Mine Automation and Data Analytics

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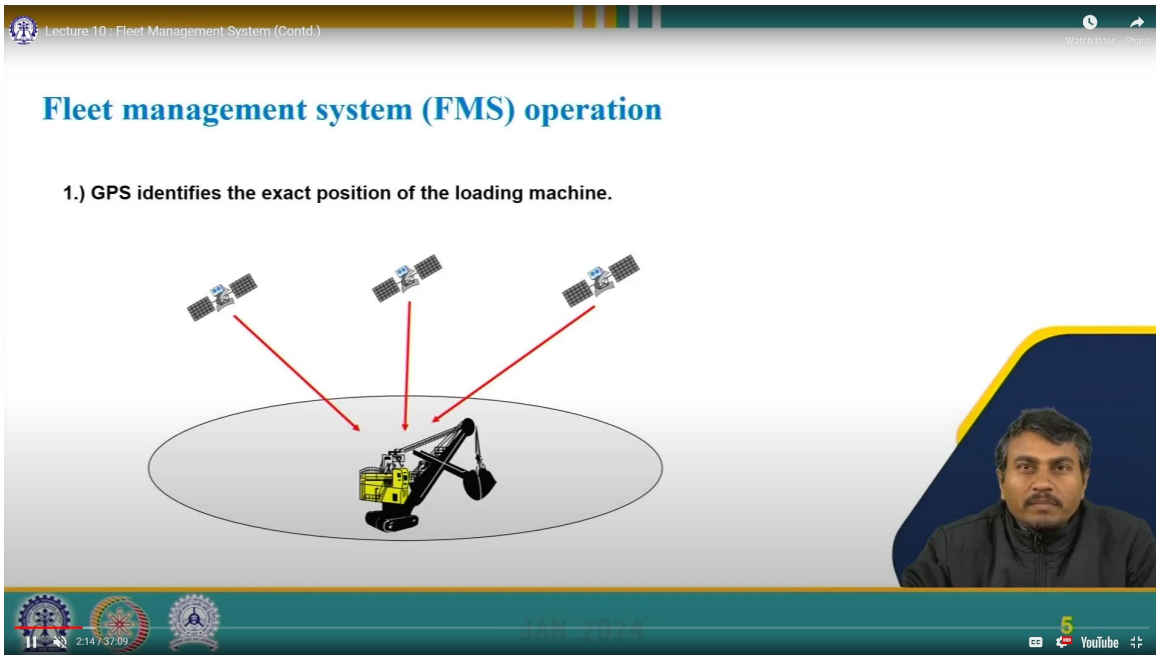
Week-2

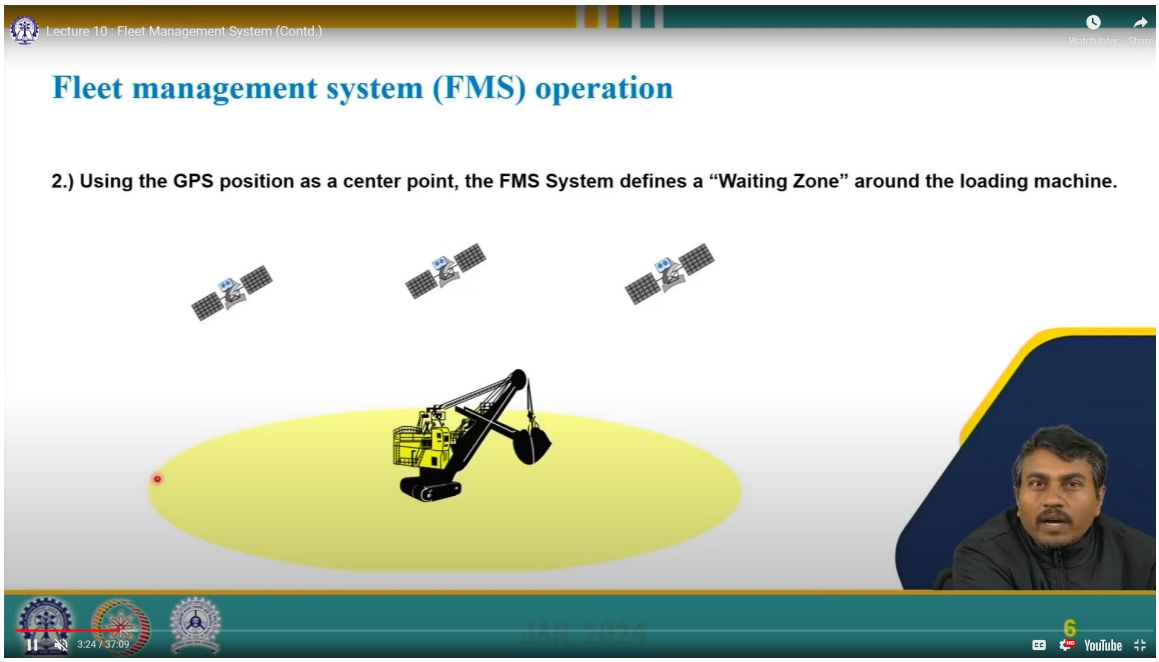
Lecture-10

Fleet Management System (Cont.)

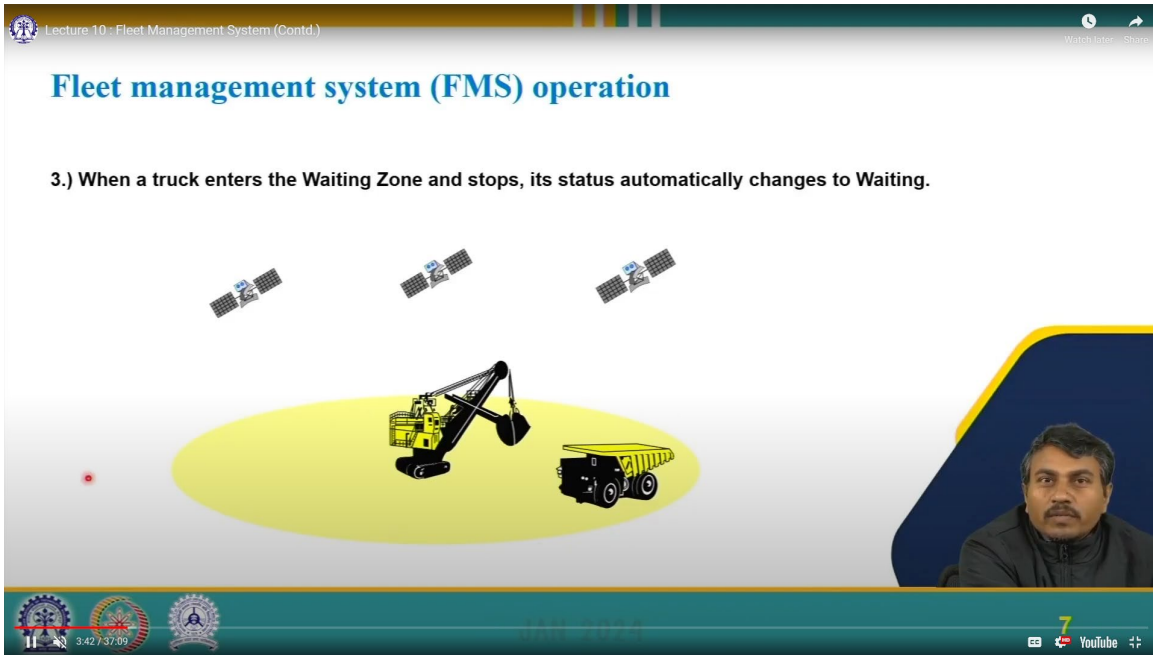
Welcome back to my course on automation and data analytics. In this lesson, we will discuss the second part of the fleet management system. In this lesson, the following concepts will be covered: We will discuss on the operational aspect how the FMS is working at the mine site. We will discuss the mining supply chain with a fleet management system. We will also discuss industrial fleet management systems, the shortest path system and its algorithm, production optimization systems, real-time dispatching, industrial mine fleet management system examples, and dynamine fleet management systems.



So, let's talk about how the fleet management system operates. So principally in FMS, the role of GPS is very high. So, GPS identifies the exact position of the loading machine, the dumping machine, the dumpers, and all machines that are fitted in the fleet management system. So, this is typical geometry, this is the area in the center of this area where this particular machine, the loader, is situated. So, the GPS receiver mounted on this particular vehicle is always in connection with the GPS satellite, and by that, it

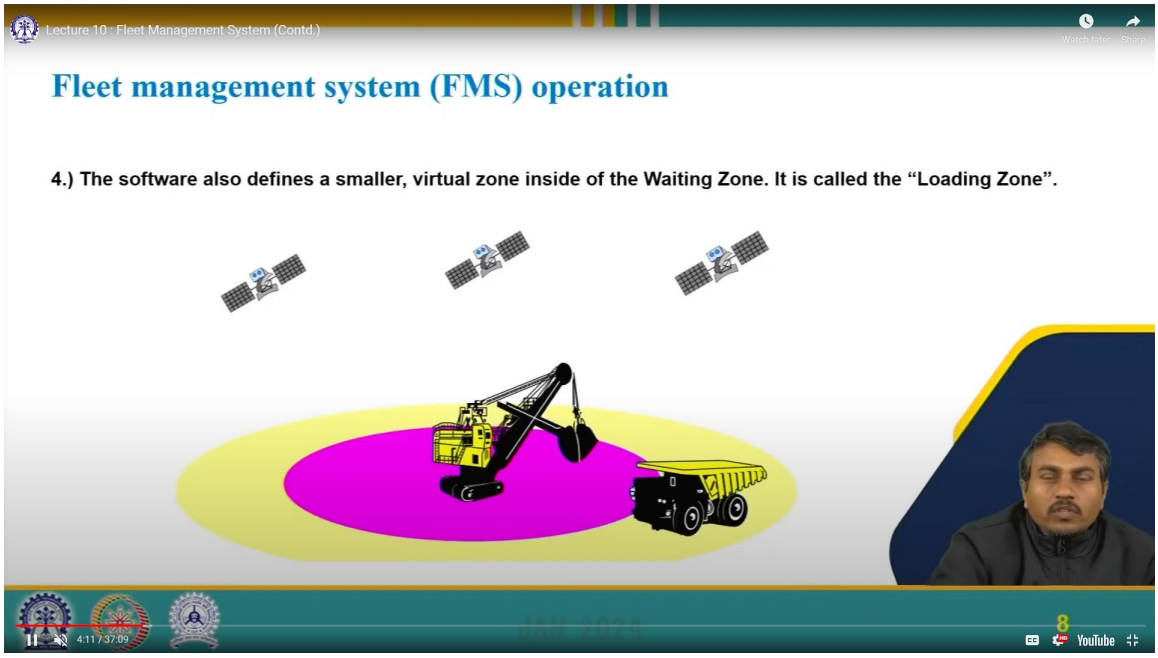


basically gives the actual position of this particular machine. So, using the GPS position as a center point, the FMS system defines this waiting zone. So, it is a virtually created zone that identify the waiting zone for this loading machine. So, this waiting zone is around the loading machine.

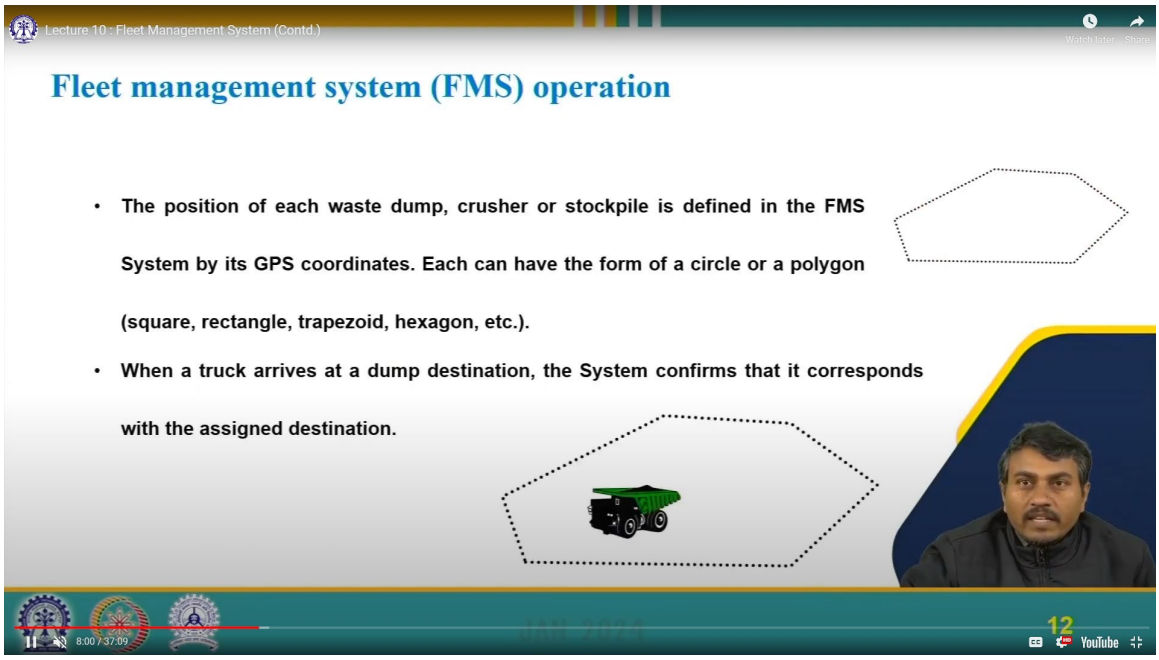


Similarly, in the dumping zone, there are also some waiting zones. So, this is the way the waiting zone is defined virtually in the system. So, when a truck enters the waiting zone, it was outside, now it enters this waiting zone, so its status automatically changes to waiting. So, this truck is now in waiting position, waiting for taking the load or taking the

material on its dumper. So, the software also defines a smaller circle inside the waiting zone.

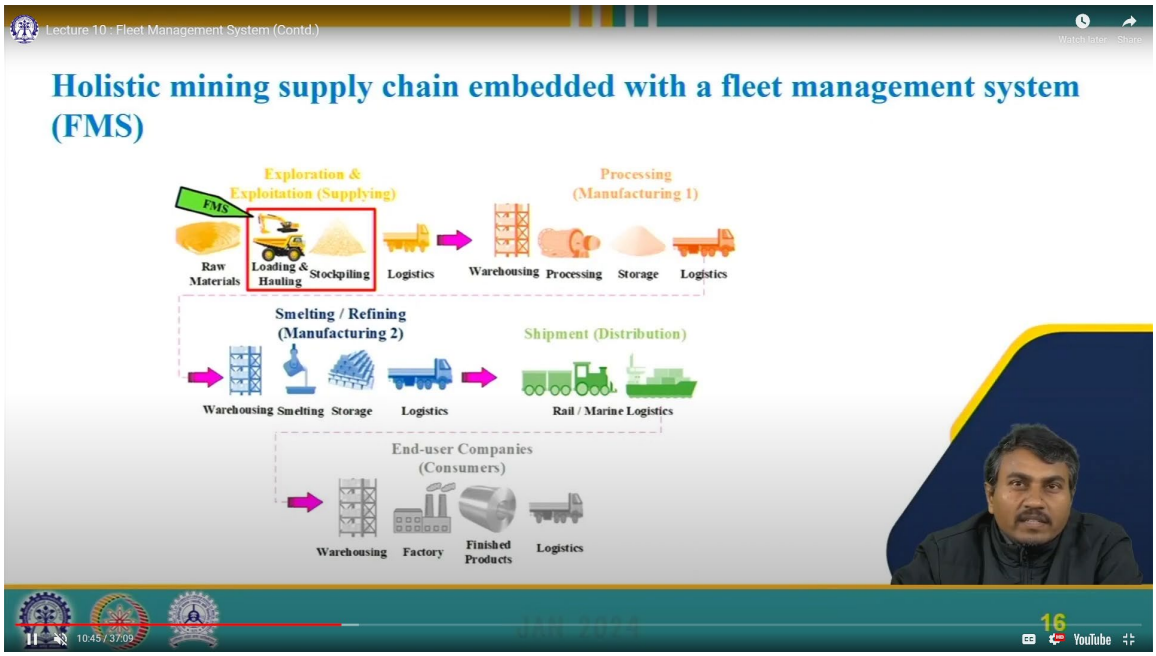


It is also a virtual zone, which is basically called the loading zone. So, there are some vehicles in the loading zone, and there are some vehicles in the waiting zone. So, when the vehicle enters the loading zone, its status will automatically be changed. So, when the truck enters the loading zone, its status and that of the loading unit automatically change to spotting. So, now, from the earlier one, the dumper was in the waiting zone; once it entered the loading zone, its status was changed to spotting. All these things are shown in real time on the dashboard of the FMS system on the control station, as well as on the dashboards of all these machines. So, when the truck stops, the status of the loading unit automatically changes to loading. It was spotting; once it entered, it stopped, and the loader started giving the material to its dumper. So, now it is automatically changed to loading. So, when the truck leaves the loading zone and attains a certain speed, its status changes to hauling. So, this triggers the status of the loading machine to change back to waiting. So, now the dumper leaves the loading zone and attains some velocity. So, it is changed to hauling state. Now, the loader is waiting. So, the loader needs another dumper to enter this loading zone so that it can spotify, and then once it stops, it will be the loading. So, this way continuously works this particular system. So, the position of each waste dump crasher or stockpile is defined in the fleet management system by the GPS coordinates. Each can have the form of a side circle, a polygon, a square, a rectangle, a trapezoid, a hexagon, etc. So, a particular area is designated or demarcated using this kind of polygon, particularly when the area is very large. So, this kind of polygon would be better. So, when some vehicle enters this particular destination, for example, this particular destination or assigned destination like this, it would be just like



that it has reached the dumping yard. So, when the operator tips the box and the status of the truck becomes dumping and soon thereafter empty, then the truck receives a new destination, which is the shovel or loader for the next haul cycle. So, when the dumper enters this polygon area, dumping area, it starts unloading. So, once it is unloaded, it is entered into the state of being empty. So, this dumper needs another assignment. So, by some mathematical model, that assignment has been allocated to this particular dumper, to which shovel or which loader this particular dumper will go into the next cycle. If a second truck arrives at the dump destination and stops while the first truck is dumping, the status of the second truck becomes waiting. So, inside this zone, one dump truck is unloading the material. So, another dump truck is entered into this particular zone. So, this particular dump truck now enters the waiting zone. Once it finishes and goes out, it will come to this particular point, and again, the status will be automatically changed. It would be basically tipping or emptying the system like that.

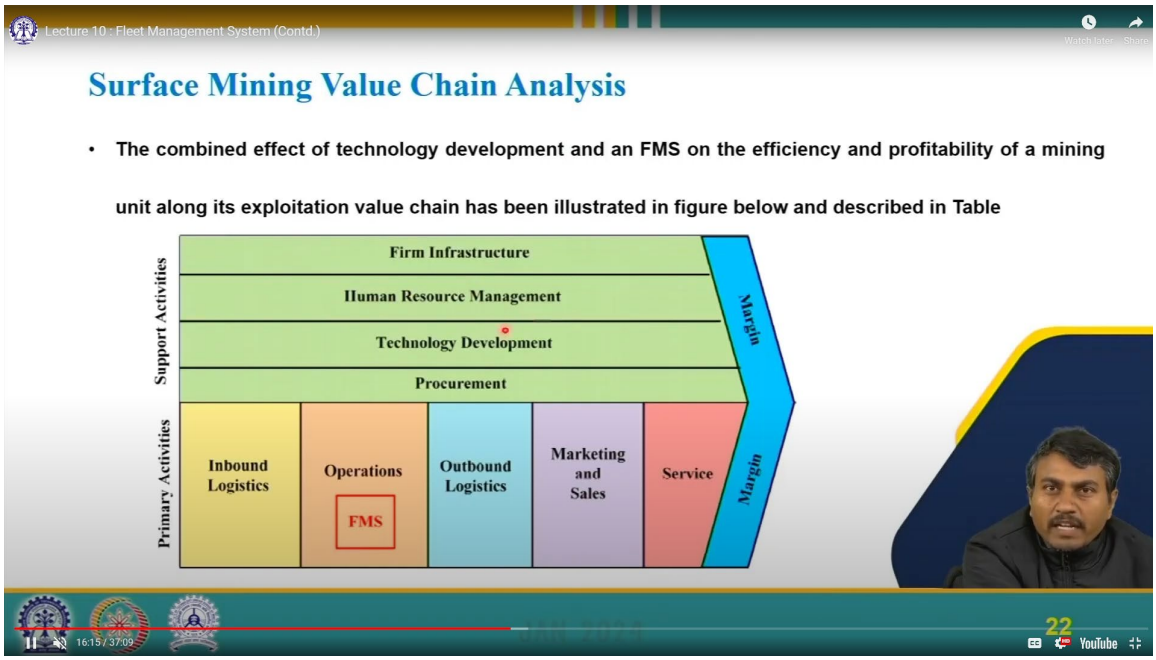
So, let us discuss the holistic mining supply chain embedded with the fleet management system. So, the FMS operates at the operational level of the mine planning hierarchy. FMS has a nested relationship with logistics and supply chain management. The mining supply chain includes exploration, exploitation, material handling, maintenance, and distribution chains. The exploration or exploitation chain is the base supplier covering activities from exploring reserves to outbound logistics. This is a typical schematic of how the FMS is playing its role in the overall mining supply chain system. So, raw material is now handled by the FMS system by loading, hauling, and stockpiling. So, here, FMS is working in the exploration and exploitation stage. Then to the next level of logistics: warehousing, processing plant, storage, logistics, and then again, it goes to the next level of warehouse. If it requires some amount of smelting, it will do that, then again



storage, then again logistics, then it will go for the shipment, rail or marine logistic, then again it will reach the end user warehousing, factory, finished product to the final logistic. So, this is the total supply chain in the mining industry. So, in this particular part, FMS is playing an important role. So, FMS handles material handling, stockpiling, dispatching, and dumping commands in the mining networks. So, the mining FMS tasks include maintenance, fuel management, and the provision of feed for the primary crossing plant. Preliminary mining phases like exploration and development can be separate value chains. Mine ores undergo treatments in a processing plant, leading to concentrate production. Concentrate is processed in a smelting or refinery plant to extract base or precious minerals. The distribution chain delivers the cargo by land, rail, or marine logistics to buyers. Purified minerals in end-user factories mark the end of the mining supply chain. The last value chain can create another supply chain with downstream industries. So, every enterprise aims to sell its commodity directly to the end user, but obstacles may arise. The mining supply chain comprises five distinct phases. So, the exploration and exploitation, the basic part of it, then the processing of the mineral and the material, then some amount of smelting on the ore, then distribution, and finally the consumer phases. So, FMS enhances the exploration, exploitation phase for raw material extraction. Real-time monitoring and data-driven decisions optimize vehicle routes and extraction processes. GPS technology tracks vehicles for efficient exploration in mineral-rich areas. Telematics in the exploitation phase monitor equipment, fuel usage, and health in real time. Early issue detection and maintenance extend the machinery's life span. That is one of the major advantages of this FMS system. So, asset utilization is enhanced here. Predictive analytics in FMS forecast maintenance need to reduce

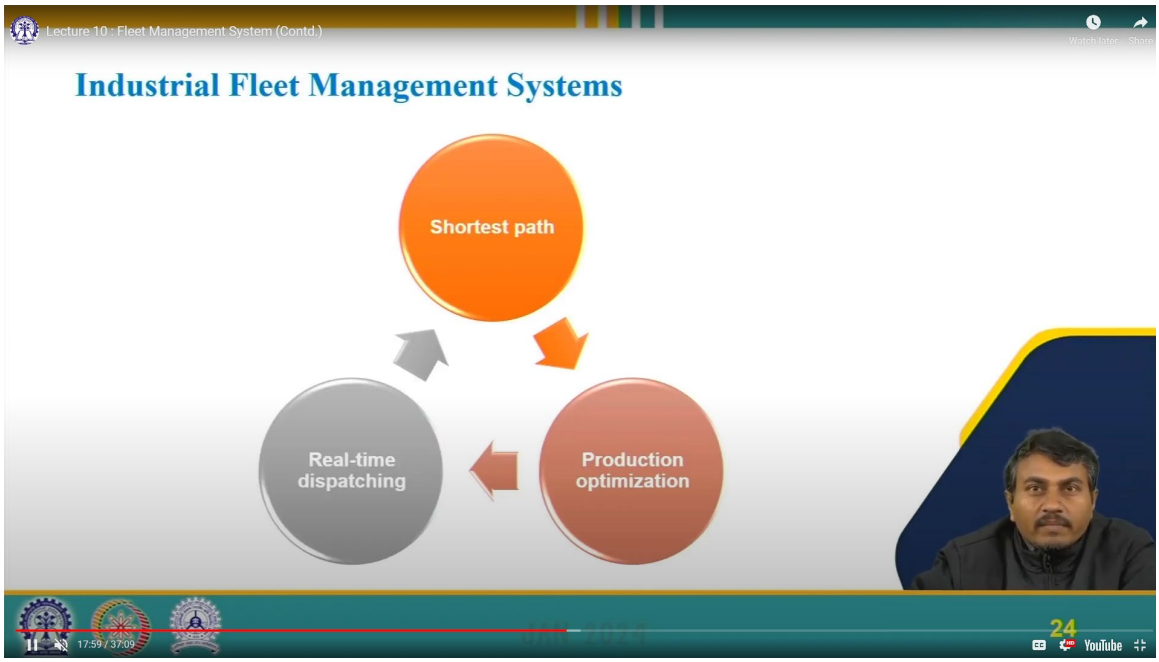
downtime. Real-time data sharing supports prompt decision-making. FMS contributes to better resource allocation, strategic planning, productivity, and cost reduction.

Surface mining value chain analysis- The combined effect of technology development and often FMS on the efficiency and profitability of a mining unit along its exploitation value chain has been illustrated in the figure below and described in the table.



So, this is a typical workflow, so here is the farm infrastructure at the top, followed by human resource management, technology development, and procurement. So, these are the supporting activities of the mining value chain. Here is the primary activity of mining: inbound logistics, then operation, where FMS plays an important role, then outbound logistics, marketing and sales, and service. So, in this particular primary area of activities, FMS can contribute to a substantial level. So, in this total table of operations, the development of a new working phase, drilling, blasting, loading, hauling, stockpiling, crushers, and feeding in this particular area, FMS can play an important role in the primary activities. In outbound logistics, ore dumps management, grade control, blending, order handling, invoicing, and shipment, and inbound with utilities, spare parts, and explosive, errands, so these would be handled by a separate system. So, in this particular value chain, operational aspects can be handled very well by the FMS system.

Industrial fleet management systems-So, its work on the shortest path algorithm, its enhanced production, its facility of real-time dispatching, and all these three-working hand in hand for achieving higher efficiency for material handling, shortest path, production optimization, and real-time dispatching all are integrated together.



Shortest path system- So, the shortest path was defined as the shortest travel time route from loading to the tipping point. Using Dijkstra's algorithm of finding the shortest to select the best route for connecting Shovel to their destinations,

Production optimization and truck allocation-As the first step, it fixes the Shovel location by implementing a combinatory mixed integer linear programming (MILP) model with respect to available trucks and the objective of maximizing production, subject to quality constraints, In the second step of this algorithm, represent the truck travel plan between Shovel and dumping points by solving a non-linear programming model (NLP). The model's objective function consists of three components. Shovel production objective is computed Shovel production. Available truck hours are computed truck hours, which include truck waiting time as well as a penalty for the deviation of the produced ore material from the blending objectives.

Real-time dispatching- Real-time decision-making on the destination of trucks in a mining operation was first used in the early 1960s with the implementation of radio communication tools to link dispatchers and truck operators in a fixed truck allocation. However, based on the utilization of modern computers, real-time fleet management in mining operation systems is divided into three major categories: locked-in or fixed-allocation semi-automated and fully automated systems.

Let us discuss the locked-in model with no effort for dispatching transportation units. Semi-automated dispatching is divided into two classes: passive and active. In the passive sector, computers display current mine operation information without involvement in

decision-making. Active, computers use current mine status as input, process them based on predefined models, and suggest assignments for dispatchers.

Automated dispatching- Data on current mine status, equipment condition, and position are collected on the main computer server. Assignments are sent to trucks after solving heuristic or mathematical programs.

Let us discuss a few questions.

Question 1:

What does the term shortest path refer to? the most scenic route, the route with the fewest number of turns, the shortest travel time route from loading to the tipping point, the route with the fewest obstacles.

The right answer is, the shortest travel time route from loading to the tipping point.

Question 2: What technological advancements facilitated real-time decision-making in the early implementation of truck destinations in mining operations? GPS technology, radio communication tools, satellite communication, Morse code.

The right answer is, radio communication tools.

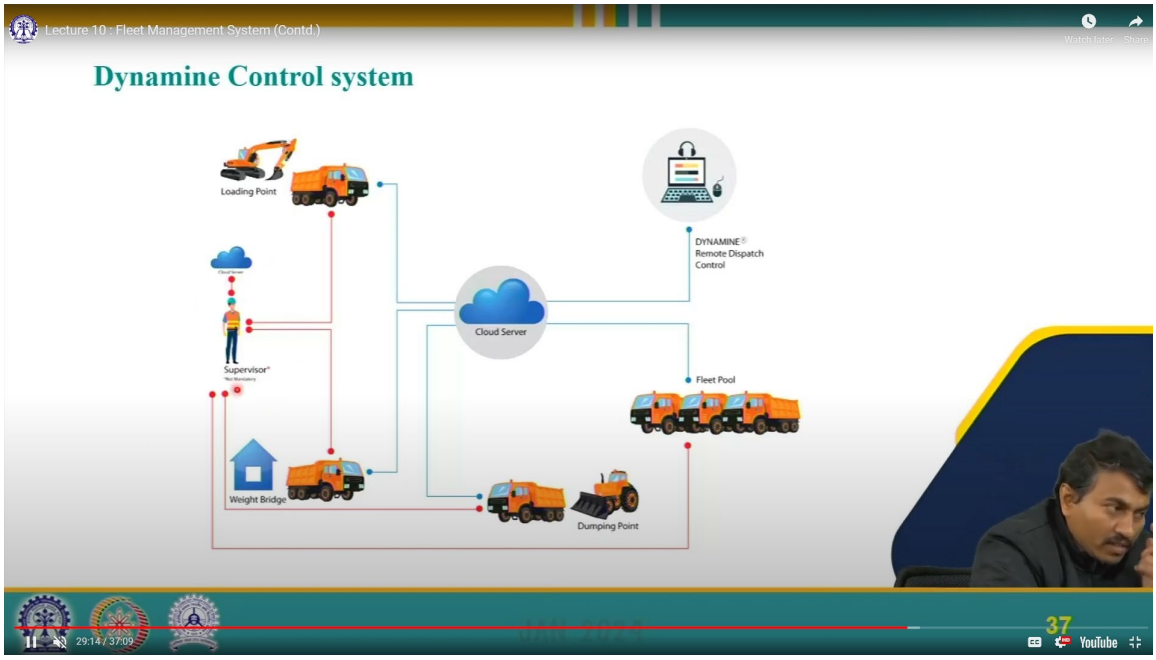
Industrial mine fleet management system

Dispatch fleet management systems-The company name is Modular Mining Systems. Above 200 mines, this particular setup is installed and the major features included in this particular FMS system. The main features are haulage optimization, qualification management, fuel service management, auxiliary equipment management, remote service supervision, payload analysis, and ore blending control. So, these particular FMS systems have all these management systems, which means they include the management of all these sectors, achieving higher accuracy and efficiency, and by that, they are going to serve in a better way in the mining industry. The last is real-time web reporting, which also helps monitor the status of the ongoing operations.

Jmineops fleet management systems-The company is Leica Geosystems, and 130 mines, this particular system is already installed. They have some key features. Universal software platform, its ability to harness any industry-standard IP-based wireless network, Identical onboard SQL database and office server that replicate in real time, Distributed database architecture, Instantaneous data relay, this is one of the main features of Jmineops fleet management system. Real-time compliance control as well, and automated cycle logic. So, these are the key features of Jmineops fleet management systems.

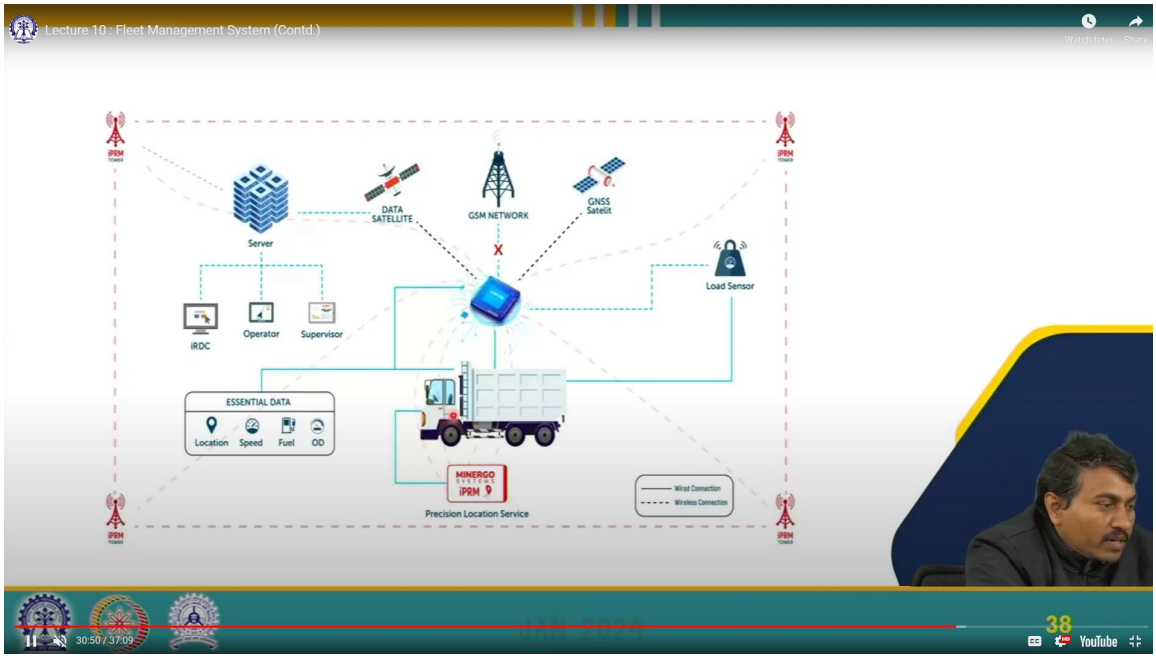
Wencomine fleet management systems-The company is Wenco Mining System, and around 65 mines, this particular system is already installed. The key features are the following: It has a real-time view of location and activity for all equipment and the mine. Include the loader, dozer, dumper, and other machines associated with the fleet management system, Assignments are sent to operators based on current mine parameters. So at every time, assignments are based on real data, and informed decisions are being taken. Operators kept on task with on-screen work. Detailed status of all shovels, trucks, drills, dozers, and other equipment monitors. Ongoing events monitored with customizable real-time alerts.

Dynamine fleet management systems- It is operated by Tata. The key features of this particular FMS system. It minimizes the cycle time for open-pit mine operations, improving mine productivity. It has efficient queue management and monitoring of mobile assets. It is very effective in visualization throughout the operational boundaries within a mine. Its ability to integrate with mine surveys, mine planning, and enterprise applications is its key advantage. Dynamite is a platform to manage the daily haulage operations of mining materials outside the pit and is also very effective for long-distance hauling. The system has many useful functions to utilize the fleet more effectively. So dynamite is equipped with advanced tools. Intelligent remote dispatch control (IRDC), telematics technology, satellites for data collection, an integrated mobile app for field workers, and others.



The schematic of the dynamite control system, here is the supervisor at the station. Supervisors have all information about the loading point, whether loading is going on, whether the dumper is in the waiting zone, or whether the dumper is going on in the

loading zone. Dumper, whether on the weight bridge, what is the status of the weight bridge, it is working properly, and the actual data is shown or not. The dumpers are at the dumping point, whether the dozer is working or not. All the data is related to are connected to the cloud server, and the operator and supervisor have access to all this data. The fleet pools, from this fleet pool, using some algorithm, the dynamite remote dispatch control, assign the dumpers to a particular location, whether to the loading point for the load, which needed a dumper like that. So, all these things are on the cloud server, and they are processed by the Dynamite remote dispatch control system, and the supervisor has access to all these points and the data.



This is the precision location service of the dumper. It is fitted with the sensors, it is connected with the GPS satellites, and its location is being used by the dumper. It is being correctly assessed, and it has data about its location, speed, and fuel level, which are basically monitored by the load sensor. It is connected to a wire inside the dumper, and through wireless communication, the data is updated on the servers.

Modules: IRDC (Intelligent Remote Dispatch Control), a module for managing haul fleets and monitoring assignments to operators on site. The advantages of IRDC are that it is a lightweight application, easy to install, an operating system based on web applications, user-friendly so that it is easy to use by authorized dispatchers, connected to applications on Android-based smartphones and industrial tablets and can be widely used anywhere, easy to navigate and operate easily to operate on site, easy to navigate and operate easily to be able to monitor various haulage activities, the ability to provide control, visibility, and consolidate fleets operated by third parties or vendors, the ability to integrate with third-party systems, customizable as and when needed.

I-Precise, this is the sensor, a telematic system that allows dispatchers to track trucks, fuel, navigation, driver records, and driver performance, resulting in optimal fuel usage and asset utilization. Routes can be optimized to reduce mileage and fuel usage, which also keeps costs proportional. I-Precise is a module embedded into the truck dashboard to monitor the position and health of the vehicle in real time.

Question 3: How does the telematic system contribute to optimal fuel usage and asset utilization? by reducing the number of trucks, by optimizing routes and monitoring driver performance, by increasing vehicle speed, by minimizing the navigation feature.

The right answer is, by optimizing routes and monitoring driver performance.

I-Drive is an application that is used by the operator on the field. Information about the task, routes, and other relevant instructions will be contained in the I-Drive app. In some applications, I-Drive limits the intensity of the operator's touch to the button that appears above the interface screen to ensure safety. I-Drive can be operated on an industrial tablet or smart phone.

Benefits of using dynamite: improved efficiency-Dynamite helps to optimize haul truck operations, reducing downtime and increasing haul truck utilization, leading to improved overall efficiency. For better dispatch management-dynamite provides real-time visibility into haul truck activity, enabling dispatchers to manage the movement of haul trucks more effectively and reduce delays. Improved load management-the system is used to assign loads to haul trucks based on factors such as truck availability, load size, and haul truck capacity, helping to optimize load management and reduce inefficiencies. For data-driven decision-making, the system provides detailed data analysis of haul truck utilization, including factors such as average cycle time, idle time, and haul truck productivity, enabling data-driven decision-making and continuous improvement of haul truck operations.

So, these are the references, and we acknowledge the help of the Tata Noamundi iron ore mines management for sharing some of the information used in these lessons. Let us summarize in a few sentences what we have covered in this lesson. We have explored the operational aspect of the fleet management system and the FMS tailored for industrial applications, focusing on optimizing fleet operations. We have discussed the implementation of the shortest path system for efficient route planning in industrial fleets. We have explored systems aimed at optimizing production within industrial fleet management and enhancing overall efficiency. We have highlighted the significance of real-time replacement in industrial fleet management for agile decision-making. We have provided examples of FMS tailored for industrial mines, showcasing practical applications in the mining sector. We have introduced dynamite as an example of a fleet

management system with a focus on dynamic optimization in an industrial context. Thank you.