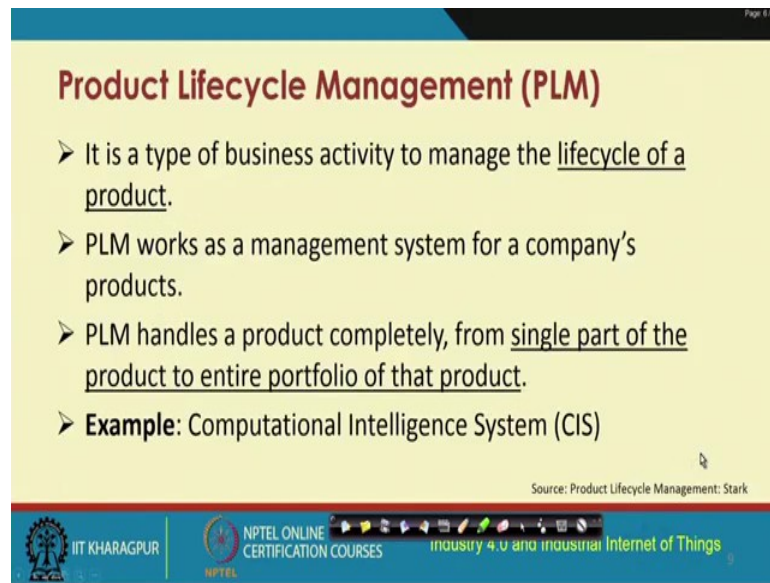
Source: Collaboration Mechanisms to Increase Productivity in the Context of Industries 4.0

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So, this is the industrialization aspect of it. And coordination is basically to ensure that there is stronger coordination between multiple industry agents in the same industry, across different industries, and so on, so that the collaboration productivity can be increased even further. Coordination can be initiated in two steps. In the first step, we can establish a network which communicates with the overall target, and in the second, providing authority to decision makers in a decentralized system.

So, this network we are talking about in the context of coordination is maintained by encouraging the exchange of employees or by using smart devices between different employees, because exchange, physical exchange, may not be required, if we equip your employees with different smart devices. This exchange of information can be maintained for stronger coordination between the employees of the same organization or across different organizations and so on.

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Product Lifecycle Management (PLM)

- It is a type of business activity to manage the lifecycle of a product.
- PLM works as a management system for a company's products.
- PLM handles a product completely, from single part of the product to entire portfolio of that product.
- **Example:** Computational Intelligence System (CIS)

Source: Product Lifecycle Management: Stark

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Now, let us try to understand the product lifecycle management aspect of it. So, product lifecycle management as this name suggests, this term suggests it is actually a widely used terminologies in the industry. So, it talks about the lifecycle of a product from ideation till deployment the entire lifecycle of a product is captured using these product life cycles.

So, this product lifecycle management works as a management system for a company's products. PLM handles a product completely from single part of the product to the entire portfolio of that product. Examples of product lifecycle management systems are basically, the CIS system, computational intelligent system, and there are many different other industry specific PLM systems that are widely used in the industries. And there are so basically these PLM systems are quite popular.

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Product Lifecycle Management (PLM) (contd.)

- The main goal of PLM is:
 - To maximise product revenues.
 - To decrease product-associated costs.
 - To increase product's value.

Source: Product Lif

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The main goal of product lifecycle management is to maximize the product revenues, to decrease the product associated costs, and to increase the products value. So, obviously, as you can understand, these are very attractive features, which will be required to be implemented in order to move towards Industry 4.0, improving efficiency in the Industry 4.0, improving automation objectives in Industry 4.0.

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P, L and M in PLM

- The P of PLM
 - P means product in PLM.
 - The product has an essential role in industry.
 - The product is origin of company earnings.
 - There are no services without product.
 - An industry leads in industry sector because of its products.
 - Product has different type of shapes and sizes.

Source: Product L

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So, P, L, M, this P, P means product. So, the product is basically the central theme in the industry, everything is governed around products and processes. So, P corresponds to

product, which is basically the central agent of consideration in PLM in the industries. So, the product is the origin of company earnings. So, this P is obviously, as I was telling you so far the most important component of product lifecycle management. And we can understand that if you do not have product, you do not have its services. So, every service is basically linked to that product.

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P, L and M in PLM (Contd.)

- The L of PLM
 - L stands for lifecycle.
 - Product lifecycle has five phases.

Source: Product Lifecycle Management, Stark J

1. Visualize
2. Explain
3. Perceive
4. Use/Support
5. Dispose/Retire

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The L of product lifecycle management stands for lifecycle; L stands for lifecycle. And there are five different parts, five different phases in this product--lifecycle so in the lifecycle of PLM. So, one is basically visualization visualize explain perceive use and then dispose. So, visualize means ideation, ideation explaining the idea, perceiving the idea, realizing the idea, supporting the system, the product that is built, and then disposing or retiring the product, that is built. So, these are the five different parts, five different phases in the product lifecycle of any product lifecycle.

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The P, L and M in PLM (Contd.)

- **Visualization:** People have an idea regarding the product.
- **Explanation:** This idea is transformed into a representation.
- **Perceiveness:** By the end of the phase, the product is in its final form.
- **Use/Support:** The customer starts to use the product in use/support phase.
- **Retire:** Company retires a product when it is not useful.

Source: Product Lifecycle Management: Stark

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Visualization as I was telling you corresponds to the ideation. People have different ideas regarding a product. So, they visualize this product to be built that is the ideation part. Next is the explanation this idea has to be transformed into some kind of a representation that is basically captured through the phase explanation phase. Perceiveness or perception is basically at the end of the previous phase, the product has to be built in its final form. And then use or support is basically the customer basically starts to use the product in the user support phase. And then once it is used, once it is no longer useful to the company, the product has to be retired.

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P, L and M in PLM (Contd.)

- **The M in PLM**
 - M means management in PLM.
 - Product management has:
 - Coordination and institution of product-related devices.
 - Fix objectives, capability of decision taking and result control.
 - To ensure that a product works well, it is managed across its lifecycle and management guarantees that the product will earn the profit for the company.

Source: Product Lif

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So, why we are talking about all of these things, we need to understand the different phase, the different phases of the lifecycle of any product. M in PLM means management. So, product lifecycle management, M stands for management.

Management, we are talking about product management over here, where the considerations of coordination and institution of product-related devices are important it is required to fix different objectives. And enforcing the capabilities of decision making, and taking result of the control, these are the different important considerations, in the management aspect of PLM. So, the whole idea in the management aspect of PLM is to ensure that a product works well, it is managed across its lifecycle and the management guarantees that the product will earn the profit for the company.

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The slide is titled "PLM for Industry 4.0" in a bold, dark red font. It contains three bullet points, each starting with a right-pointing arrowhead. The first bullet point states that the efficiency and effectiveness of PLM have an important role in today's enterprise operation systems. The second bullet point states that this efficiency and effectiveness of PLM improves market share and market size with increasing revenue. The third bullet point states that PLM systems manage a product's portfolio and also manage services from the initial concept to the final disposal. The slide has a yellow background with a blue header and footer. The footer includes the IIT Kharagpur logo, NPTEL Online Certification Courses logo, and the text "Internet of Things".

PLM for Industry 4.0

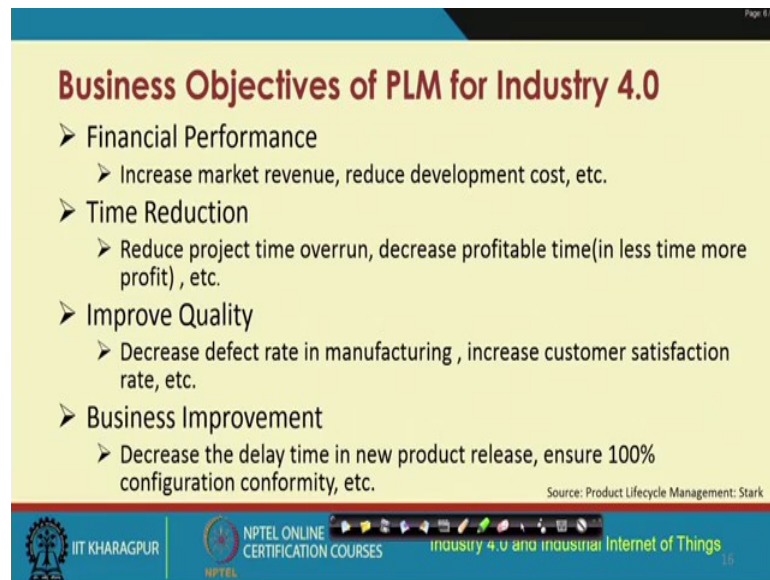
- The efficiency and effectiveness of PLM has an important role in today's enterprise operation systems.
- This efficiency and effectiveness of PLM improves market share and market size with increasing revenue.
- PLM system manages product's portfolio. It also manages the services from the initial concept to the final disposal.

Source: Product Lifecycle Management: Stark

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In terms of Industry 4.0, it is required to improve efficiency, effectiveness, automation has to be poured in order to be able to achieve it. So, automation in the PLM is something that the industries will have to be striving for, with the help of different things such as computers alone embedded systems, cyber physical systems everything has to be taken together in order to improve upon this efficiency and effectiveness in the automation of PLM. So, this efficiency and effectiveness of PLM improves the market share and market size, with increasing revenue.

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Business Objectives of PLM for Industry 4.0

- Financial Performance
 - Increase market revenue, reduce development cost, etc.
- Time Reduction
 - Reduce project time overrun, decrease profitable time (in less time more profit), etc.
- Improve Quality
 - Decrease defect rate in manufacturing, increase customer satisfaction rate, etc.
- Business Improvement
 - Decrease the delay time in new product release, ensure 100% configuration conformity, etc.

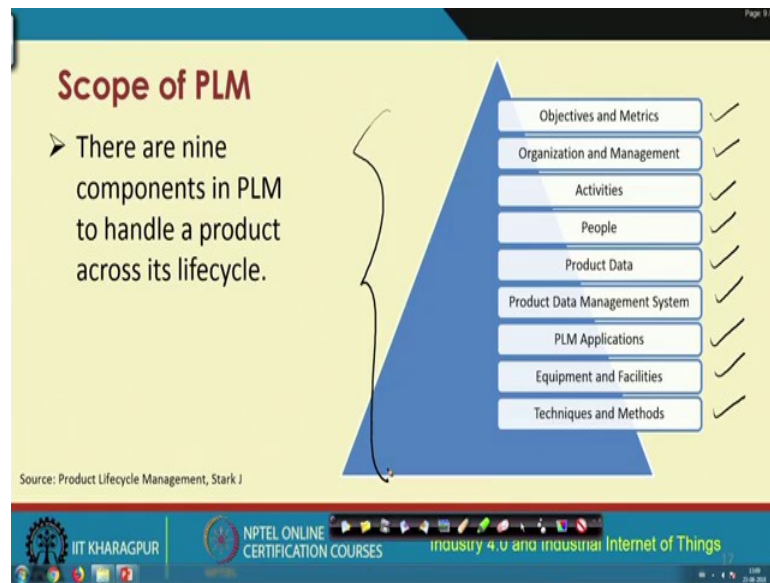
Source: Product Lifecycle Management: Stark

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These are some of these business objectives of PLM for Industry 4.0, financial performance, which obviously talks about increasing the market share, increasing the market revenue, reducing the development cost. Time reduction basically, reducing the project time overrun, decreasing the profitable time; improving quality talks about decreasing, the defect rate that means the rate at in which, rate at which the manufacturing defects in these different products are going to be there.

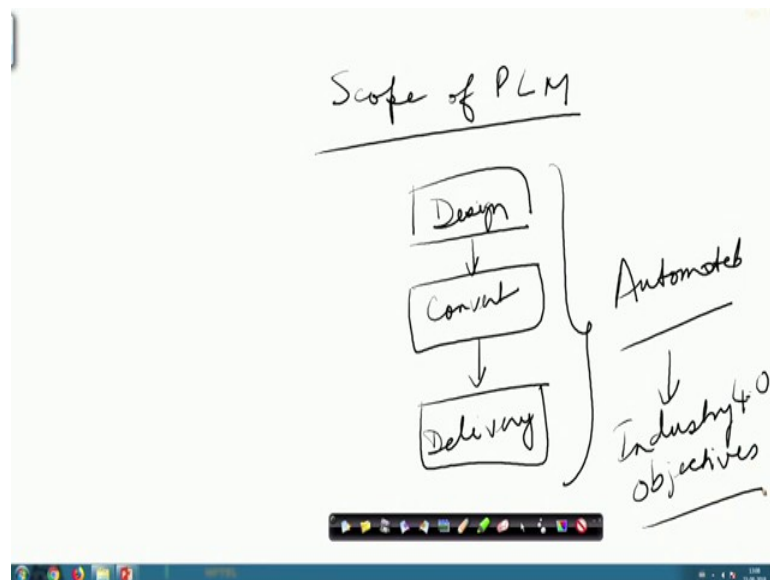
So decreasing that rate improving the customer satisfaction and so on, these are basically improving quality aspect of the business objectives of PLM. And overall improvement of the business decreasing the delay time in product release ensuring 100 % configuration conformity, improving 100 % customer satisfaction, these are all the different business objectives of PLM for Industry 4.0.

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So, if we are talking about PLM, we need to understand few things. So, let us look at some of these different aspects.

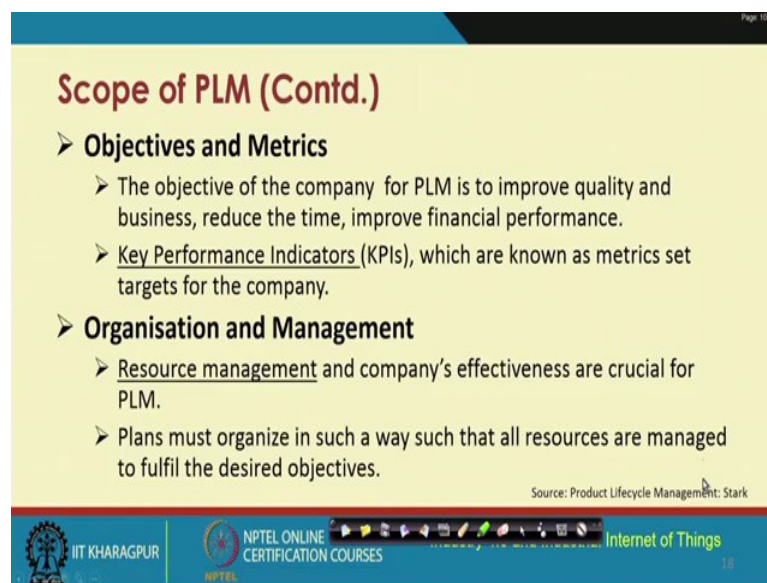
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So, let us talk about the scope of PLM, in the context of Industry 4.0. So, first of all you need to design the product. Then this product has to be built in its final form conversion. Conversion of the design into the physical form of the product and then this product will be delivered. So, all of these, basically will have to be automated to the extent possible in order to comply with the Industry 4.0 objectives.

So, we will be going back what is the scope of PLM. So, there are nine components in PLM to handle a product across its lifecycle. And these are the different components of it. These are the different components objectives and matrix, organization and management, activities, people, product data, product data management system, different PLM applications, equipments and facilities, techniques, and methods. So, all of these different nine components will have to be handled in the lifecycle of a product in PLM.

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The slide is titled "Scope of PLM (Contd.)" and is presented on a yellow background with a blue header and footer. The content is organized into two main sections, each with a blue arrow icon. The first section, "Objectives and Metrics", includes two bullet points: one stating the company's objective for PLM (improving quality, reducing time, and improving financial performance) and another defining Key Performance Indicators (KPIs) as metrics set by the company. The second section, "Organisation and Management", includes two bullet points: one stating that resource management and company effectiveness are crucial for PLM, and another stating that plans must be organized to manage all resources to fulfill objectives. The footer contains logos for IIT KHARAGPUR, NPTEL ONLINE CERTIFICATION COURSES, and Internet of Things, along with the page number 18.

Scope of PLM (Contd.)

- **Objectives and Metrics**
 - The objective of the company for PLM is to improve quality and business, reduce the time, improve financial performance.
 - Key Performance Indicators (KPIs), which are known as metrics set targets for the company.
- **Organisation and Management**
 - Resource management and company's effectiveness are crucial for PLM.
 - Plans must organize in such a way such that all resources are managed to fulfil the desired objectives.

Source: Product Lifecycle Management: Stark

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So, objectives and metrics, the objective of a company for PLM is to improve the quality and business, reduce the time, improve the financial performance. So, KPI is commonly known as KPIs key performance indicators are considered in the companies these are basically some kind of a metrics that are considered in the company. And these are targeted by the employees to be achieved, towards the development of a particular product.

The next thing is basically the organization and management. Here we are talking about resource management aspects. And the overall management of the different resources resource management means all kinds of resources. All kinds of resources including the product, the infrastructure, the human resources and all kinds of resources the management aspect of it should also be consideration alongside.

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Scope of PLM (Contd.)

- **Activities**
 - There are many product associated activities such as idea management, program management, new product development.
- **People**
 - Many people are involved to progress and maintain a product. E.g.- Business analyst, cost accountant etc.
- **Product Data**
 - It is a major asset throughout the product lifecycle.
 - Product will face problem, if we provide false product data.

Source: Product Lifecycle Management, Stark

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Activities, there are many products product associated activities such as idea management, program management, new product development. People are involved to progress and maintain a product, example a business analyst, a cost accountant, so these are the different people aspects. And the product data it is a major asset, throughout the product lifecycle.

So, product will face problem if we provide false product data. So, product data means like you falsify some kind of a data. You say that the product is defect free, but let us say that there is some small or big defect, that exists in the product. So, this falsification should not be done. So, then the product itself will fail, and it will face problem in the market.

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Scope of PLM (Contd.)

- **Product Data Management System**
 - It manages all the generated product data and it is used for product lifecycle.
 - It provides correct information at the right time.
- **PLM Applications**
 - To get desired performance levels, these applications are responsible for enabling the people to take decisions.
 - These applications support the people to build and maintain the products.

Source: Product Lifecycle Management: Stark

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Product data management system. As this name suggests, it manages all the generated data and that is used for improving the life cycle product lifecycle overall. So, it provides correct information at the right time. PLM applications to get desired performance levels, different applications are required, which are responsible for enabling the people to take different decisions. These applications support the people to build and maintain these different products.

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Scope of PLM (Contd.)

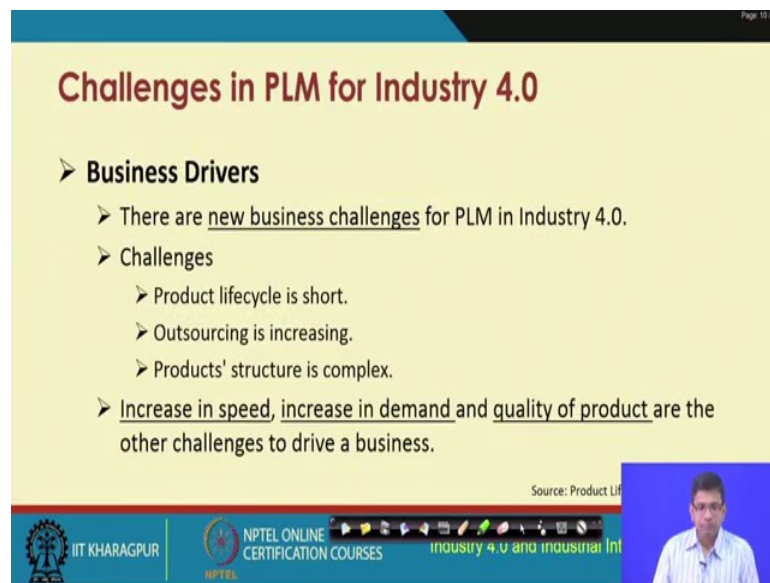
- **Equipment and Facilities**
 - Product lifecycle use equipment and facilities in every phase.
 - They are required to produce, maintain and service the product.
 - Cost and quality of the product are effected by them.
- **Techniques and Methods**
 - To refine production across the lifecycle by means of product progress time, product cost etc. many methods and techniques are proposed:
 - ABC (Activity Based Costing)
 - Concurrent Engineering
 - DFS (Design For Sustainability)
 - LCA (Life Cycle Assessment)

Source: Product Lifecycle Management: Stark

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Equipment and facilities talking about the use of different equipments, use of different facilities, the use of different infrastructure, that are already existing in the industry and procuring the ones that are not already there in every phase of the PLM. Techniques and methods, to refine the production across the lifecycle, by means of product progress time, product cost, many methods and techniques can be used such as activity based costing, concurrent engineering, design for sustainability, and lifecycle assessment.

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The slide is titled "Challenges in PLM for Industry 4.0" in a bold, dark red font. Below the title, there is a section header "Business Drivers" with a right-pointing arrow. Under this header, there are four bullet points, each starting with a right-pointing arrow. The first bullet point states "There are new business challenges for PLM in Industry 4.0." The second bullet point is "Challenges", which is followed by three sub-bullets: "Product lifecycle is short.", "Outsourcing is increasing.", and "Products' structure is complex." The third main bullet point is "Increase in speed, increase in demand and quality of product are the other challenges to drive a business." The slide has a yellow background with a blue header and footer. The footer contains logos for IIT KHARAGPUR, NPTEL ONLINE CERTIFICATION COURSES, and "Industry 4.0 and Industrial Int". A small video inset of a speaker is visible in the bottom right corner of the slide area.

Challenges in PLM for Industry 4.0

➤ **Business Drivers**

- There are new business challenges for PLM in Industry 4.0.
- **Challenges**
 - Product lifecycle is short.
 - Outsourcing is increasing.
 - Products' structure is complex.
- Increase in speed, increase in demand and quality of product are the other challenges to drive a business.

Source: Product Life Cycle

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Business drivers there are many new business challenges if you have to adopt PLM for complying towards the objective of Industry 4.0 there are different business challenges such as reduced or shortened product lifecycle. Increased outsourcing in the new products in the context of Industry 4.0, and the products structure has become complex. So, think about IIoT systems, think about a CPS system, in Industry 4.0. We are talking about small sensor enable devices small actuator enabled devices.

So, the way these IoT systems are developed, it is a kind of different product lifecycle that is used for these IoT systems. So, the essentially what has happened is in IoT the product life cycle has reduced it has shortened, and a lot of things are basically lot of components are outsourced. And many of them are in sourced from different companies. So, basically this outsourcing and in sourcing in the context of IoT, and their use in Industry 4.0 has increased and consequently the structure of the product the building of

the product, because there are so many different complex components in these different products IoT products that the product structure has also become complex.

So, these are some of these new business challenges for PLM in Industry 4.0 that will have to be kept in mind. Increase in speed, increase in demand, and quality of product are the other challenges to drive a particular business.

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The slide is titled "Challenges in PLM for Industry 4.0 (Contd.)" and is presented on a yellow background. It features a section header "Industrial Requirement" with three bullet points. The first bullet point discusses the need for collaboration between geographically dispersed design teams and supply chain partners. The second bullet point mentions the need for a new perspective to hold net-centric technology, which can free the inherent value in today's enlarged business model. The third bullet point states that performing project management, exchange, and maintenance of product information is a challenge in industry. The slide also includes a source attribution to "Product Lifecycle Management: Stark" and a footer with logos for IIT KHARAGPUR, NPTEL ONLINE CERTIFICATION COURSES, and the course title "Industry 4.0 and Industrial Internet of Things".

Challenges in PLM for Industry 4.0 (Contd.)

➤ **Industrial Requirement**

- To design products virtually, geographically dispersed design teams and supply chain partners are required to collaborate.
- A new perspective must be generated to hold net-centric technology. This perspective will be able to free the inherent value in today's enlarged business model.
- Perform project management, exchange and maintain product information is a challenge in industry.

Source: Product Lifecycle Management: Stark

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Industrial requirement. Nowadays, we are not talking about physical presence of the different units, there could be virtual presence also. There could be geographically dispersed design teams supply chain itself has been made virtual to a large extent. And this could be further increased with the increase of adoption of these IoT systems. So, what is required is that the different industry components will have to collaborate with one another. So, net-centric technologies have increased in their use in PLM nowadays, and that has also not only improved not only increased the efficiency of the production process, but has also made it much more complex, in terms of development.

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So, for Industry 4.0, these are the 10 step approaches that can be used for PLM. Number 1 data gathering education of PLM. So, education component is very important and is often neglected, but education and training is very important. Practice of management in PLM concept, PLM roadmap generation, development strategy, rate of interest calculation, management report preparation, executive preparation and executive decision support.

If you need to know in further more detail about each of these many of these are quite well understood, and I think most of them you can understand from these names alone. But if you need to understand in further more detail this is the source that can help you to understand in further more detail. So, you can go through this particular literature in order to understand these.

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So, with this we come to an end of this lecture. So, collaboration platform product lifecycle management, their automation improvement in the context of IoT, IIoT, Industry 4.0 is very important. So, these are often overlooked, but should not be from our perspective and that is why we have included these things in this particular course on Industry 4.0 and IIoT.

Thank you.