Mine Automation and Data Analytics

Prof. Radhakanta Koner

Department of Mining Engineering

IIT (ISM) Dhanbad

Week-2

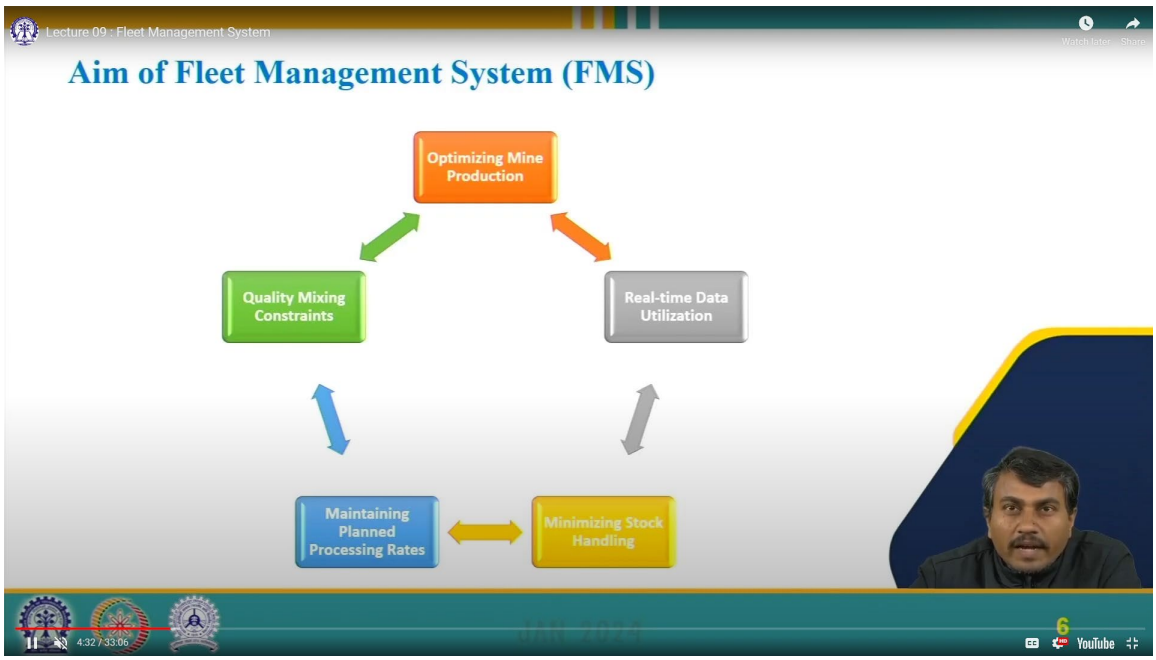
Lecture-9

Fleet Management System

Welcome back to my course, Mine Automation and Data Analytics. In this course, we will discuss the Fleet Management System. It is part of an autonomous mining system. So, in this lecture, the following concepts will be covered: What is the Fleet Management System all about? Then the aims of FMS, the advantages of FMS, the disadvantages of FMS, the FMS from a global perspective, FMS workflow, FMS work setups, types of FMS systems, and benchmark truck dispatching model.

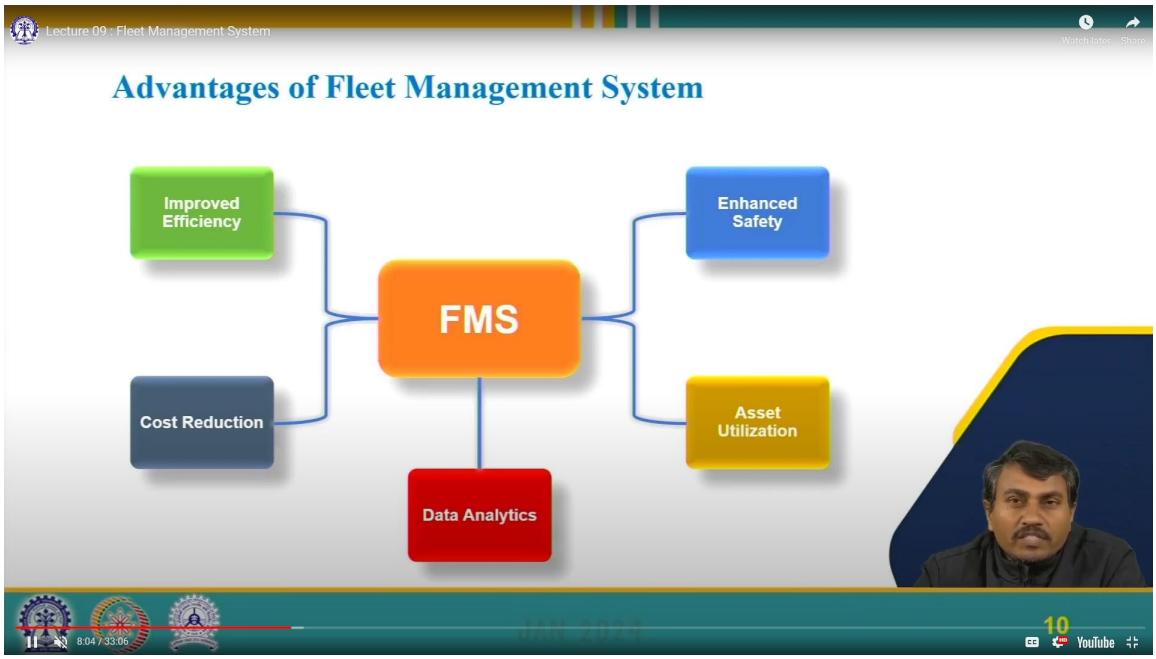
So, what is a fleet management System? This fleet management system in a mining operation is a decision-making system that makes real-time decisions for handling material in a surface mine. FMS obtains the required information regarding the status of operations from the database and makes decisions accordingly. The decisions are then implemented in the operation, and the FMS is called again whenever a new decision is required. Here is the mine site, where many equipment's are operating and executing their work through telecommunication systems and radio frequency module

communication systems. They are connected, and it is finally displayed in a control room. In the control room or from the control tower, the control crew can see the real-time status of different equipment that is operating at the mine site, and they will also monitor if some necessary action or some amount of intervention is required from time to time. So, this FMS module is about establishing introduction and control over all the equipment that is operating on the mine site, as well as sending and executing commands for achieving higher efficiency in the operation.



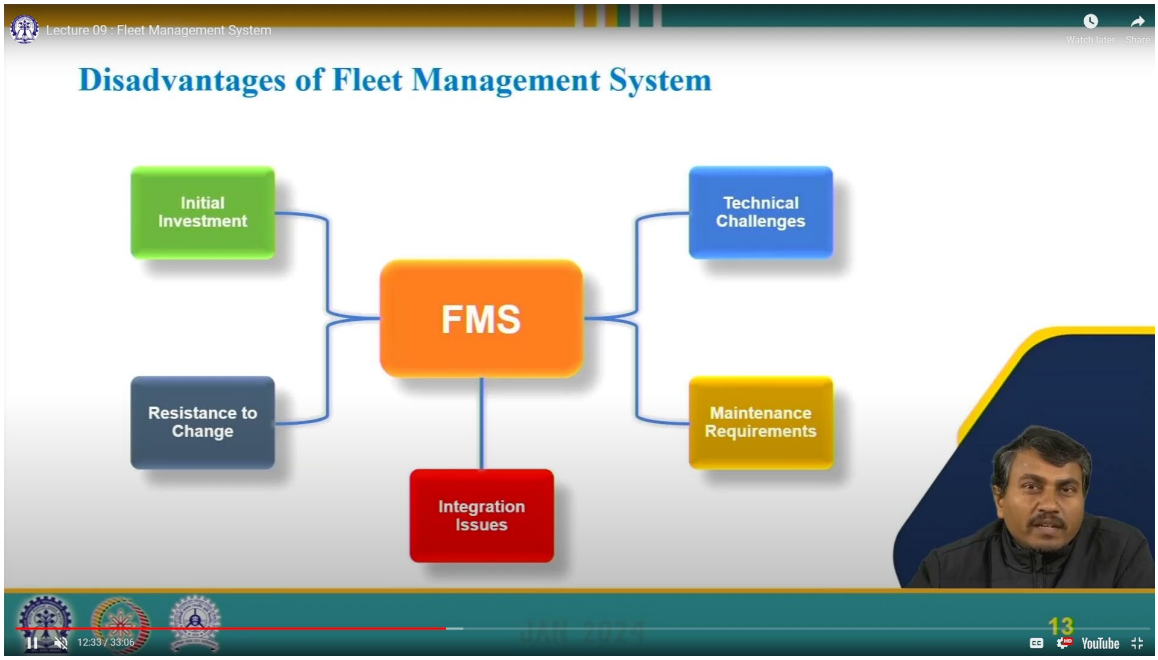
The aims of the FMS system are to optimize mine production, utilize data in real time, minimize stock handling requirements, maintain planned and processing rates for the processing plants, and also maintain the quality of the material that it delivers. So all are working together side by side and integrating together to achieve higher accuracy and higher control over the system. Optimizing mine production-the fleet management system is essential in the mining sector, it focuses on optimizing mine production, utilizes real-time data for informed decisions, and aims to enhance overall output in the mining industry. Real-time data utilization: the primary function of the FMS is leveraging real-time data, it involves collecting and analyzing information as it becomes available, which enables quick adjustments and improvements in operational efficiency. Minimizing stock handling is an essential objective of FMS; it aims to reduce operational costs, ensure a streamlined and efficient workflow in mining operations, and maintain plan processing rates. FMS design ensures processing plants receive material at a planned rate; it aims to avoid bottlenecks in the production process; and it contributes to a more consistent and predictable workflow. Quality mixing constraint: FMS addresses meeting quality mixing constraints, it involves managing and controlling material compositions and their grades, it aims to meet specific quality standards, for example, sometimes in iron ore mines, it

requires that there should not be more than 2.5% alumina content in the iron ore. So in the FMS system, sometimes it is possible to maintain the quality of the iron ore below 2.5% alumina content and ensure the final product meets required specifications.



Advantages of a fleet management system: FMS improving efficiency is one major advantage; cost reduction is another advantage; enhancing safety is another advantage; asset utilization is another advantage; and last but not least, data analytics. So, with the huge amount of data in the in the pool and the database, there is enormous opportunity for the optimum level of performance of this FMS system, and with the help of data analytics tools on each parameter, there are further levels of enhancement people are looking at the mine site they are achieving, and they are significantly improving the usefulness of the FMS system in the mine site. Improved efficiency-real time monitoring allow for better coordination of mining activities, it optimized route planning and scheduling lead to reduce idle time and increase operational efficiency. cost reduction- the fuel consumption can be optimized by monitoring and controlling vehicle speed and engine performance and majority of the time when the shovel and dumper combination working on a mine site for handling the ore the path allotted for a dumper has to be such that a number of times use of brake may be reduced or if possible the brake use is number of times brake use is negligible and by that with a rate of speed the vehicle operates on the mine site it will enhance finally the fuel consumption of these dumpers, maintenance cost can be minimized through predictive maintenance and condition monitoring, and also with the time to time in the machine dashboard, it would be shown that when the maintenance is required so that in actual time before the machine becomes damaged, the maintenance is activated on the machines, and by that, we are reducing the cost in the overall cycle. Enhanced safety- real-time tracking and monitoring

contribute to better safety management, and proactive alerts and warnings can prevent accidents and improve overall safety. Asset utilization- the optimum level of use of equipment and vehicles, reducing downtime, and increasing overall productivity are achieved by utilizing the asset in a more beneficial way. Improved allocation of resources based on real-time data, data analytics, and data collected by the FMS system can be analyzed to identify trends, patterns, and areas for further improvement. It helps for making informed decisions with an accuracy level of very high and with the up-to-date data information that it is getting from time to time. So, these data analytics tools help these FMS strategies in a broader way, significantly improving their efficiency at the mine site.



Disadvantages of fleet management systems: FMS's major disadvantage is the large initial investment required for this system. Another disadvantage is the resistance to change and the technical challenges, maintenance requirements, and integration issues of whole setups. So, let us discuss them one by one.

Initial investment and implementation of a fleet management system involve significant upfront costs, including software, hardware, and training. Resistance to change: employees may resist the adoption of new technologies, leading to challenges in implementing and training them. Technical challenges- technical issues such as system functions, software glitches, and connectivity problems can disrupt operations. Maintenance requirements: the system itself requires regular maintenance and updates to ensure optimal performance, adding to ongoing costs. Integration issues and integration- with existing systems and processes may pose challenges, leading to potential disruptions during the implementation phase.

Let us discuss a few questions.

Question 1.

What does the fleet management system do with the information obtained from the database? archives it for historical analysis, collaborates with other industries, utilizes it for employee evaluation, and makes real-time decisions accordingly.

The right answer is makes real-time decisions accordingly.

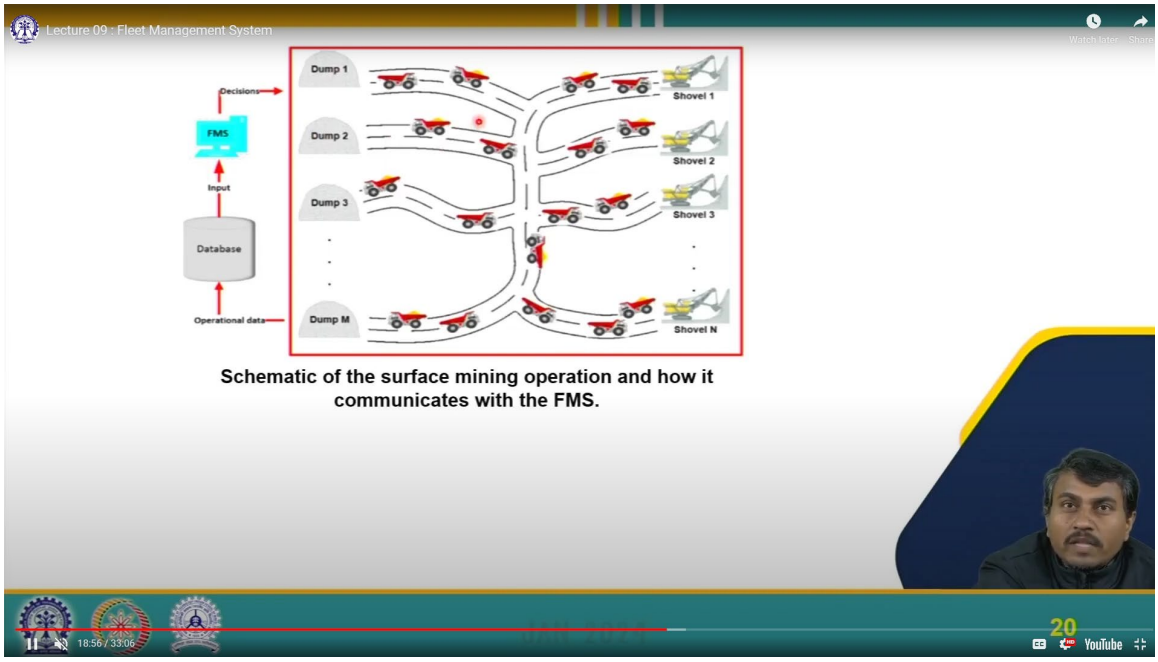
Fleet management systems: a global perspective.

Leading providers include modular mining systems, jigsaw software, WENCO, DynaMine, and Tata services consulting. Complex demand addresses- their solutions are designed to meet the intricate demands of contemporary mining operations. Commonly adopted systems: Micromine pitram, Viste and Cat MineStar emerge as the most widely adopted fleet management systems. Evolutionary significance: as the mining industry evolves, these solutions play a crucial role in shaping and defining modern mining operations.

FMS workflow: FMS system for a mine site, is a set of software running on rugged hardware. Using GPS and a wireless radio network, the FMS tracks and monitors production maintenance and safety in the mine. At the top, we have the control center connected to the wireless network and a GPS satellite network. The wireless network sends a signal to equipment that is fitted with an onboard computer. The equipment sends

back data, including location, payloads, ore quality, cost grade, etc. This is a typical example of the FMS system that is working on a mine site. These are the machines that are plying on the different sides of the mine site, and all machines are connected through the wireless communication systems with the wireless tower, and through that, they are basically established in a connection in the headquarters control room. So, from the headquarter control room, the cabin crew in the headquarter control room can see and monitor the real-time data of these machines plying on the mine site.

So, for example, this is the dumper working with another machine. So, this has been updated on the system. Here is the dumper taking the material from the shovel. So, this dumper is now in the loading stage. Once the loading is complete, the dumper will enter the hauling stage. So, that data will be shown here on the FMS module. So, this is a perspective of the overall FMS system, including how it establishes connections with the different machines that operate on the mine site and gets valuable data in real-time for establishing control over the system and also enhancing the system efficiency to the next level.



This is another schematic of the surface mining operation and how it communicates with the FMS system. Here in the FMS, some decisions are given to the dumper so that those dumpers are moving from one site to another site as decided from the database that is sent through the wireless signal, and it is assigned to some particular shovel sometime, or it is assigned to some fixed path like that. So, all of these are in the database, and the real-time status is also updated on the database. Based on that, if new informed decisions are to be forwarded to these dumpers, that can also be done. So, this is the complete workflow or schematic of how saw belt dumper combinations work and their connections established

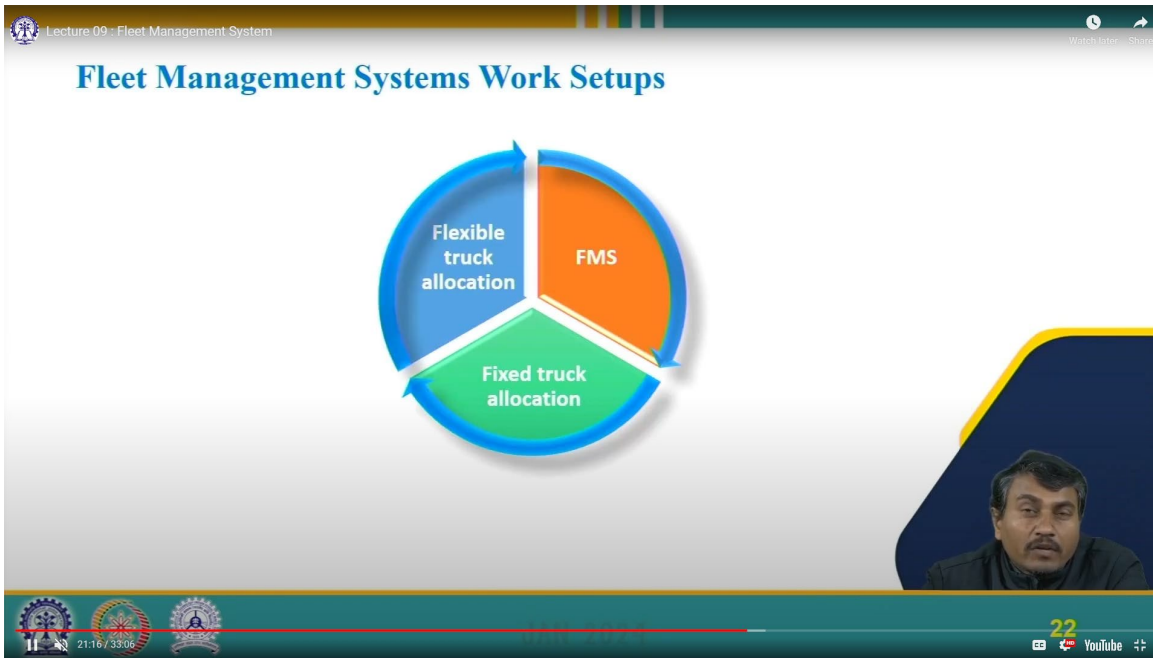
through the database and commands from the central control units. The main decision to be made by the FMS is to dispatch trucks to the shovels. So, these decisions should be made in a way that meets the production requirement with the minimum deviation and maximizes the productivity of the active equipment, including both loaders and transporters.

Question 2:

how does the fleet management system prioritize the dispatch of trucks shovels? by choosing the shovels with the shortest route, randomly selecting trucks for dispatch, Ensuring the trucks are arranged by color, meeting production requirements with minimal deviation and maximizing equipment productivity.

The right answer is, meeting production requirements with minimal deviation and maximizing equipment productivity.

Fleet management system work setup: So, this FMS system works on two setups. One is the fixed truck allocation system; the other is the flexible truck allocation system.



Fixed the truck allocation system. At the beginning of its shift, a set of trucks is assigned to specific transportation routes. Allocation is based on various criteria, including production requirements and the availability of trucks in the fleet. The trucks remain locked to their designated paths throughout the shift. So, the path assignment is typically static unless there is a breakdown or a critical event occurs. So, this method provides stability, but it lacks adaptability to changing conditions.

Criteria for allocations- Allocation decisions are influenced by factors such as production needs and the availability of trucks. The criteria for assigning trucks to specific paths aim to optimize efficiency and resource utilization.

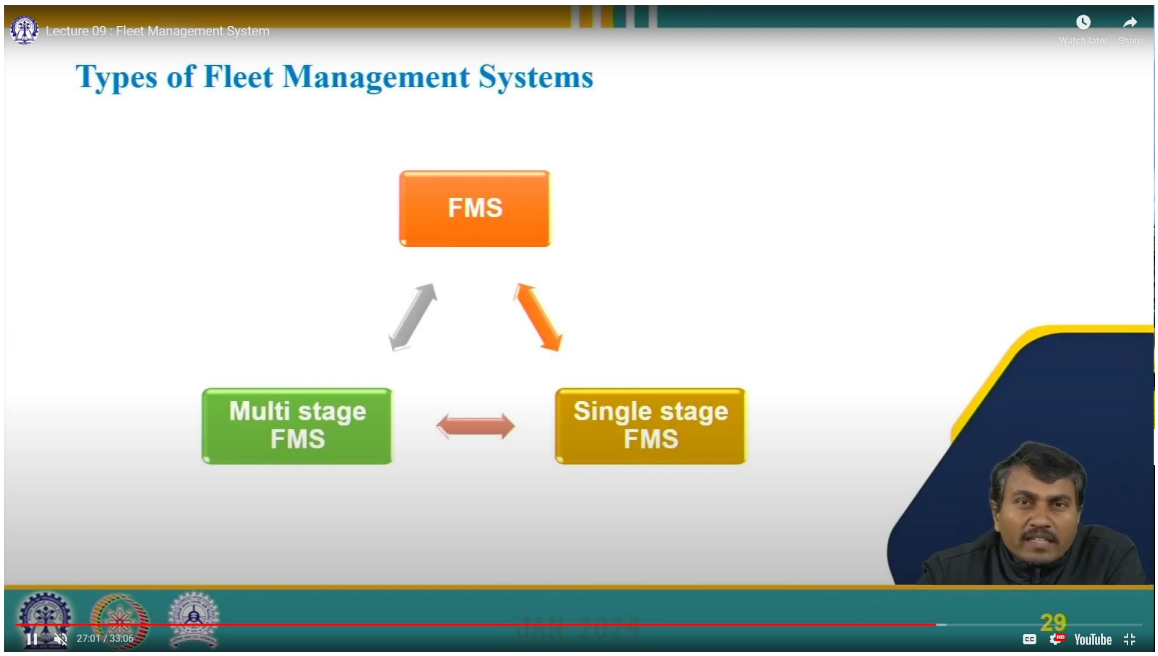
Base method for performance evaluation- The fixed truck allocation methods serve as a foundational approach for evaluating the performance of other algorithms and operational strategies at the mine site. The researcher uses it as a benchmark to assess the effectiveness and efficiency of proposed modifications and innovations in mining logistics. +

Flexible truck allocation- Flexible truck allocation involves assigning a number of available trucks in the fleet to a specific working shovel at the beginning of the shift. Unlike traditional allocation methods, these trucks are not dedicated to a single shovel or a route during the shift. Instead, they receive new assignments from the dispatching system after loading at shovels and tipping at dumping destinations. Flexible truck allocation has been shown to significantly improve the productivity of mining operations because of its increased flexibility and increased adoption in new situations. According to reports, the use of a flexible truck allocation system increased production at the Bougainville copper mine by 13%. The barrick gold strike gold mine experienced a 10 to 15% improvement in productivity, and a 10% growth in iron ore production was also observed. Additionally, the quintette coal mines reported a 10% increase in production with a flexible truck allocation system. A similar study of the Sungun copper mine operation demonstrated an 8% increase in mine productivity with the implementation of a flexible allocation strategy compared to a fixed allocation system.

This is a typical example of how the dumpers are plying on the mine roads using the FMS system. In India, in one of the iron ore mines situated in Noamundi operated by Tata, they basically operate with this fleet management system of WENCO, and they have added shovel dumpers to the system. They regularly monitor the status of the health of the shovel dumpers in real time, and they track the routes, monitor, and they time to time intervene, using some informed decisions, a shovel to a particular dumper or a dumper to a particular shovel based on necessity. So, this is now also working in India.

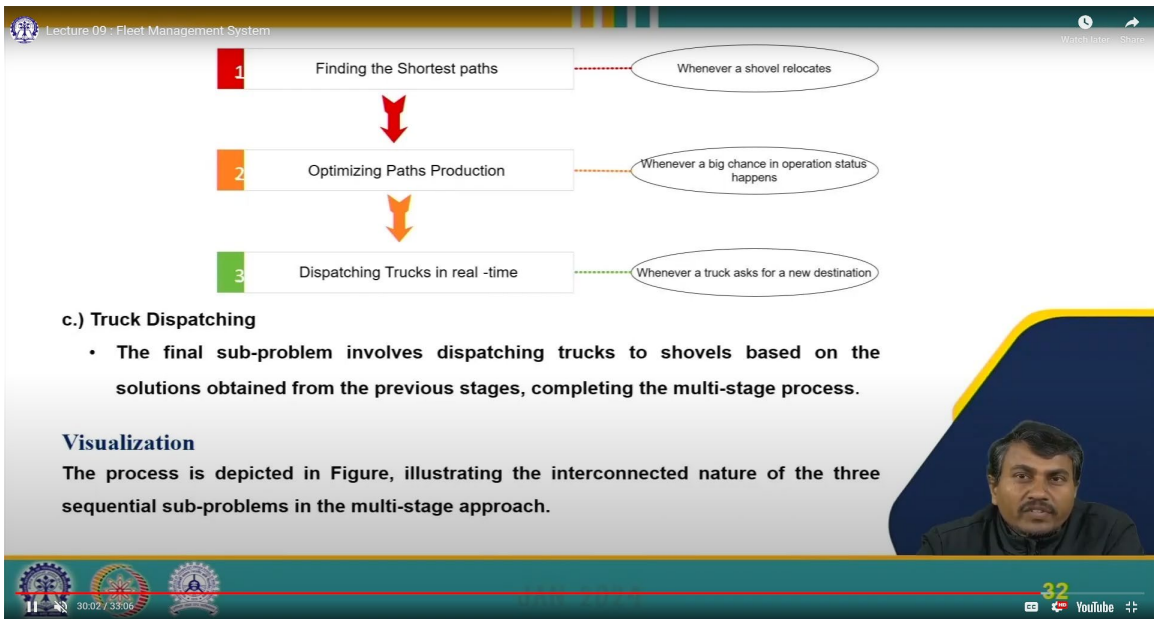
Types of fleet management systems, FMS single-stage and FMS multi-stage. There are two varieties: one is the single-stage FMS, and the other is the multi-stage FMS.

Single-stage FMS: Shortest part identification-The single-stage fleet management system is designed to identify the shortest paths connecting loaders to their respective destinations. Optimal trip calculation- It determines the optimal number of truck tips needed for each available path, optimizing efficiency and minimizing travel time. Historical significance- Hauck developed the FMS system in 1973, which represents one



of the earliest instances of this technology and operates on a single-stage approach, contributing to the foundational development of fleet management systems.

Multi-stage FMS- Most mining fleet management systems adopt a multi-stage approach to their operation. Sequential sub-programs- The multi-stage approach involves solving three sequential subproblems, with each stage building upon the solution of the previous one. shortest path identification-The first subproblem focuses on finding the shortest path that connects all the sources to their respective destinations. Optimal material production-in the second stage, the goal is to determine the best possible amount of material to be produced for each identified path.



Finding the shortest path whenever a shovel relocates, then optimizing path production whenever a big chance in operation status happens and the third dispatching truck in real time whenever a truck asks for a new destination is truck dispatching. The final subproblem involves dispatching trucks to shovels based on solutions obtained from the previous stage, completing the multi-stage processes. Visualization- The process is depicted in a figure illustrating the interconnected nature of the three sequential subproblems in the multi-stage approach.

Benchmark truck dispatching model- The real-time dispatching model in the benchmark FMS is the backbone of modular mining dispatch. The model flows on the M truck for one shovel strategy. In the M truck for one shovel strategy, M trucks that need to be assigned in the near future are considered for one needy shovel. The model requires two lists. The list of needy shovels and the list of available trucks. The list of needy shovels, which are the operating shovel behind their production schedule, is ordered based on the next time a needy shovel needs truck assignment. The list of available trucks is ordered based on their next availability. The first truck on the available truck list is assigned to the shovel at the top of the list of needy shovels. After the first truck is assigned, the shovel moves to the bottom of the list. The model repeats the same procedure until all available trucks are assigned to the needy shovel.

So, these are the references. Let us conclude in a few sentences. In this lecture, we have explored the fundamental concept of fleet management systems and emphasized their role in optimizing the operations of vehicle fleets. We have defined the objectives and goals of the fleet management system. We have illustrated how this system contributes to enhancing the efficiency, safety, and overall fleet performance at the mine site. We have discussed the advantages and disadvantages of FMS and its importance. We have provided an overview of the workflow within a fleet management system, detailing the processes involved in monitoring, tracking, and managing a fleet of vehicles. We have classified and discussed different types of fleet management systems, showcasing the diversity and adaptability of these systems to meet specific industry needs. We have introduced a benchmark model for truck dispatching within the fleet management system, emphasizing best practices and efficiency benchmarks. Thank you.